ROOFTOP



PROJECT MANUAL

berlin

Solar Decathlon Europe

Federal Ministry for Economic Affairs and Energy

ROOFTOP

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RULES & BUILDING CODE COMPLIANCE CHECKLIST



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Welcome to the heart of the Rooftop Project. The entire house is described and observed from every angle and every viewpoint. Technical and lyrical essays await.

ROOFTOP

6.1. URBAN DESIGN, TRANSPORTATION AND AFFORDABILITY REPORT

Berlin cityscape, with its picturesque, sometimes confusing and emotive elements, at times seemingly trivial, is a mirror-image of its uneven history. Opposing concepts were developed, fought for survival and turned into their own opposites. Berlin became a city of the extremes, with many forces shaping the city and few that could be traditionally categorized.

ROOFTOP

6.2. ARCHITECTURE DESIGN NARRATIVE

What is a house without context? The architectural section describes the Rooftop House as part of a whole, at conceptual peace with its context. Rooftop is a part of Berlin, continue to learn why.

ROOFTOP

6.3. ENGINEERING AND CONSTRUCTION DESIGN NARRATIVE

Welcome to the royaume of numbers. In the pages that follow, our aspiring engineers outline the main technical aspects of our project. The report begins with the hands-on structural design which assures everything will stay in its place. We explain our construction process strategies and the thermal envelope. After our plumbing and water design we elaborate on the electrical and photovoltaic design. At the end of this narrative the Building integrated Active Systems, including Solar Thermal Design, our cooling circuit and the movable façade, are explained.

ROOFTOP

6.4. ENERGY EFFICIENCY DESIGN NARRATIVE

We will implement innovative and energy saving solutions for the applicable features of our house. All the house appliances and building services are chosen based on energy efficiency.
A detailed energy efficiency analysis of our building shows the potential for energy savings in the heating and cooling sections.

ROOFTOP

6.5. INNOVATION REPORT

Nowadays it seems difficult to innovate in a strictly regulated environment like the construction industry — yet is there a better place to rethink the world than the technology sector? There is no redundancy for failures and there is a dire need for new solutions that answer today's and not fifty-year-old questions. Whilst taking into account safety, regulation and reliability issues, we humbly look for new solutions or adaptions to existing ones.

ROOFTOP

6.6. SUSTAINABILITY REPORT

It presents the current design in energy savings at this stage of development. The different applications are described in the related sections according to rule 24 ongoing for the sustainability report. Not only the design for a more efficient handling during the use phase, referring to savings of direct energy like electricity and heat is part of the following articles, but also the use of the chosen materials to reduce the impact of grey energy.

ROOFTOP

6.7. COMMUNICATIONS PLAN

New ideas are not relevant unless they are heard. This section describes our efforts, strategies and successes in communication management and how we are creating the brand Rooftop.

ROOFTOP

DINNER PARTY MENU

This section is designed to make you jitter with anticipation for the big show: the Rooftop dinner! Unfortunately paper is not edible. Please wait for that fresh evening breeze after a hot summer day to savour Berlin's local specialities.

ROOFTOP

CONTEST WEEKS TASK PLANNING

Housework. Ouuugh.
Metering. Mmmmh.
Cooking. Yum.
All these daily activities will be fun once we perform them in our own house. Taking people on a tour around the house, inviting experts to review our concepts 1:1 — Awesome!

ROOFTOP

COST ESTIMATE & FINANCIAL SUMMARY

The numbers that make it all possible.

ROOFTOP

SITE OPERATIONS PLAN

ROOFTOP

HEALTH SAFETY

Safety first! In this section we describe our risk assessments, safety measures and fire regulations.

ROOFTOP

WATER BUDGET

Water is life. And we are dealing with it in a smart way. In this section you can have a look at the numbers behind the pipes that are hidden in the walls of our core module.

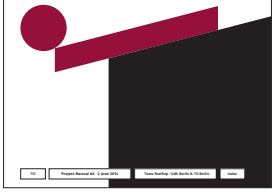
ROOFTOP

PROJECT SPECIFICATIONS



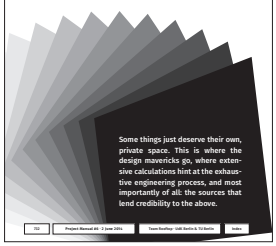
ROOFTOP

STRUCTURAL CALCULATIONS



ROOFTOP

APPENDICES



Some things just deserve their own, private space. This is where the design mavericks go, where extensive calculations hint at the exhaustive engineering process, and most importantly of all: the sources that lend credibility to the above.

SUMMARY OF CHANGES



#	Chapter	Changes
1	Title Page	New layout to small pages added
2	Summary of Changes	Small changes added
3	Table of Contents	One content subpoint added
4	Rules & Building Code Compliance Checklist	no changes
5	Contest Support Documents	small changes in all chapters
5.1	**Urban Design, Transportation and Affordability Report**	
5.1.1	Urban Design Strategy	some sentences added/corrected
5.1.2	Market Viability of the Product	No changes to last deliverable
5.1.3	Individual or Collective Housing Building Project	updated with images and some sentences
5.1.4	Mobility Strategies	
5.1.5	Affordability Strategies	readability enhanced
5.2	**Architecture Design Narrative**	no changes
5.2.1	Architectural Concepts	no changes
5.2.2	Summary of Reconfigurable Features	no changes
5.2.3	Lighting Design Narrative	no changes
5.2.4	Acoustic Design	no changes
5.3	**Engineering and Construction Design Narrative**	Layout changed
5.3.1	Structural Design	

#	Chapter	Changes
5.3.2	Contructive Design	added changes of insulation material of wall, roof, floor (changed from wood fibre insulation to celluslose insulation): actualized all tables and figures 51, 55, 57) added changes of insulation material of wall, roof, floor (changed from wood fibre insulation to celluslose insulation) added figures: figure 53, table 2 actualized figures 59,60
5.3.3	Plumbing System Design	no changes
5.3.4	Electrical System Design	removed the 300mA RCBOs for the inverters and changed them to 30mA sensitivity. The surge protection devices are protected with a circuit breaker for maintennance. changed module type to 120W. Reduced the Steca batterycharger which exceeded the limitation in the charger-inverter power. The inverter charger is now protected with RCBOs. Added the anti-islanding device ENS26NA that is compliant with DIN-VDE-126-1-1
5.3.5	Photovoltaik System Design	Updated the new calculation images Updated Rooftop and façade string calculations as a result of new PV modules. **Added monitoring data evaluation**
5.3.6	Electrical Energy Balance Simulation	text revised, images added
5.3.7	Solar Thermal Design	Text revised, Images added

#	Chapter	Changes
5.3.8	Building Integrated Active Systems	added some context Revised pcm texts and updated the affected calculations.
5.4	**Energy Efficiency Design Narrative**	small introduction updated
5.4.1	Technical Project Summary	Differentiation between Berlin and Versailles updated, list of appliances incorporated here, list of appliances changed slightly
5.4.2	Comprehensive Energy Analysis and Discussion Report	Simulation added, graphs added, parameters changed, text revised
5.5	**Innovation Report**	introduction changed
5.5.1	Innovation in Architecture	No changes in this deliverable
5.5.2	Innovation in Engineering and Construction	Typos corrected
5.5.3	Innovation in Energy Efficiency	Text revised, restructured, sections added
5.5.4	Innovation in Communication and Social Awareness	completely revised chapter, parts added and deleted
5.5.5	Innovation in Urban Design, Transportation and Affordability	Section about mobility added, all texts revised
5.5.6	Innovation in Sustainability	text revised
5.6	**Sustainability Report**	introduction changed
5.6.1	General Concept of the Project and Sustainability	Text revised, language corrections, illustration adapted to visual identity
5.6.2	Urban Design and Transportation	Text revised, Images added
5.6.3	Bioclimatic Strategies: Passive Design Strategies	revised ventilation texts, added description of passive ventilation
5.6.4	Construction System	New text
5.6.5	Materials	text revised, added changes of insulation material
5.6.6	Active Systems and Equipment	Text revised, Images added, Efficiency of appliances added
5.6.7	Solar Systems	Text revised, Images added

#	Chapter	Changes
5.6.8	Water	Images added, the first part of the text changed. Added data regarding water consumption
5.6.9	Solid Waste	no changes
5.6.10	Life Cycle Analysis	Text revised
5.7	**Communications Plan**	
5.7.1	Communication Project	no changes
5.7.2	Public Tour Description	no changes
5.7.3	Visual Identity Manual	no changes
5.7.4	Sponsorship Manual	slight changes
6	**Dinner Party Menu**	no changes
7	**Contest Week Task Planning**	no changes
8	**Cost Estimate and Project Financial Summary**	no changes
9	**Site operations Report**	no changes
10	**Health & Safety Plan**	finished
11	**Detailed Water Budget**	Text revised, Images added
12	**Construction Specification**	Updated missing documents required in the checklists. esp. datsheets and certificates.
13	**Structural Calculations + Approval**	New link
	Appendices	Appendices changed and updated.

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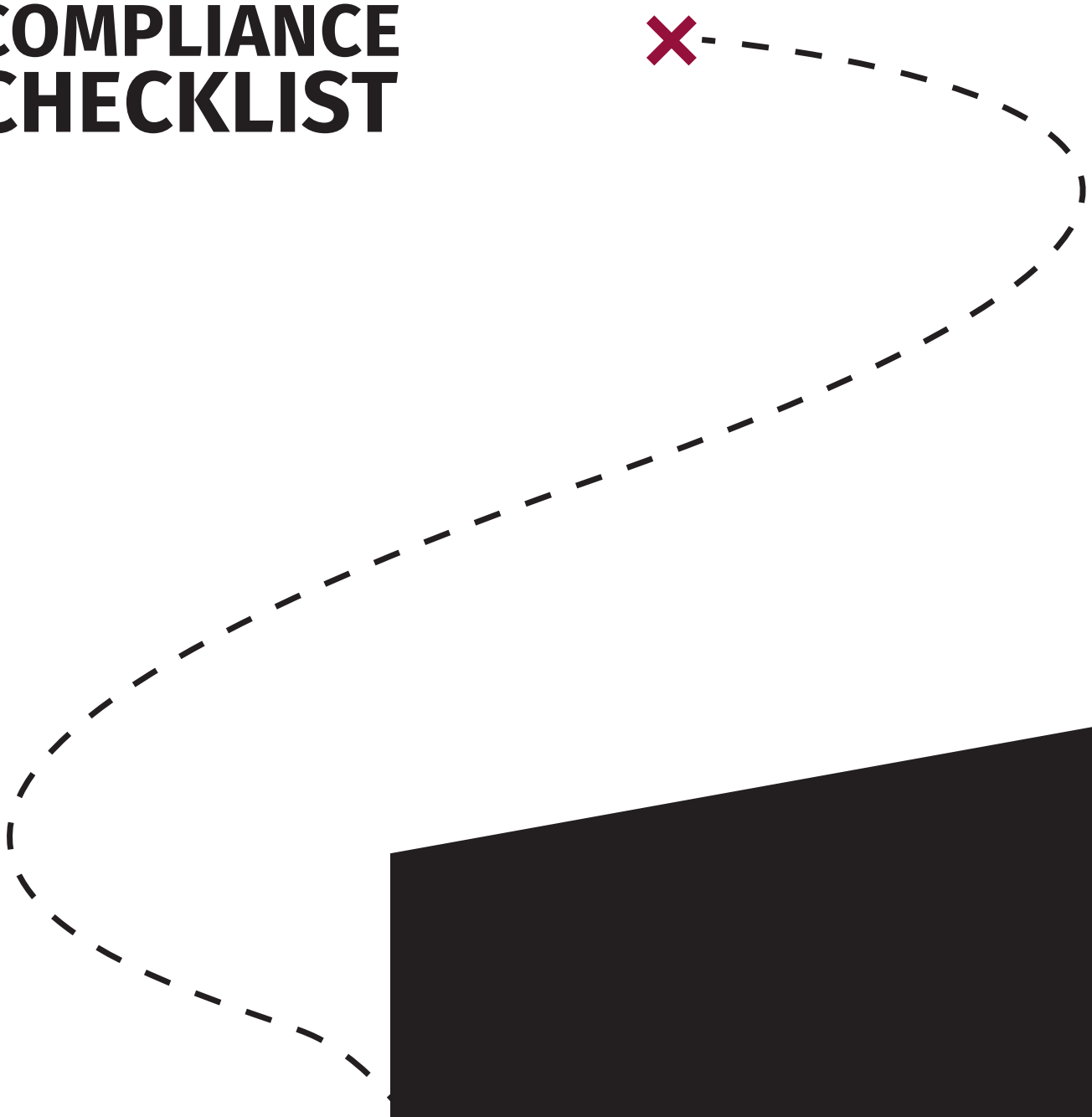
RULES &
BUILDING CODE
COMPLIANCE CHECKLIST



Rules Description	Content Requirements/Drawings/ Reports	Done and Uploaded	Name of Plan and Section where it is located
3.2 Team officers and Contact Information	team officer's contact information completely fulfiled in Table 1	x	Press Release
4.3 Lot Conditions and attribution	drawings showing the storage and unloading areas and corresponding load's calculations	x	SO-102 to SO-104
4.3 Lot conditions	Calculations showing the structural design remains compliant even if there is a level difference, and drawings showing shimming methods and materials to be used in case	x	Structural Calculations, Chapter 4.7
4.4 Footings	Drawings showing the locations and depths of all ground penetrations on the competition site	x	ST-001
4.4 Footings	Drawings showing the location, contact area and soil-bearing pressure of every component resting directly on the ground	x	ST-002
4.7 Construction Equipment	Drawings showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site and specifications for heavy machinery	x	SO-200 and following
4.10 Spill and Waste Products	Drawing(s) showing the locations of all equipment, tanks and pipes containing fluids during the event and corresponding specifications	x	PL-002
5.1 Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	x	AR-011

Rules Description	Content Requirements/Drawings/ Reports	Done and Uploaded	Name of Plan and Section where it is located
6.1 Structural Design Approval	Structural drawings and calculations signed and stamped by a licensed professional	x	Section 13 of the Project Manual
6.1 Electrical and Photovoltaic Design Approval	Electrical and Photovoltaic drawings and calculations signed and stamped by a qualified licensed professional	x	Section 12.3.4 and 12.3.5 of the Project Manual and Drawings PV-001-S and PV-011-S and PV-021-S, PV-031-S
6.1 Codes Design Compliance	List of the country of origin codes complied, properly signed by the faculty advisor	x	See Appendix A
6.2 Maximum Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to digitally measure the architectural footprint	x	AR-014
6.2 Maximum Architectural Footprint	Drawing(s) showing all the reconfigurable features that may increase the footprint if operated during contest week	x	AR-041
6.3 Minimum & Maximum Measurable Area	Drawing(s) showing the Minimum & Maximum Measurable Area	x	AR-017
6.4 Entrance and Exit Routes	Drawing(s) showing the accessible public tour route, specifying the entrance and exit from the house to the main street of the Solar Village	x	PT-001, FP-001
7.3 PV Technology Limitations	Specifications and contractor price quote for photovoltaic components	x	Secton 14.3.5 of the Project Manual
7.4 Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices and corresponding specifications	x	PV-001,PV-011,PV-012, PV-013, PV-021, PV-031

Rules Description	Content Requirements/Drawings/ Reports	Done and Uploaded	Name of Plan and Section where it is located
7.4 Batteries	Drawing(s) showing the location(s) and quantity of hard-wired battery banks components and corresponding specifications	x	EL-301
7.6 Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components and corresponding specifications	x	Me-101-103
7.7 Desiccant Systems	Drawing(s) describing the operation of the desiccant system and corresponding specifications	x	ME-201
7.8 Humidification systems	Specifications of the humidification systems and corresponding certifications of the different elements.	x	ME-041
8.1 Containers locations	Drawing(s) showing the location of all the water tanks	x	PL-001
8.2 Water Delivery	Drawings showing the fill locations, quantity of water requested at each fill location, container dimensions, diameter of opening(s) and clearance above the tank(s) 8.3 Water Removal	x	Pl-002
8.3 Water Removal	Drawing(s) showing the quantity of water to be removed from each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s).		delivered on 17.3.14
8.5 Grey water reuse	Specifications for the grey water reuse systems	x	PL-011, Section 5.6.8 of the Project Manual

Rules Description	Content Requirements/Drawings/ Reports	Done and Uploaded	Name of Plan and Section where it is located
8.6 Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	x	AR-331, AR-333
8.8 Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems and corresponding specifications	x	Me-101-103, ME-031, PL-101
8.9 Grey Water Heat Recovery	Specifications for grey water heat recovery systems	x	ME-031, PL-011, Section 5.6.8 of the Project Manual
9.1 Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	x	AR-002
9.2 Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems	x	PL-011
10.2 SDE Sensors' Location and wire routing	Drawing(s) showing the location of bi-directional meters, metering box, sensors, cables and feed-through to pass the instrumentation wires from the interior to the exterior of the house	x	ME-101-103
11.2 Use of the Solar Decathlon Europe Logo	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	x	Use of the NEW logo: Appendices E,F,G,H,J,K Section 5.7.3 of the Project Manual
11.3 Teams' sponsors & Supporting Institutions	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	x	Press Release

Rules Description	Content Requirements/Drawings/ Reports	Done and Uploaded	Name of Plan and Section where it is located
11.4 Team Uniforms	Drawing(s) showing the art-work, content and design of the team uniform	x	Appendix G of the Project Manual
12.4 Public Tour	Drawing(s) showing the public tour route, indicating the dimensions of any difficult point, complying with the accessibility requirements	x	PT-001, PT-101, PT-201

CONTEST SUPPORT DOCUMENTS

Welcome to the heart of the Rooftop Project. The entire house is described and observed from every angle and every viewpoint. Technical and lyrical essays await.

5.1. URBAN DESIGN, TRANSPORTATION AND AFFORDABILITY REPORT

Berlin cityscape, with its picturesque, sometimes confusing and emotive elements, at times seemingly trivial, is a mirror-image of its uneven history. Opposing concepts were developed, fought for survival and turned into their own opposites. Berlin became a city of the extremes, with many forces shaping the city and few that could be traditionally categorized.

5.1.1 URBAN DESIGN STRATEGY

Berlin was founded by enthusiastic young colonialists who had been lured from the overcrowded Rhineland by east elbian sovereigns. They arrived in the hope of reclaiming the area that had once been inhabited by their ancestors, but was at the time more populated by wolves and bears than Slavic people. It was in 1238 that the townships of Berlin and Cölln were first documented. Set in the middle of dark Pomeranian woods and imponderable swamps, they were nevertheless on the crossroads to eastern Europe and naturally took on a role as trading towns. Dealing skins, furs, honey and wax was what made the townships become successful and finally members of the influential Hanseatic League. The adjoining towns were united and became Berlin. It featured a typical colonial town scape and street map. The search for organically grown, winding alleyways is futile; straight streets and square angles shaped Berlin, leading up to a well accessible central market place. Berlin grew quickly, and just 50 years after the founding it was necessary to double its area. The rich surrounding nature provided more than enough building materials, so that in the 14th century 10 000 inhabitants populated the town, making it one of Germany's most significant cities.

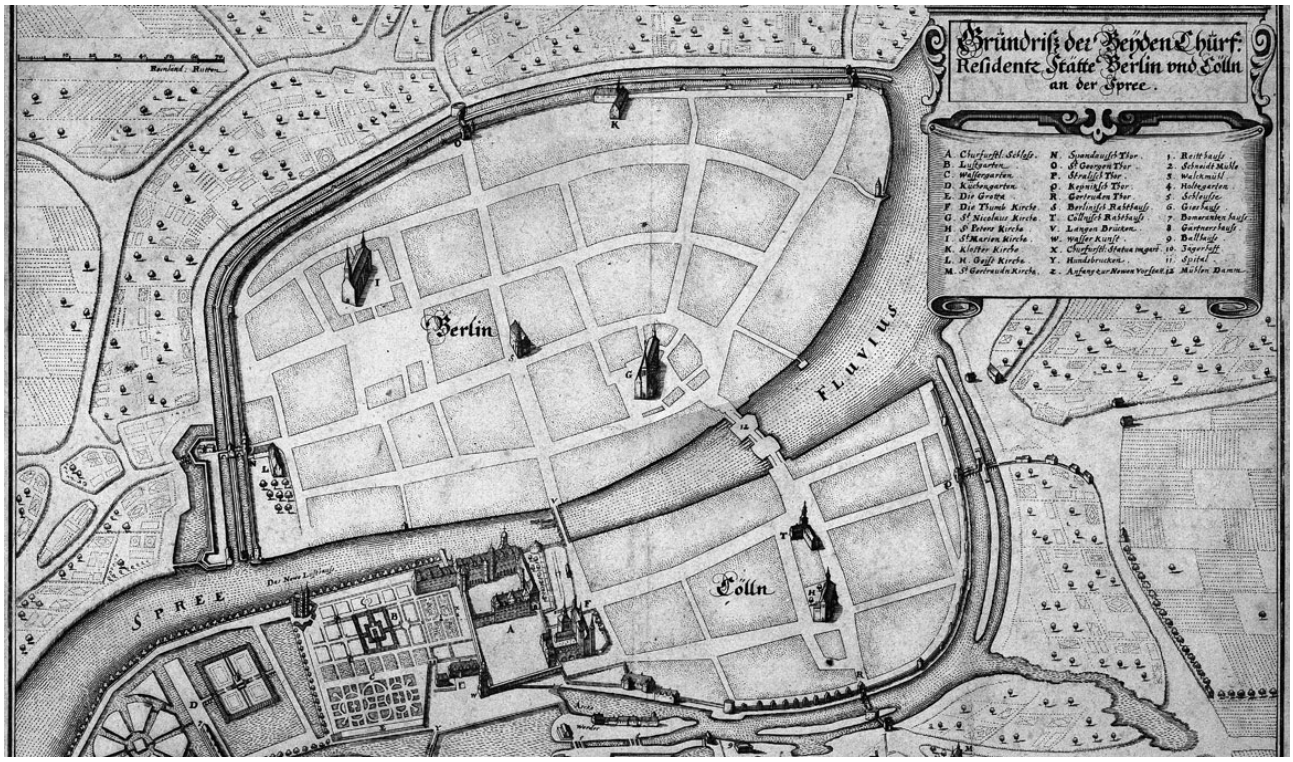


Figure 1: **Oldest Berlin city plan from 1652**

Around 1400 the region often fell victim to the raids and robberies of poverty-stricken knights. It was then that the emperor decided to send the house of Hohenzollern to Brandenburg in order to put an end to dubious on-goings. In Berlin, they were not welcome and restricted the town's freedom in many ways. The squirearchy was sidelined in a way that suited them well, but not the town itself. They received the right to tax the township as they wished and rebellions against this provision were violently crushed. In 1448 the brandenburgian elector Friedrich Eisenzahn split the city into two and robbed both halves of their sovereign rights. As a result, the towns could not command over their own land, and they were not even allowed to cobble their own streets. This state of things lasted until 1875. In order to strengthen his arbitrary rule, a

stronghold in was erected in the North of the town and riots were consistently quelled. Berlin population became depraved. When all autonomy had been destroyed, the towns were permitted to reunite, but Berlin's development was still vigorously prevented. The once so promising city of Berlin sank back to being not much more than a farming town, lacking craftsmanship and skilled trades. The sovereigns no longer had anything to fear and put their energy towards converting their castle into an impressive palace. Their extravagance was financed by several questionable taxing schemes. With land taxes evermore rising, many townsmen left their properties to lay idle. This created a tax loss that had to be compensated by the remaining citizens. Towards the end of the 16th century this system was abolished and land taxes were replaced by excises.

The Thirty Years' War caused the elector to move his residency into the safer eastern part of Prussia, but he left an enormous army for the protection of Berlin. This wild marauding soldiery, infiltrated with mercenaries and common criminals, had to be accommodated by the citizens of the town. Each family had to take in several soldiers and provide for them. After the war, the elector returned and found as little as 7500 people living in the town and pigs roaming the streets. However, this did not seem to bother him much, as he concentrated his efforts on garnishing the castle area. Once again he was in need of excises and he even endangered the Westphalian peace of 1648 by going on robberies once again.

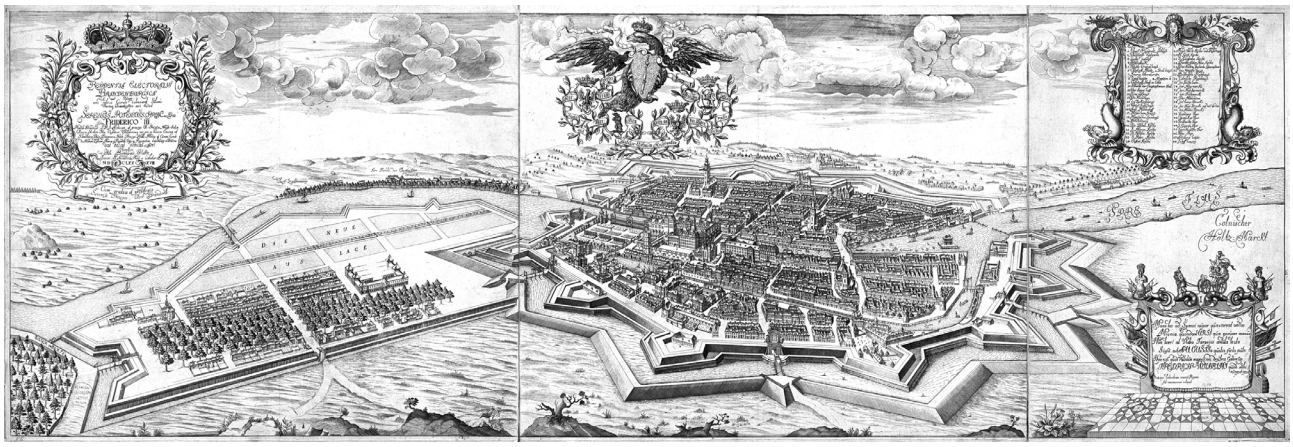


Figure 2: **View on the garrison city Berlin with its suburb Dorotheenstadt, 1688**

The importance of the military grew steadily and with it the burden Berliners had to carry. The town resembled a vast array of barracks more than a trading town. Trying to equal his french role model Louis XIV, the elector commanded a vaubanian style fortress to be built. Once again, it was the citizens of Berlin who were required to work for the goals of the sovereign. The marschian ground made the construction straining and tedious, overall it lasted 25 years. When completed, the design seemed outdated and it was torn down. The only thing that remained from this building attempt until today is a series of serrated squares and disruptive confusions in the city map.

In order to create accommodation for his increasing army, the great elector recruited new settlers and in the West of Berlin Friedrichwerder and Dorotheenstadt were erected. But it was only his son, the King of Prussia, that contrived to lure large numbers of religious refugees from all over Europe into the Prussian capital. In 1700, 5682 of the roughly 20000 citizens were Huguenots. The assiduous immigrants drove the economic power of the city to unknown heights. New manufactures were built and rich tax revenues prompted King Frederick I to build Friedrichstadt, the final new town. "So as to realize the ideals of regular geometric shapes and endless perspectives, the structures consciously does not relate the existing town." (32Oswald)

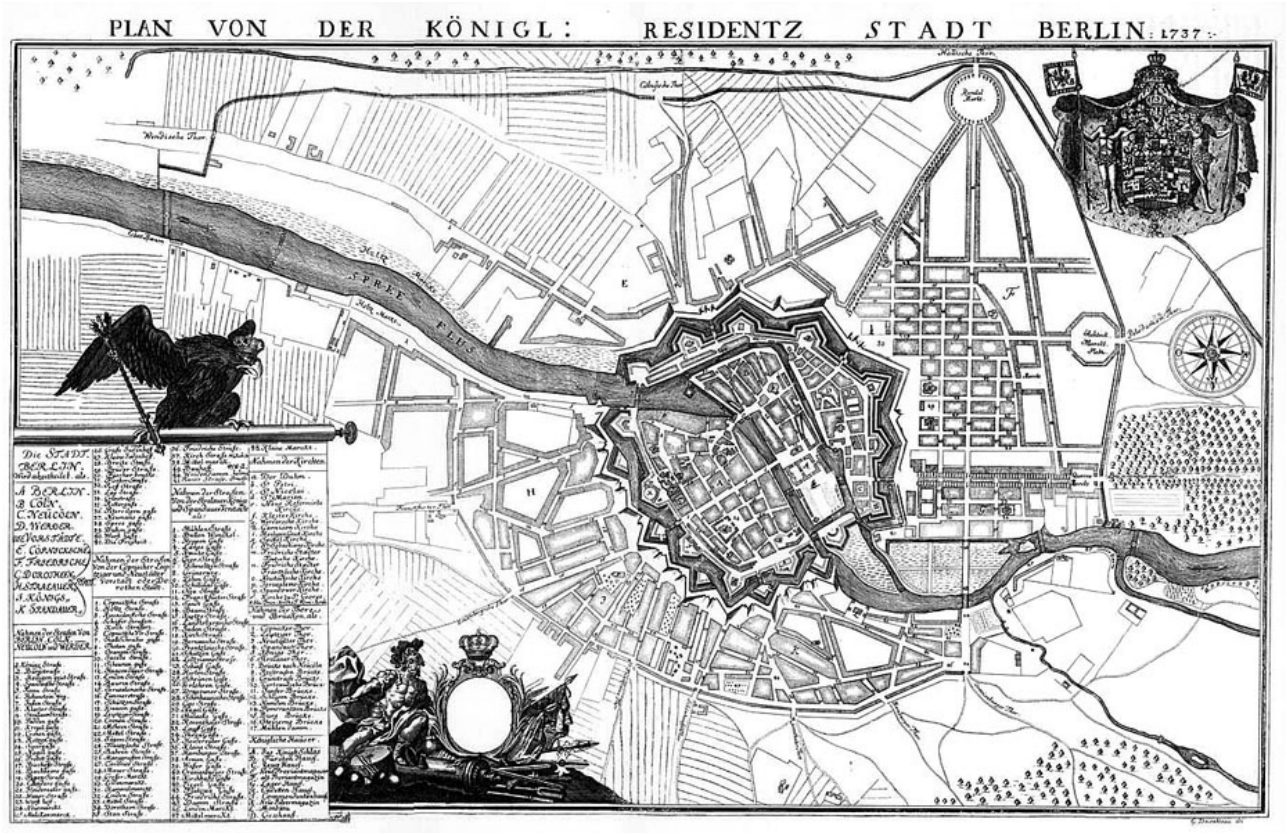


Figure 3: **Royal residence city of Berlin, 1737**

In 1709 the king officially proclaimed the capital and united the 5 separate townships to form Berlin. It was in 1713 that Frederick William I was crowned to be the King of Prussia, and his career as the Soldier King began. Under his reign, Prussia became a feared military power and a serious player in the struggle for power in Europe. He increased his army to 72000 soldiers. The king's roughness and violent military leadership transferred to his population. House owners were urged to report renegades, if they did not do so they were in risk of serious harassment. Others were commanded to build on designated plots of land in Friedrichstadt at their own costs. The baroque amplification of the city took place in this time and some of Berlin most beautiful architectures were created. "The Rondell of the Belle-Alliances Platz with its three out-fanning streets complete the incomplete structures. In the West, the Pariser Platz and the octagonal Leipziger Platz formed the most important entrances to the new quarter."(32Oswald)

Frederick II, also known as Frederick the Great, neglected his duties towards the capital, seeming to prefer to lead wars. In his absence, the population density rose significantly, counting on average 21 citizens per house. Such density was three times higher than the one of London at the time (which was, however, seven times bigger than Berlin). Consequently, the rents increased and wild speculations began. Only when it became apparent that the accommodation of his troops was endangered, the king intervened. He built barracks that were meant for "married soldiers and their relatives" and hoped to thus "systematically drill the Berliner families towards a barracked lifestyle"(114). The reforms of the mortgage laws forced civil house owners to make the absolute most of their plots; consequently the houses grew higher. And "when any land for building purposes became available, the vendor was able to demand prices, that only became profitable and interest-bearing if houses with many layered flats according to the kings model contributed to the high

interest rates of the land prices."(116)

After Napoleons victory over Prussia and the end of the Holy Roman Empire of the German Nation, Frederick William III finally had to agree to reforms that guaranteed freedom of trade, abolition of serfdom and the private ownership of land. These good intentions resulted in a devastating social development. Poor farmers and peasant labourers moved to the crowded city. Lacking a general building concept and due to the restrictions of the town precincts, the newcomers built along the canals and in front of the city gates. This phenomenon created structures that later hindered the further expansion of the city. In 1804 the authorities hired the landscape architect Peter Joseph Lenné to establish a plan for an entire muncipal area of Berlin. His landscape architect heritage became apparent when he created a green ring around the city and introduced compositional features such as Bordertrains that united the different parts of Berlin. However, only the "parts that were economically furthering the community, such as the fit out of the Landwehrkanal [...] were realized, whilst the more aesthetically [...] justified elements were only partially realized." (33Oswald) Towards the middle of the 19th century, Berlin had a population of 450000 and the misery could no longer be ignored. The government's solution for this distress was a new building code and a new development plan. The building code dating back to 1641 was still the official regulation, when in 1853 it was agreed upon a new municipal building inspection regulation. This was shaped by the fear of fires and - to a lesser extent - by hygiene aspects or social needs. The fire prevention requirements included many costly details that cheap houses could not fulfil. Houses bordering onto at least 15 m wide streets were allowed to be indefinitely high. The courtyards had to wide enough to allow for a fire engine to turn, the entrance to the courtyards also had to respect the width of the fire engines. Building complexes such as "Meyers Hof" in the Ackerstraße emerged around 1874.

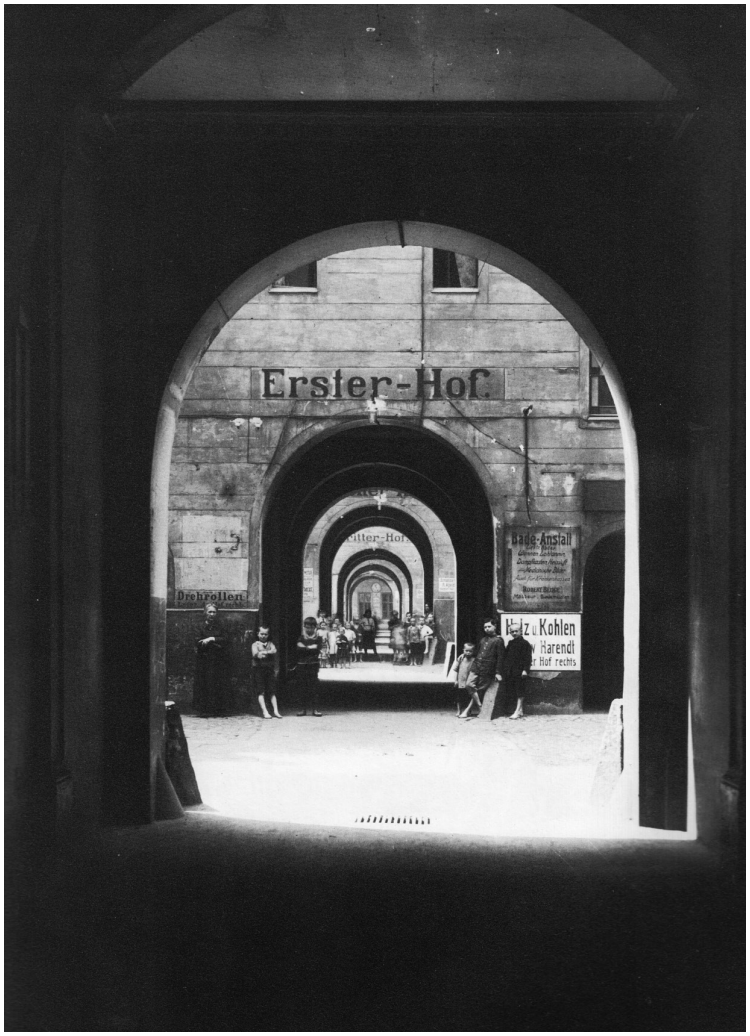


Figure 4: **View through the many backyards of "Meyer's Hof"**

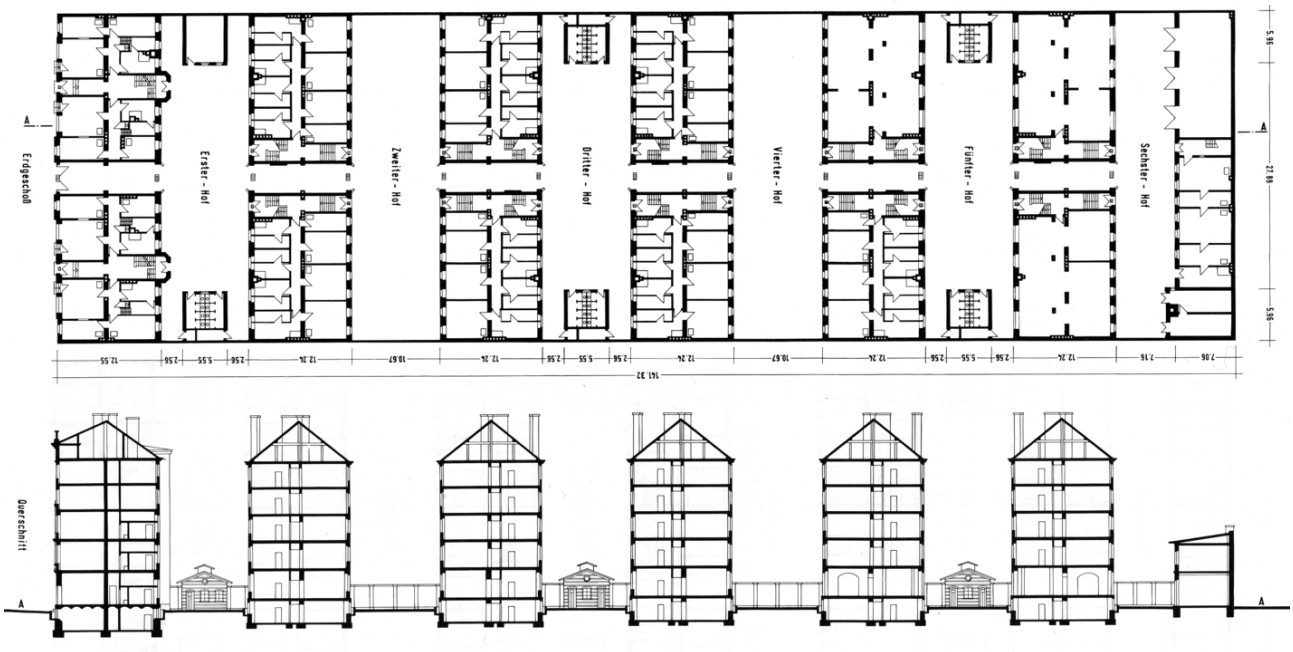


Figure 5: **Section and floor plan of the tenement "Meyers Hof"**

The layout of the front house and the six rear houses barely differed from barracks. "A long hallway passed through the entire length of the house, to one side there were only rooms, and to the other rooms and kitchens, so that a separation between flats did not exist."(169 Posener) After a long struggle concerning responsibilities and maintenance costs, the Chief of Police hired the Engineer James Hobrecht in 1859. It was his job to set up a land-use plan for Berlin and the surrounding areas in just three years. He included considerable parts of Lennés plans and even some parcelling concepts that had been developed by profit-orientated companies. This happened in accordance with the stingy military state, that was aiming at avoiding compulsory purchases and buy-outs. Thus the plan only specified "a rough development and canalization system. No building presets were set."(33 Oswald) Large and wide blocks, that were up to three or four times bigger than those of the baroque-an Friedrichstadt. Furthermore, wide and sharp angles were avoided in order to lower building costs. Berlin industries also fought for the big blocks, which allowed them to spread out. The aim was to create a socially mixed town, and thus avoid the existence of working class districts and any areas that could host a rebellion. Opposing the concept of a "stone-faced" Berlin private investors began building mansion districts in the South-West of the city.

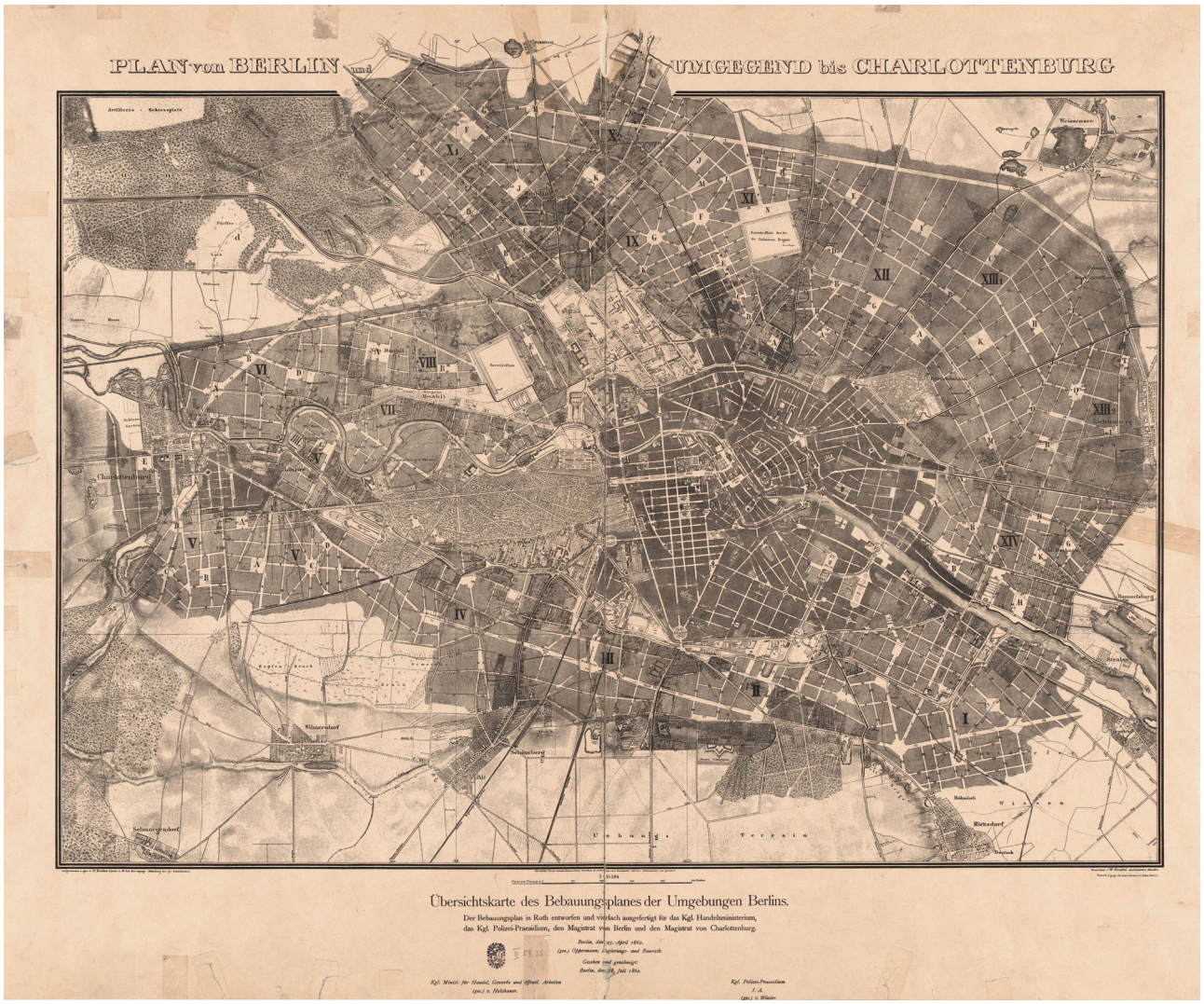


Figure 6: **Hobrecht Plan 1862**

In opposition to brick-built Berlin, some private adventurers were setting up mansion arrangements in the South-West of the city. More and more well-off inhabitants were drawn to these green areas, meanwhile the limitless development of Hobrecht's much-vaunted 'Mietskasernen' (block of flats) came to a halt. Designated residential areas for the working class emerged, similar to the ones in London and other metropolises. But "whether it becomes a slum depends on the kind of occupancy". (169 Posener)

The landowners along the city limits could not afford to erect their buildings themselves without mortgages. Needing one at first, then a second and a third one in order to keep building operations running. Thus, building business became mortgage bank business. But where did the people find occupation? "Constructions sustain constructions." (169 Posener)

Until the first world war a new construction type evolved and was used broadly. Property widths hardly vary. Eaves height was limited by an amendment of 1887 to 22 m in order to uphold access with fire fighter ladders. Centrally arranged a court passage was placed and the infrastructure provision of the 6 floors thereby organised decentrally. The building was finished off with an attic and in order to keep ridges from rising up in enormous heights, flat roofs were used.

Rear houses were connected with side wings. In corners the notorious 'Berliner Zimmer' came up, providing just one window.

Overall, the city with a population of about 2 million grew with a possibly record-breaking density of 75,9 people per building to a 'Reichshauptstadt' (state capital). At the same time, the radial railway lines constructions progressed most rapidly. In between, open spaces were left and mostly taken up by allot settlements.



Figure 7: **"Mother, hand out the two flower pots! Lieschen likes to sit in the green field, you know." (Heinrich Zille)**

City and countryside permeate one another unplanned, starting in the 1920s, purposely.

The 1918' revolution pushed all the reformers, who were not successful in coming up with a socially healthy city planning during the prewar era, into high positions.

The democratically elected municipal authorities quickly tackled the most urgent issues: all towns and communities within Berlin's agglomeration got incorporated in the city of Berlin and formed the centrally organised greater Berlin. Protected natural habitats and forest also belong to the city's area. Cooperative construction and federal social housing could not actually ease the housing shortage.

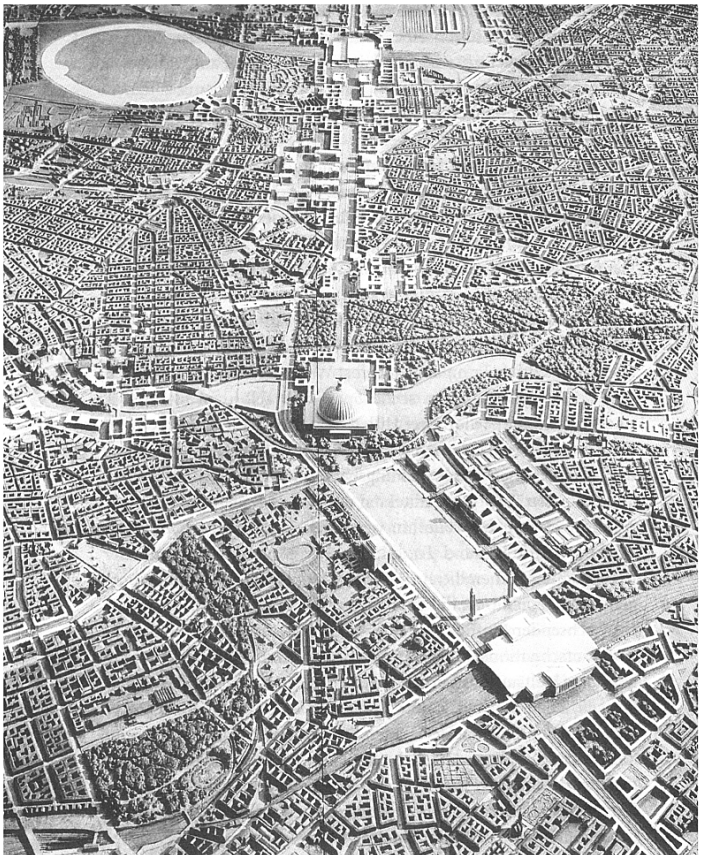


Figure 8: **World capitol of Germania - North-South-Axis plan from 1939**

The unordered city with its four million inhabitants and its nonlinear sceneries did not appease Adolf Hitler. His goal would be to transform it into the world capitol Germania through the implementation of axis and avenues.

Everything that stood in the way of this master plan should be destroyed ruthlessly. The process started with the even today still well visible East-West-Axis. In secret, the leadership of the Third Reich took the destruction through the carpet bombing strategies of the Allied Forces after 1940 and especially after 1943 as a welcome aid in clearing the Old Berlin from its unwanted tenements. The carpet bombing did not happen evenly, but rather perforated the city surface and created areas of different building densities. (35 Oswald)

The rebuilding after the war was taken as an opportunity to completely reorganise Berlin into an organic cityscape.

The idea of fast travel streets and an interconnected network was integrated into the new city planning. For the realisation of these ideas large gaps were torn into the remaining residential areas, while the planned

infrastructure was never installed. Early enough, the aversion of the Berliners against these plans began to rise. Even today, the course of never built highways and connection streets can be extracted from the study of empty spaces and differently aligned block structures. Berlin as the setting for the Cold War did not only experience a hermetic isolation, but it was also seen as the scene of display for the two competing political systems. In Eastern Berlin, a centralistic order is created with the TV tower at its centre and, in the process of city enlargement through endless lines of prefabricated blocks, the remaining prewar buildings are almost forgotten. Neither in their destruction nor in their preservation a single penny is invested. The West Berlin strategy is decentralization: starting from different sub-centres, the existing building stock since the 1980s is extended.



Figure 9: **Appropriation of spaces - a treehouse in the district of Kreuzberg**



Figure 10: **the "Tacheles", an artist settlement and nightlife location where once one of the largest wareheouses of Europe stood until the WW2**

What connects both halves of the city are the youth- and protest-cultures that developed in the partly derelict tenements, and which began to see the war gaps between the buildings as laboratories for the experiments of whole generations. "Apart from the conventions of society, an enormous spectrum of spon-

taneous, often illegal activities ranging from gardening, wagon forts, markets, sports and pastime activities to artistic experimentation and nightlife flourished here. With this possibility, new fashions and lifestyles arose."(65Oswald)

They are also catalysts of the new, and they are until today of absolute importance for a city that sees its future perspectives mainly in the relentless "creative-industry".

To preserve these spaces, aiming instead at the densification of preexisting buildings is the goal of the Rooftop House. The typical old tenements, which can still be abundantly found in Berlin and whose roof spaces are neglected and unused, are ideal for prefabricated additions such as the Rooftop House.



Figure 11: **Kreuzberg - a typical way to deal with the famous Berlin bare brick fire wall, the "Brandwand"**



Figure 12: **Typical eave structure**

After the fall of the Berlin wall, West Berliners lost their island position as well as East Berliners gained freedom, but also responsibility, for themselves. During this uncertain period of transition, many citizens sought a foothold and oriented themselves towards their compatriots in West Germany: By all means, they went for the private residential housing. Since the land at the city limits was cheap and the construction of residential housing was promoted with tax incentives, the suburban carpet always continued to spread out around the city. To reach every house in this loose structure with electricity, water, gas, cars, sewage network, supermarkets, schools etc., millions were put into the infrastructure, meanwhile the already existing networks within the city had to be developed and maintained.

These were designed for a much higher population density. Before the war, whole families lived in the tenements in one room and shift workers shared their beds. After the war the average amount of living space per person grew to 38.9/m².

(http://www.welt.de/welt_print/article2545456/Pro-Kopf-Flaeche-in-Deutschland-steigt-auf-42-Quadratmeter.html) .

The consequences of the now oversized infrastructure are particularly evident in the sewage system. Also due to the efforts to save water, on some days additional water needs to be drained into the sewers to ensure smooth rinse. On the other hand, the new networks in the suburbs of Berlin must be designed so that during heavy rain all sealed surfaces can be drained.

Such measures illustrate the mistakes of the housing policies of the last decades.

In an unused state, attics of Berlin's tenements await their usage since an intensification of fire protection regulations. Laundry rooms were set up there before, as well as storage rooms. Following the new amendment, all partitions had to vanish due to their high fire loads. Now the attics are empty, serving only the pigeons as a dovecot.

When a homeowner wants to upgrade his property's energy envelope, the roof is the first component which has to be insulated. Consequently, if one cannot get around energetic investments concerning the roof, then why not also use this as a chance?

Actually, it pops to your eye. The attic's brick-built access provides a natural development in the sense of

the staircase representing a common entrance. The already existing brick walls prevent fires from spreading to neighbouring buildings. The entablature and the rafter have to be reconstructed. These were built hastily after the war as a makeshift structure in lower quality and are often already affected by humidity. Additionally, the ceiling height can be increased. The Berlin Building Code limits the height of the eaves of the buildings traditionally to 22 meters. Then there is either the option to build a typical Berlin-shaped Rooftop again - to come from the eave at a steep angle to the desired ceiling height and fall from there with bitumen felt at a shallow angle towards the backyard - or to build setback-storeys. The penthouse floor offers the possibility of wider terraces and large windows. In this case, the façade elements of the new attic are pulled back. Thereby the view from the street stays the same in terms of uniform eaves.

Because of the similar socioeconomic conditions during their construction period, floor plans of prewar buildings only differ in detail. In accordance to that predictable factor, prefabricated roof installations are a promising approach. Thus, the construction activities on site can be minimized, which protects the neighbourhood. Before the old roof is torn off, the upgrade of the ceiling above the highest floor can already start. By doing so the risk of incoming water during the construction period is prevented. The consideration of the residents is a major advantage with this construction method. For the planners, the connection details decrease.



Figure 13: **multiple rows of usable makeshift Rooftops**



Figure 14: roofscape overview of mostly makeshift Rooftops

Translated into an architectural typology, a roof pavillion advertises itself under these conditions. In terms of design, it appears modest and light compared to the, often stucco equipped, Wilhelmine façades. Moreover, the pattern beneath it clearly appears in the pavilion's structure: The eight axes of the windows of the 15 meters wide tenements can in fact be found in the layout of the roof pavilion.

Part of the concept of prefabricated construction consists of the building services; all devices are centrally compiled in a space-shaping module for easier installation. Around this module an open floor plan unfolds, which can respond to the diverse requests of its inhabitants.

Namely, the new freedom that has emerged in many districts of Berlin after the reunification always attracts new young and curious people. Not the wealthy old industrial entrepreneurs and business executives, rather their creative daughters and sons. People who wish to experiment with new life concepts. People who feel responsible for society and environment. Nowadays such typology is so common that an entirely new market is created. With their innovative products and unconventional ideas, they understand how to make money. Money they wish to invest in sustainable personal comfort that, at the same time, can support the community. Because these people are very realistic and pragmatic, they unite responsibility and good taste, know the value of trained professionals and want to create something really sustainable.

To sum up, in the recent years we have come to the point where new Berliners fight against the vanishing of their cherished freedom spaces. Citizen protests and petitions have sensitized many people for the maintaining of experimental fields. In fact, that was what those people came to Berlin for in the first place. To maintain the potential of those spaces, while densifying the city in a sustainable way, is what Team Rooftop stands for. For more information on how the rooftop house deals with its immediate surroundings and given urban factors please refer to the section „5.1.3 Individual and Collective Housing Building Project".

5.1.2 MARKET VIABILITY

LOCATION CHARACTERISTICS

The Rooftop housing unit concept was inspired by and caters to the needs of the building sector of Berlin. Therefore, the market entry strategy is tailored to the demands of this city; the first market entry will take place in Berlin. However, this concept will be adapted in other cities throughout Germany where we identify a business potential for our housing unit.

The characteristics of Berlin's housing sector can be divided into two main parts: the constraints given by the geographical situation and the unique situation of the Berlin real estate market.

As for the geographical conditions, Berlin's location between a maritime and a continental climate causes intense winds and areas of high pressure especially during the winter. These characteristics can lead to very cold days in winter and very warm days in summer, ranging from -25 °C up to 38 °C. Due to this wide range, houses in Berlin need to protect their inhabitants from both summer heat and winter cold weather. The climatic dispersion within the city due to differences in altitude is small, although there can be differences in temperature between dense city quarters and open spaces within the city or on its edge due to the Urban Heat Island effect. In this case, Berlin profits heavily from its amount of green spaces representing 40% of the city zone. Smaller green spaces and especially the city's big park areas like "Großer Tiergarten", "Grunewald" and the former airport "Tempelhof" make the city's climate extremely agreeable if compared to other capitals. These so called green lungs are very dear to Berlin's population, which is very sensitive and protective about its open spaces.

Berlin's real estate market is characterized by its large stock of prewar buildings - called ***Altbau*** in German - that are built in a standardized way throughout the inner part of the city centre. Outlying districts in East Berlin are mainly home to industrialized apartment blocks built during the time of separation. The rural areas close to the city borders are dominated by single or two-family houses. Especially in the Altbau sector there is a relatively high backlog in the restoration in terms of thermal insulation and energy efficiency. Thus, the federal state of Germany financially supports owners who wish to refurbish their building in order to meet current standards in energy consumption and indoor climate. The latest census in 2011 counted an amount of approximately 125.000 of these prewar buildings.

Of course, it should be noted that this number represents the upper limit of potential houses that can be equipped with a Rooftop Unit. When possible problems like the structural bearing capacity of buildings or trusses that have been rehabilitated are taken into account, the number decreases.

Berlin's population is estimated to constantly grow by 7 percent until 2030. This growth will not be proportional, but the there is a current period of higher growth with more than 120.000 new inhabitants by 2015. With 54% of the population living in single person households, there will be a growth of single person and two-persons households from 1.66 million to 1.72 million in 2015. This equals to a demand of 60.000 new flats.

Additionally, the level of vacancy steadily decreased over the last years and lately fell below the critical hurdle of 3 percent which is a required fluctuation reserve for a balanced real estate market.

Therefore, Berlin's real estate market can expect a further growth in demand for flats. This will lead to

increase in tension and the need for housing construction.

DEFINITION OF PRODUCT BENEFITS

The Rooftop Unit combines a unique selection of buying criteria which cannot be satisfied by any other product on the market.

The most important factor in a home's value is its location – both now and in the future. On top of an existing structure, at an elevated penthouse site in the middle of one of the most popular cities in the world, the phrase "location, location, location" is brought to a new level. On one hand, the folding façade, the architectural highlight of the Rooftop Unit, that adapts to the climate by opening up and folding down. This way the house visibly reacts to the environment, providing a new living experience and a high level of climate and energy awareness in the minds of its inhabitants.

On the other hand, the Rooftop Unit is a highly energy-efficient living space. It does not only produce energy for itself, but it also feeds surplus green energy into the city's power grid. Furthermore, its business model is designed to dissuade one of the biggest problems popular cities are confronted with these days: gentrification. Through the use of crowd-funding as well as a contracting solution (details can be found in the affordability section, „5.1.5 Affordability“ on page 67), the house owners do not have to increase the rents in the existing apartments. The Rooftop Team is paying for the renovation of the existing house. Both product specifics, the folding façade and the ecological and social sustainability of the Rooftop Unit, are crucial factors to appeal to our target customer.

DEFINITION OF THE TARGET CUSTOMER

The target customer of the Rooftop House is typically a single person demanding for an individual single person household, aged between 25 and 45 years and with a monthly net income of about 2100 €. This person typically wishes for an extraordinary way of living to differentiate from others.

The micro census in Berlin from 2010 named over a quarter million people aged between 25 and 45 with a net income over 2000 €. For many of those people living "green" means an important part of their individual life. Of course at this point comes the question on what amount people usually are willing to pay for a condo.

The Mietspiegel Berlin (rent index) tells us that for a flat with 60 m² in Berlin the average rent is 9.85 € per m² a month. The rent of the Rooftop Unit – not the usual flat – will be slightly more expensive. You can read the details on how the low renting price is achieved in the affordability section.

Although the tenant has to pay slightly more for the Rooftop Unit, the payment is still significantly lower than on the high value penthouse market in Berlin. Additions on existing buildings often result in new energetically optimized stories with good quality, which are inhabited by the higher earning end of the middle-class. That however helps keeping the rental market stable by maintaining a vacancy rate of 3 % through new living space and also combats urban sprawl, as young high earning couples don't have to move to the suburbs to find high-quality apartments. All in all there are many indications for a lot of potential customers in Berlin. Regarding that Berlin's average net income is growing and its population is growing and becomes elder this trend will even increase.

Contractual relationship between the Rooftop Unit and the existing building

In order to build the Rooftop Unit on top of the prewar building a declaration of condominium will be put in place by a notary, which divides the whole property into two single owned units: One unit is the prewar building and the other one is the Rooftop Unit owned by our company. This means that the owner and the company will form an owners association. Team Rooftop will ensure that the construction law and all statutory provisions are respected while the unit is being built.

Team Rooftop will agree on a renting contract with the tenant of the unit, which includes that the tenant has to pay Team Rooftop for his consumed energy an equivalent of the lowest price of green energy on the market.

Another important part of the project is the mobility concept. The company will provide charging stations for e-bikes in the base- house's hallway. It is therefore responsible for the maintenance of these stations. Team Rooftop has to guarantee that the batteries for e-bikes can't be stolen or used without the permission of their owner, while the tenants have to ensure that their bikes are safe.

Financial relationship between the Rooftop Unit and the existing building

The Financial relationship between all parties involved is described in detail in the upcoming affordability strategy.

Team Rooftop will pay for the refurbishment of the prewar building thereby bringing down operating costs for old tenants. The cost for an up-to-date façade modernisation amounted to 80–120 € per square meter, 50–60 € per square meter of living space for electrical installations and 70–150 € per square meter for heating installations. In average the heating consumes 80 % of the whole energy consumptions. Approximately. 40 % are wasted due to insufficient isolation of the building. In this concept we do not consider several refurbishment levels or packages and prevent a full and state-of-the-art modernization. In fact the specific condition of the base house as well as its location need to be taken in account.

The refurbishment of prewar buildings is highly rated in German society. It preserver architecture and the cultivation of home decor. Concerning financing the modernization several financing plans and support programs are given by the BAFA (Bundesamt für Wirtschaft und Ausfuhrkontrolle) and by KfW (Kreditanstalt für Wiederaufbau). The BAFA is supporting the modernization of prewar buildings by direct financing program and direct cash flow to the enterprise. The KfW are providing loans on favourable terms for the investments. Furthermore provides the KfW administrative support for the modernization of landmark buildings.

For the payment the owner of the base house makes it possible for the company to earn revenues through the rent paid by the solar house tenant and through the sold surplus electricity. The inhabitants though will not profit from the decrease in costs, as the owner of the building is contractually bound to pay the Rooftop Company the saved amount on a 20 years basis. However they do profit from the better atmosphere, noise protection and looks of the renovated roof structure and façade.

The surplus energy produced by the solar house will partly be used to charge batteries for e-bikes both owned by a specific resident of the building. The tenants who use the service will pay Team Rooftop an annual flat-rate for the provided charging stations and the electricity consumed.

The refurbishment and green mobility will increase the living standard of the residents while at the same time keeping costs low for the existing tenants and the owner of the prewar building.

Environmental Analysis

For a detailed and comprehensive analysis of the environment in which the product will be released, we established Porters six forces of market opportunities.

COMPETITION

For most industries, the intensity of competitive rivalry is the major determinant of the competitiveness of the industry. In order to analyse this environment it is necessary to split up the terms competition and rivalry for our specific product. On the one hand we face competition concerning the actual idea, on the other hand competition for building sides. The Rooftop idea is unique that no firm can provide a comparable product. This fact generates a very comfortable situation in order to gain customers and market share so that we consider the competition environment as a blue ocean. The above described situation of scarcity of the building side creates competition available construction areas. The space is limited and as stated above the expansion of roof timbers is getting more and more attractive. Due to the exclusiveness of the product we see that Rooftop has advantages over the pursuer, so that the limited space is going to these undertakings which provide the solution customers are seeking for.

Threat of new entrants

Due to the high profitability of the market and high returns new firms maybe attracted. This results in many new entrants, which eventually will decrease profitability for the product Rooftop. The construction industry in Germany is characterized by its high fluctuation within micro and small enterprises. In the last ten years the mount of companies decreased by 31% from 19.202 to 13.262 companies. Figure 15 and Figure 16 illustrated this fluctuation. Even that insolvencies are decreasing the number of start-up companies is highly increasing. This fact is giving by the steadily improving market condition (shown in Figure 17). describes the structure of the building industry and shows that micro enterprises and small enter-prises (up to a revenue less than 2 million.) present 91,9% of the industry but just 28,5% of the total revenue of the industry. This situation shows us that the market is dominated by the big companies. Hence the threat of new entrants is given and creates an increasing competition for the limited construction sides in Berlin/Germany.

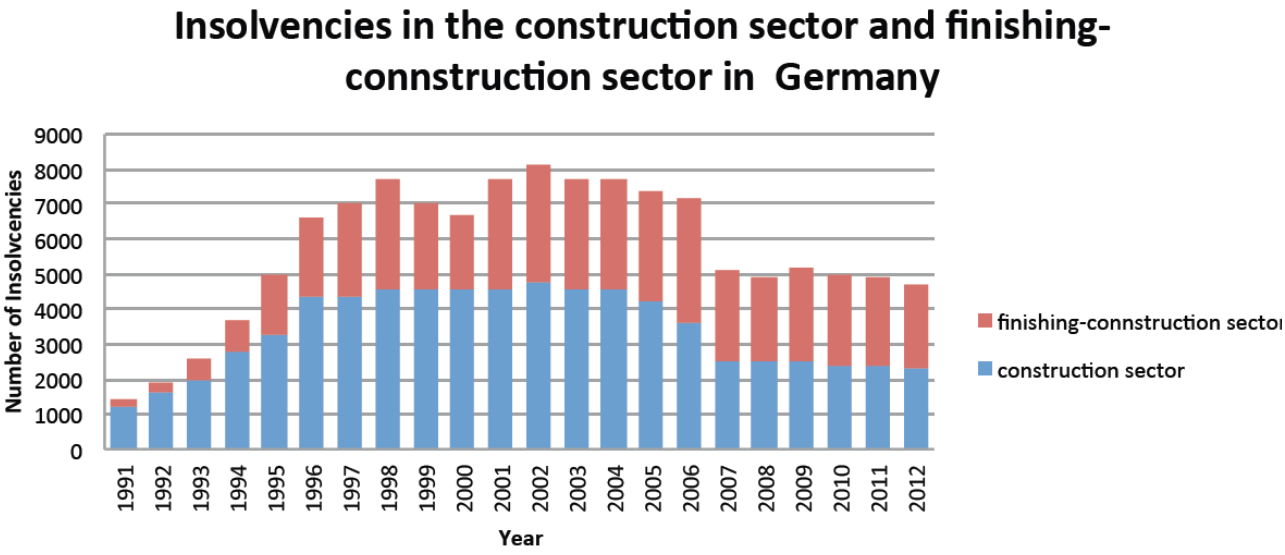


Figure 15: **Involvencies in the construction sector and finishing-construction sector in Germany**

End use/buyers

The bargaining power of customers is also described as the market of outputs. In this environment, customers don't have the bargaining power of putting Rooftop under pressure. Like stated above the demand for extended roofs is highly increasing. Due to the face that no other company can provide customers this unique loft combined with the unique business model described in the affordability section, buyers cannot substitute the product.

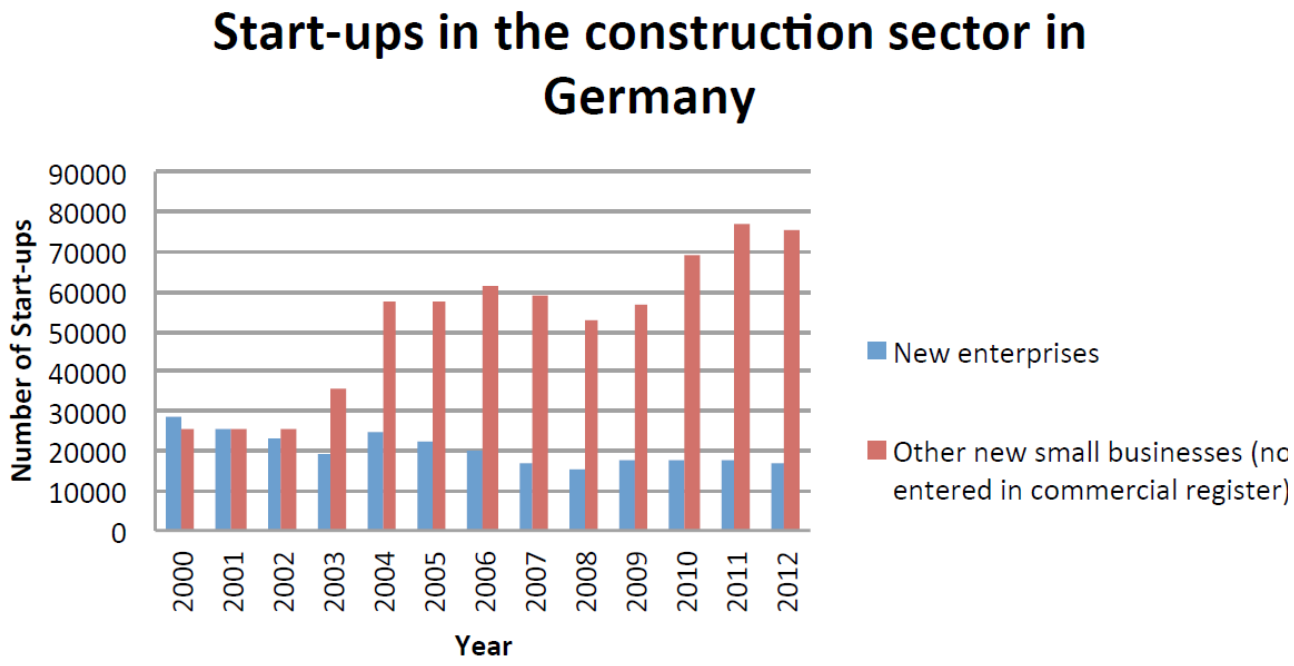


Figure 16: **Start-ups in the construction sector in Germany**

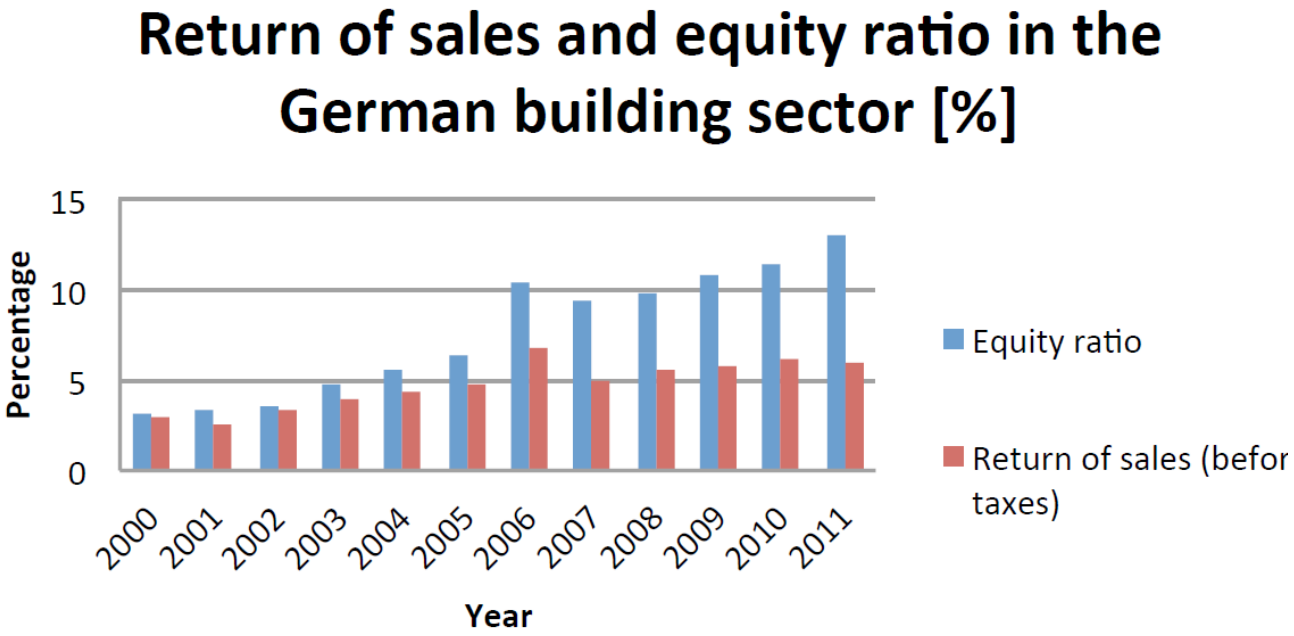


Figure 17: **Return of sales and equity ration in German building sector**

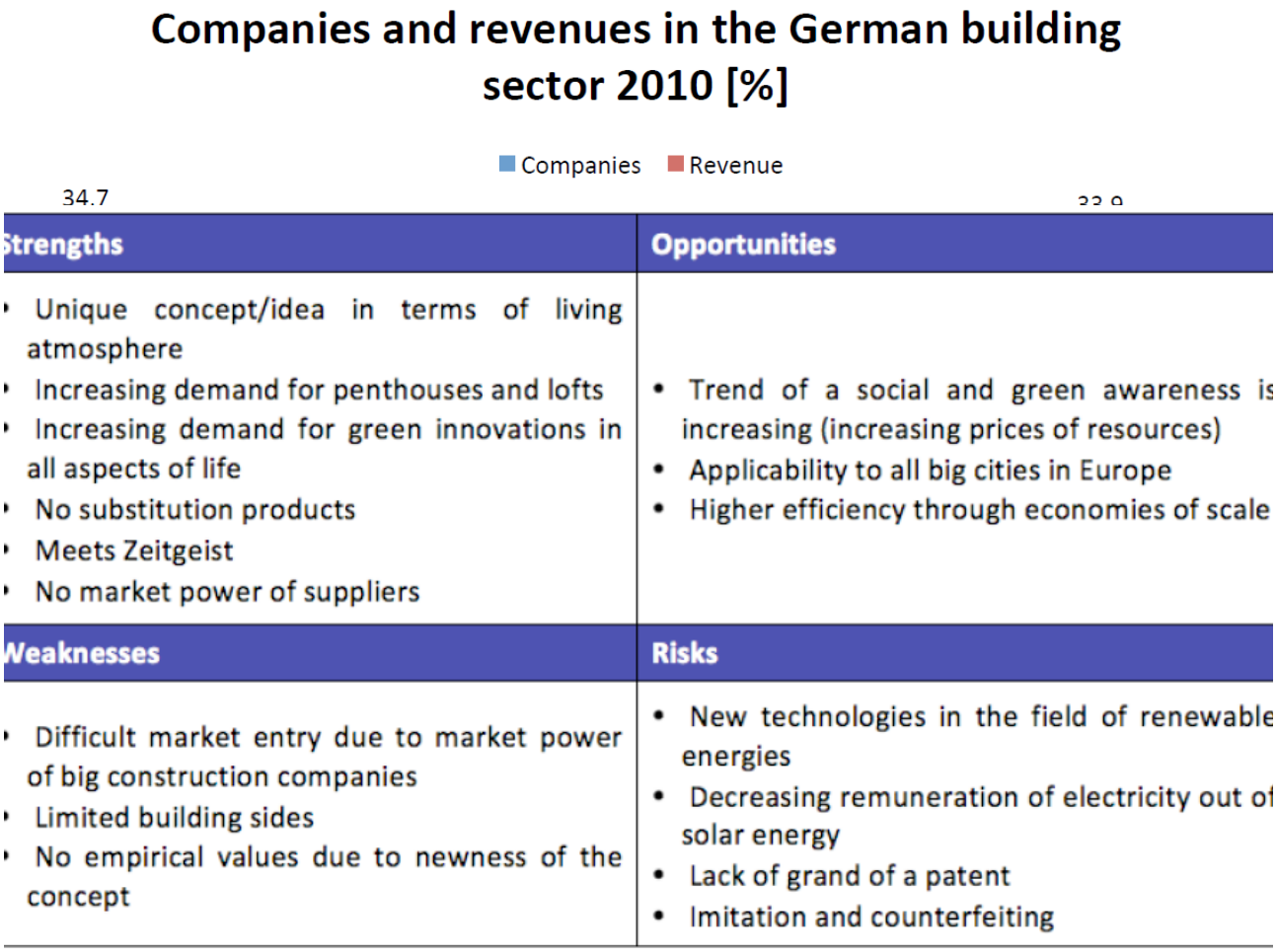


Figure 18: **SWOT analysis**

Suppliers

Germany has a long history of solar housing. German engineering is still world leading and produces renowned products. However, the solar industry in Germany is under strong pressure as prices decrease significantly and imports from Asia are increasing. This normal market behaviour –supply increases, prices drop– puts Team Rooftop into a comfortable and powerful position, especially regarding price negotiations.

Substitutes

The Rooftop idea is unique and no other product on the market provides this housing concept and is satisfying the needs in this special way. The missing existence of products outside of the realm of the common product boundaries prevent customers to switch to alternatives.

Government/public

In order to extend and complete the existing five forces model of Porter we add the analysis of environment like government and public. Green technologies are booming in Germany and Rooftop is meeting the trend in all matters. This political and social movement is not going to end in the next decades and will generate

a supportive environment for our Rooftop Unit.

SUMMARY

To provide a detailed overview about the project we decided to develop and integrate the project in a SWOT analysis (Figure 18). This analysis involves specifying the objective of the business venture and identifying the internal and external factors that are favourable and unfavourable to achieving that objective.

5.1.3 INDIVIDUAL AND COLLECTIVE HOUSING BUILDING PROJECT

In this article, we will focus on one chosen, typical example of the Berlin inner city context. We will schematically outline why this strategy can be applied to a large number of Berlin buildings.

The concept is explained from different points of view:

- The general urban setting of Berlin,
- The particular buildings our concept addresses,
- Our strategy for implementing our Rooftop Unit on top of that typical building, elaborating on financial, electrical, thermo-energetical and social challenges,
- and finally: An outlook.

ANALYSIS: EXPLORING THE BERLIN BUILDING STOCK

For the exploration of the quantitative potential for roof exploitation some facts need to be established about the Rooftop Unit.

- The Rooftop House will unfold its architectural potential in the context of a Berlin pre-war building roof situation.
- The Berlin pre-war building as developed in context with the Hobrecht city plan is a unit for itself. Ownership of single houses by private small businesses have naturally developed over the course of the century. Therefore, as opposed to larger, more modern block development projects, it can be viewed as an energetically independent unit.
- The Rooftop Unit can be implemented on any flat roof in the city, expanding the amount of suitable buildings by a large number.

As stated in the urban design narrative, Berlin has the largest stock of pre-war buildings in Europe. Also, there are only a small number of different house models from this time, only slightly varying in size and shape.

Berlin Altbau as it is

The Rooftop Unit enters a symbiosis with its host building thereby improving the quality of life of its inhabitants and its sustainability. The solution of a prototype fits perfectly with the fact that the Wilhelmine tenements are almost all surprisingly similar in shape and size: Most of them were errected after James Hobrecht's masterplan from 1862. There are not many special angles, simply two types of lot widths and remarkably similar floorplans.

Only the picturesque façades feign a certain diversity, like it is said in a famous Berlin vernacular slogan:

> *„Der Rohbau ist fertig, Meister, was soll'n jetzt für'n Stil ran?“ „The shell is ready master, which style should be stuck on now?“*

The risk to find something unexpected will be very little.

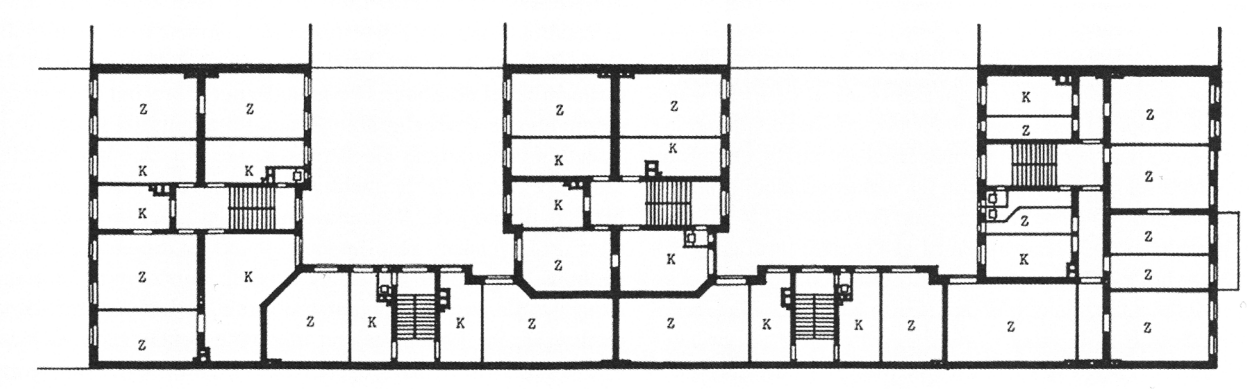


Figure 19: **In this floor plan a typical backyard-to-backyard situation is shown, with the main street access on the right side. This is one of the few variations of Berlin pre-war houses.**

Potentially, almost all of these old houses' roofs are well suited for a Rooftop Unit. In the wake of higher earning newcomers after the turn of the millenium, the refurbishment of these roofs has been going on for some time.

Berlin has around 30.000 pre-war houses left standing, and they are waiting to be rediscovered as a potential host for our concept. We can identify the density of pre-war houses in Berlin through a close analysis at the as-built figure ground plan:



Figure 20: **A plan showing potential Rooftop Houses. Our studies reveal a large number of blocks even by looking only within the inner city quarter of "Mitte", the historical town centre.**

In this quarter, all suitable houses have been highlighted for a better understanding of the city structure. The study focused only on a small part of the very spread out city. But nonetheless a large density of suitable houses can be identified. After having analysed the situation on this scale, one can now plan further steps. After chosing the appropriate Block, we zoom into the map. For this, let us look at the following plan, which highlights the property lines inside the individual block.

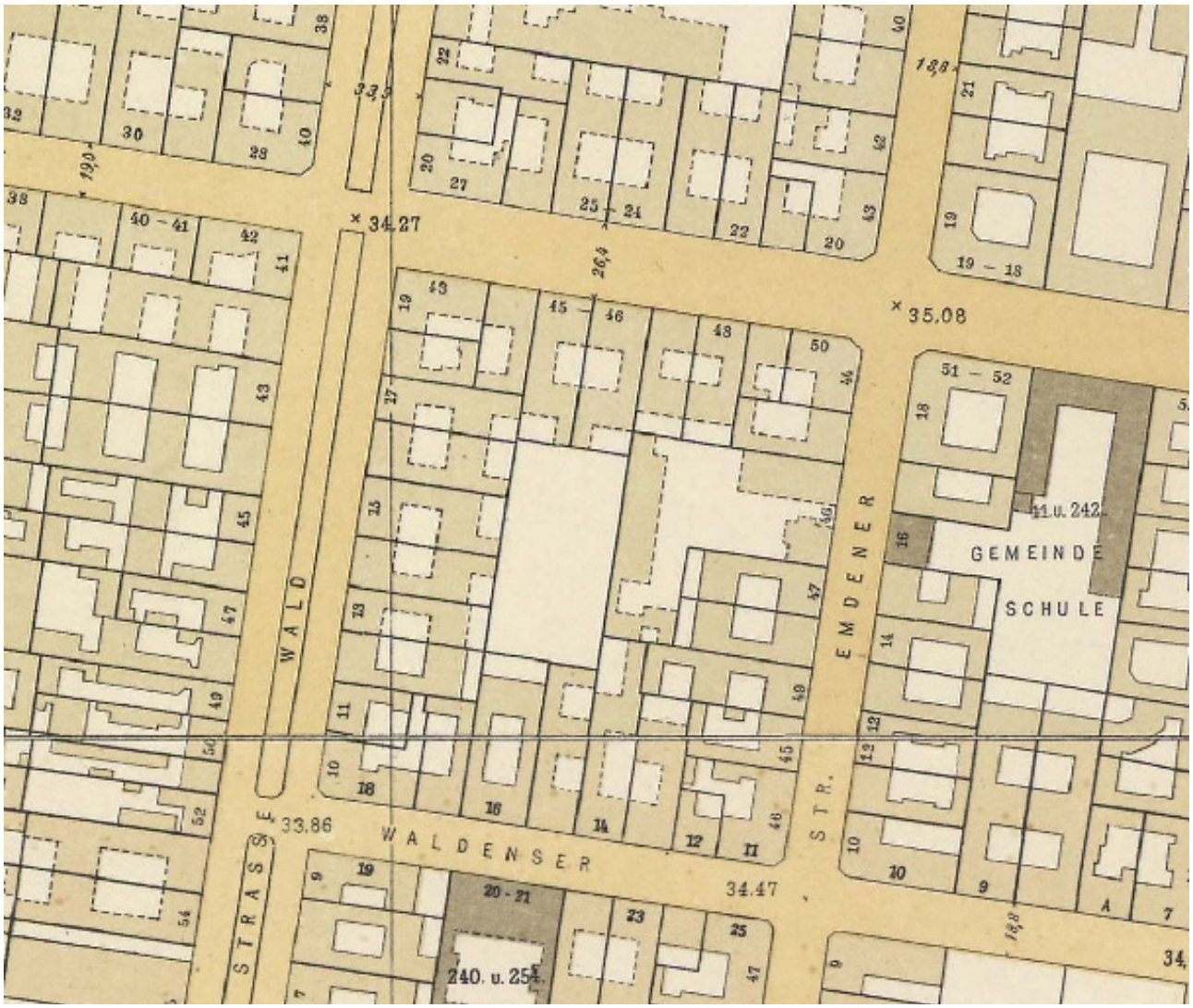


Figure 21: **A plan showing the lot boundaries in a typical Berlin inner city situation**

In this image one can clearly see the isolated nature of the pre-war blocks, consisting of a street front house, a narrow side building, and a back house. They were designed to be expandable towards the back, adding backyards as one moves deeper into the large block structure.

The nature of these houses creates a collection of individual units, each one separated by thick fire walls and each one with an individual connection to the city grids such as electricity, water and heat. And each one of these houses has different ownership states – one unit may consist of privately owned appartments, the next one may be rented out by a small company that owns only this house, and others again may be owned by a large investment fund.

Therefore, while realistically thinking about the refurbishment of the city centre, the first step should focus on the individual housing unit and community, not on an heterogenous block as a whole.

CONCEPT: BERLIN ALTBAU REIMAGINED

Our approach has several steps.

1. IDENTIFYING HIGH POTENTIAL ROOFS IN THE INNER CITY

As stated in the market viability section, our target group does not subsist of large development companies, but of small private house owners and house ownership communities who are interested in the further development and continuous autonomy of their homes.

Berlin, as a traditionally self-made city, has over the past 50 years been an ideal nesting ground for these individual collectives. On one side the private ownership situation of whole houses has been preserved through the city's division since it was very difficult for large investment companies to establish footholds within the city. Also, the divided city has been a hotspot for the squatter scene in the 80s and 90s, many of these very strongly connected communities developing into ownership collectives through legal contracts after the wall came down. These constellations are very often not solvent enough to renovate an entire house, but they exist in abundance all over Berlin – commonly located within more residential areas of the inner city and often easily recognizable by the state of their façades. Instead of leaving them prey to powerful, cold investment funds we want to be part of this collective solution.

2. DIVING INTO THE BERLIN KIEZ-SCENE

Berlin has a plethora of holding organisations and house owner's associations. The first thought would be to approach these forums, holding presentations and making a name within the community. Traditionally, and through the rapidly changing real estate landscape in Berlin, these associations have a preserving tendency, conservative in thought and action. Other options are promising to be far more fruitful.

As a small upstart business with an innovative idea Team Rooftop has to dive deep into the „Kiez“, the local neighborhoods. Throughout the most promising areas in the city we organise „Kiez-Cafés“, a very common sight around the more residential districts. Unlike many other cities, the natural growth of Berlin has led to a dispersion of residential and business centres all over the city, without creating a single inner city core of high rise business blocks. Berlin is called a city of many villages, because a street community can be very introvert, centreed on self-organisation and local collective, sprouting a „Quartiersmanagement“, a quarter management beacon. These places focus on integration of new residents and also act as mediators within the community.



Figure 22: **A "Kiezcafe", a typical Berlin neighbourhood meeting place. It may look like a regular cafe, but the local stakeholders and resident collectives meet here regularly.**

If there is a place in Berlin where local summonings and presentations of innovative concepts can be heard by the target groups mentioned above, it is here. Because of the fact that the Berlin city map stock in the land registry offices still mostly exist only on paper, there is no choice but to implement a face-to-face acquisition of partners.

3. KICKOFF: BUILDING THE ROOFTOP UNIT

After finding a suitable host building with the fitting proprietary boundary conditions, our crowd-investment contracting concept kicks in, providing the house's residents with a refurbished roof and a certain access to locally produced electricity. This is where the cost-control mechanism and therefore the difference between a gentrifying loft and a local community project sets in. The concept is described in detail (here: Financial)

4. INCORPORATING THE ALTBAU

Our fixed budget may or may not be entirely used up by the time we are finished with the roof and the implementation of the Rooftop Unit. Now we use the drive that has developed throughout the past weeks to continue the dialogueue. In the wake of the energetic refurbishment of the roof we strive to unite the house community, meet, discuss and develop a plan that will engulf the entire house, providing an opportunity for a complete remastering of all energetic aspects. The Rooftop Unit acts as a catalyst, spreading the message and drive for energetic renovation through real actions rather than pointless debate. It becomes a starting

signal for a local movement that may well spread across to other housing communities. We provide the ground not only for talk, but a financial base with our left-over budget to pick up momentum.

This phase of our vision model consists of several levels of refurbishment, chosen by their effectiveness over cost ratio. Based on the funds accessible to the house's community and the left budget from the initial Rooftop Building phase, the level of refurbishment for the host building is established and carried our by the community, connecting the Rooftop House not only in an energetic way to the house below, but establishing a true inner bond among the collective, becoming a part of the house's spirit itself. What happens here is the true Berlin, and we could not think this way in any other metropolis. It is a hand-tailored solution by design in architecture and spirit that catches the vibes of our home and exhausts the local conditions.

Explanation by example

We have chosen a typical Berlin Altbau situation, the building at Waldenser Str. 15, to show our concept. Our whole design has been mapped onto this building to show the flexibility and integrative nature of our concept. These contemplations are backed by the research from different points of view.

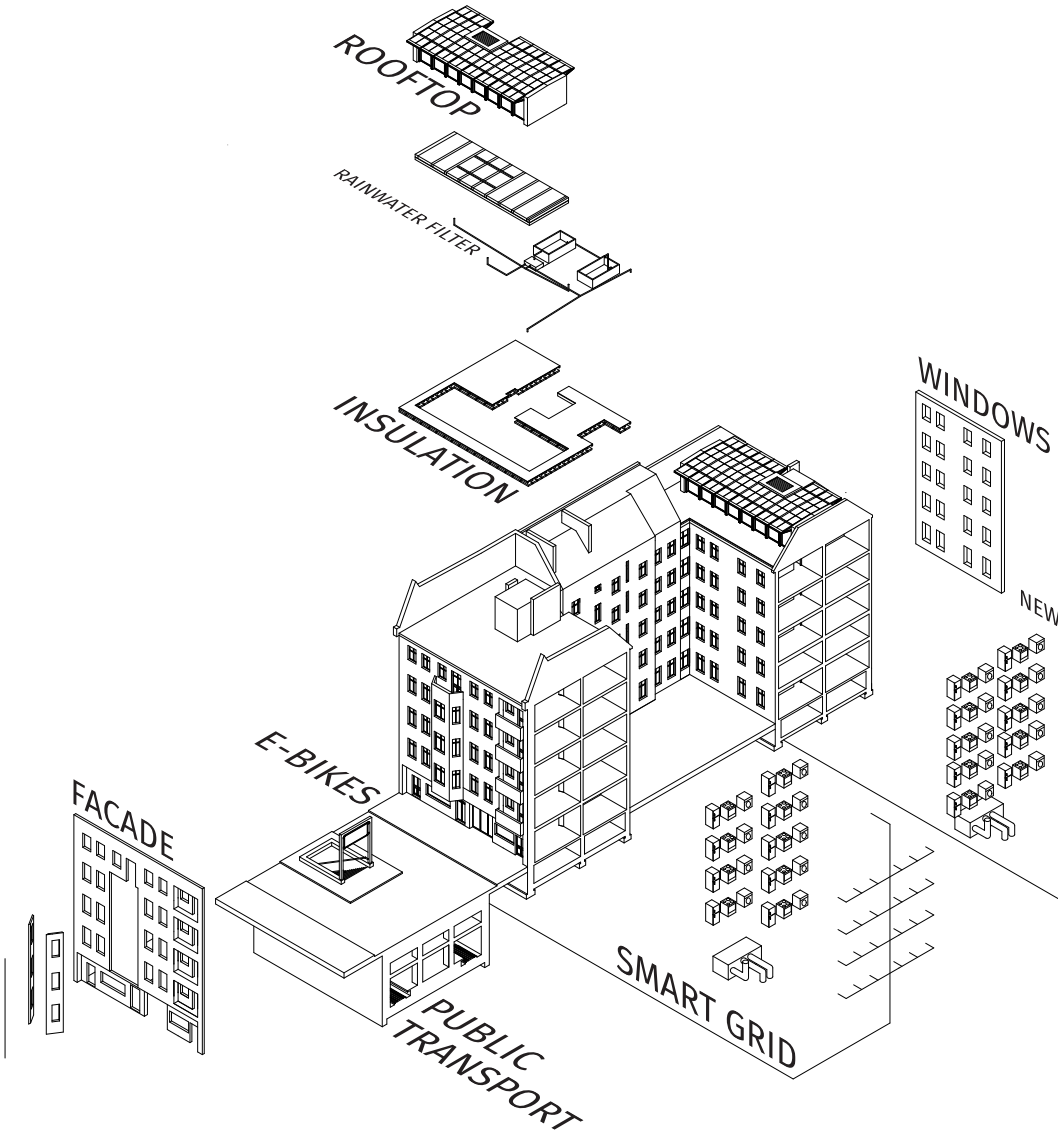


Figure 23: **Blow-up of the chosen house and refurbishment concept**

We have chosen to develop a step-plan according to the financial capabilities of the house's tenants. The concept is described in detail below.

- Rooftop Building + roof retrofit
- Replacement of electrical appliances
- Replacement of central heating unit with appropriate local solution
- Façade retrofit
- Windows retrofit
- e-mobility

a) Rooftop Building + roof retrofit

The advantages of the Rooftop Building on top of an existing old building have been extensively discussed. In old buildings a lot of heat is actually lost through the attic. This is easily understood as the roof represents a large area directly connected to the outdoor, and hence fully subjected to the atmospheric conditions. On the other hand, during the summer the room could become unbearably hot as it could act like a sun room. These extremes are enhanced in the northerly facing properties during the winter and in the southerly facing ones during the summer. Therefore, a restoration often begins here, at the roof level. The current target U-value for new or replacement flat roofs should be of 0.18 W/m²K. There are two main possibilities of insulating a flat roof: placing the insulating material between the joist spaces that support the roof structure (cold roof) or putting the insulating materials on top of the roof (warm roof). In the first case, 50-60 mm should be left between roof material and insulation in order to allow air to flow through the structure. The second solution is to be preferred as no condensation issues will occur.

As the best moment to perform such operation is when the attic is to be expanded anyway, we will include this first insulation step in the positioning of the Rooftop Building.

The saving effect to expect by roof retrofit are an average of 15 to 20%. The costs go from 10 to 50 €/m² depending if the insulation is positioned between the rafters, on the rafters or under the rafters.

b) Replacement of electrical appliances

Sharing Team Rooftops electric energy surplus - establishing a micro grid

We have got approx. 1000 kWh excess energy with the competition configuration. With the maximum PV active power we increase this excess energy up to 5500 kWh. We want to share this amount with the apartments within the host building. There are different ways to achieve this.

The classic way would be to send the surplus energy directly to the grid receiving feed-in compensation from the German government. However, this solution is an economically and technically rigid strategy. There is no opportunity to adapt to the conditions in the energy market. For an innovative solution more flexible strategies have to be developed.

First, the general consumption of an apartment house has to be considered. The base load of a two person household varies between 200 to 500W, depending on the stand-by devices in the apartment. With 12 apartments in a building the base load ranges from 2.4 kW up to 6 kW. The energy demand is between 8 kWh and 12 kWh a day and therefore 96 -144 kWh for the complete building.



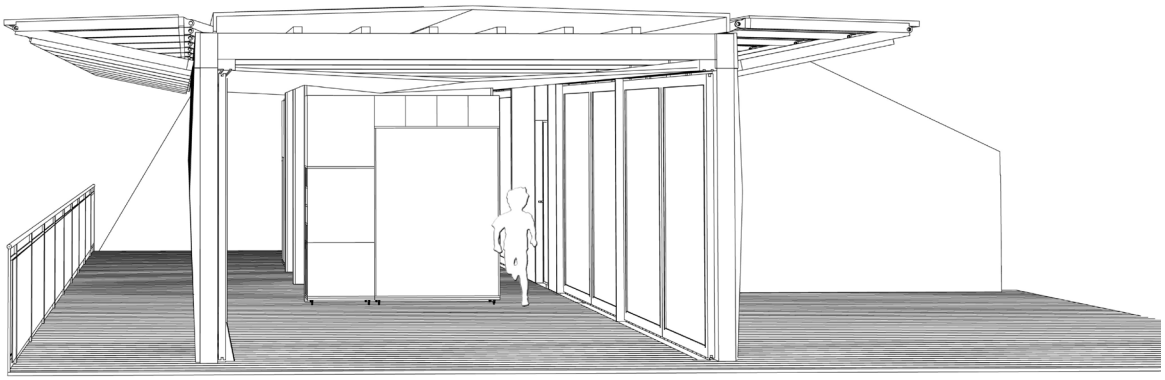
Figure 24: **Rendered section of the electricity being fed through the old unused chimney c**

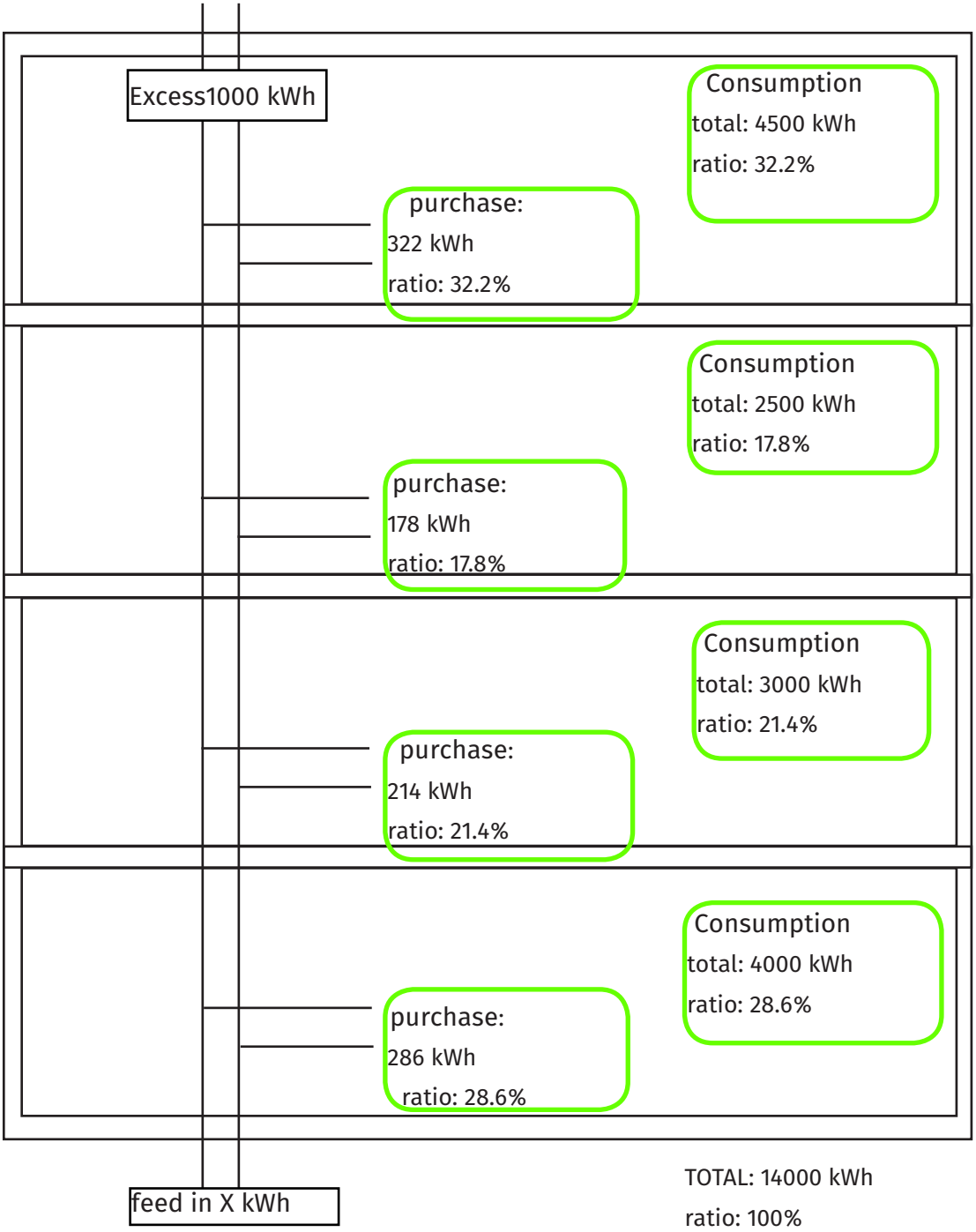
1) Basic solution

The first opportunity is characterized by a very easy cost-effective realization. Without any storage system (below the storage inside the Rooftop Building) the main cost factor is eliminated. The grid feed-in is not realized at the ceiling level but in the level of the basement. A main power line comes from the Rooftop Building to the basement. This main power line branches to the other apartments in the host building.. The main power line is like a big energy pool or a micro grid. The residents can choose to use the additional energy available. The amount of PV energy consumed by each apartment can be measured in addition to the grid-feed in energy consumed.

With this solution a small energy market would be developed. Yearly contracts with the consumers in the host building with prices below average electricity tariff and above the feed-in compensation will guarantee a benefit for the users and suppliers of the Rooftop energy.

There are two different ways to realize this concept.




Excess1000 kWh
Consumption
total: 4500 kWh
ratio: 32.2%
purchase:
322 kWh
ratio: 32.2%
Consumption
total: 2500 kWh
ratio: 17.8%
purchase:
178 kWh
ratio: 17.8%
Consumption
total: 3000 kWh
ratio: 21.4%
purchase:
214 kWh
ratio: 21.4%
Consumption
total: 4000 kWh
ratio: 28.6%
purchase:
286 kWh
ratio: 28.6%
feed in X kWh
TOTAL: 14000 kWh
ratio: 100%

One approach is to install an additional electricity meter for each branch connecting to an apartment. This meter will count the electricity units from the excess PV generated electricity used by each apartment. However, this is an expensive solution, because of the extra meters needed for each branch. The standard meter for each apartment, for energy coming from the official grid, will still exist. Thus, the installation costs for this approach would be very high. If the additional meters are not required, the installation costs could be decreased significantly.

To overcome the need for the extra meters, we decided to use the consumption rates of each apartment provided by the standard meters. These consumption rates of the main grid energy would be the similar to the consumption rates of the PV generated excess energy. Using the consumption rates we can calculate the amount of PV generated excess energy used by each apartment. If you multiply these rates with the total consumption of Rooftop energy in the building you will get the individual purchase for each housing unit. To calculate, the consumption rate found from the standard meter has to be multiplied by the total PV generated excess energy. The accuracy of these values should be enough to compute a fair bill for all tenants. The main benefit is that due to reduced installation costs the prices of electricity could be reduced within the micro grid.

The main benefit is that due to reduced installation costs the prizes for electricity could be reduced in the micro grid.

The benefit of a solution like this is that energy is consumed where it's produced, keeping the transmission losses to an absolute minimum. Due to the high average base load level of the host house, the energy sent to the grid would most likely be very little. The apartments work like an expansion to the Rooftop Building to maximize the own consumption with the benefits for grid stability as avoiding power peaks (positive and negative). Using smart devices like time -controllable washing machines, power peaks can be reduced to a minimum while increasing the PV energy to consumption. Thus the economic benefit for all participants would be best. This solution could be driving force to consciousness for efficient and smart electricity usage.

2) Storage solution

The distribution is the same as in solution 1) using a main power line to the basement of the building. In addition to this there will be storage units in the cellar of the building. It's more economical to give up the storage units inside the Rooftop Building to implement a bigger central battery storage for the whole building. For this a, separate cellar place would be suitable. To reduce DC losses and cable costs for this configuration the battery manager from Studer should be moved to the basement. The cellar should also have enough space to upgrade the SuperB battery pack to ensure a 24V system for the complete host house. This will be done by connecting more batteries in parallel. It is also possible to change the Studer Inverter and increase the storage capacity to a standard 48V system. For our host house, it is not economical to increase the storage capacity of the main battery bank. The base load of the house is between 2.4 up to 6 kW, while the Rooftop Unit is able to produce approx. 10 kWp. Thus, during PV peak times only 7.6 to 4 kW is for battery storage. Therefore, a slightly bigger battery system than the 4.5 kVA Rooftop configuration should be enough for the host house.

3) Renewing house appliances

We want to consider two different types of host buildings in the electrical analysis. The table below compares these different types of buildings. Building type A is smaller than type B and has less housing units so there is less energy consumption on the one hand and smaller Rooftop Units on top on the other hand.[1]

	Building Type A	Building Type B
Number of housing units	24	40
Average consumption [kWh/a]**	2850	2850
Total consumption [kWh/a]	68400	114000
Costs [€/a]	18.468,00 €	30.780,00 €
Rooftop Units	2	2
Number of modules per Rooftop	8	11
Number of PV modules in total	184	256
Approx. PV output per Rooftop [kWh/a]	9000	12500
Approx. total PV production [kWh/a]	18000	25000
Net PV gain minus Rooftop consumption [kWh/a]	11000	18000
electric coverage [%]***	16,08	15,79

If we assume the average consumption for each household and 100%consumption of the excess PV produced energy in the host building, the PV generated energy accounts for 16% of the electricity consumption of the host house.

The average consumption for a German household with two people and without electric water heating is 2850 kWh a year. These consumption breaks down to the numbers shown in the following table.

	Percentage in concsumption*	Amount [kWh/a]
Home office	0,145	413,25
TV /Audio	0,133	379,05
Fridge	0,12	342

1 *Source Energieagentur NRW

** Source: Energieagentur NRW (2 persons household without electric water heating)

*** assumption: 100% local consumption of generated PV power

****Source: energiesparmobil.de

	Percentage in concsumption*	Amount [kWh/a]
Lights	0,111	316,35
Cooking	0,101	287,85
Diverse	0,076	216,6
Dryer	0,074	210,9
Circulation pump	0,074	210,9
Washing	0,059	168,15
Dishes	0,055	156,75
Freezer	0,053	151,05
Sum	1,00	2852,85
Costs [€]		770,27 €

A rough estimation is that you are able to reduce your electric consumption by 30% by replacing old electric devices with more efficient new ones. For replacing light bulbs with LED this reduction potential is about 80%. For other consumers and e.g. losses inside the building (here named “Diverse”) we assumed no saving potential. Thus you can calculate an electric efficient household having an optimized electric consumption of 1902 kWh.[2]

	Savings potential [%]****	Reduced consumption [kWh]
Home office	0,3	289,275
TV /Audio	0,3	265,335
Fridge	0,3	239,4
Lights	0,8	63,27
Cooking	0,3	201,495
Diverse	0	216,6
Dryer	0,3	147,63
Circulation pump	0,3	147,63
Washing	0,3	117,705
Dishes	0,3	109,725
Freezer	0,3	105,735
Sum		1903,8
Costs [€]		514,03 €

Assuming the German price of energy of 27ct/kWh, the update of the electric appliances would generate an economic benefit of 256.24 €.

Updating the calculation of the entire host building, 24% of the host building’s energy consumption can be provided by the excess PV energy.

2 *Source Energieagentur NRW

** Source: Energieagentur NRW (2 persons household without electric water heating)

*** assumption: 100% local consumption of generated PV power

****Source: energiesparmobil.de

	Building Type A ECO	Bulding Type B ECO
number of housing units	24	40
average consumption [kWh/a]**	1900	1900
Total consumption [kWh/a]	45600	76000
Costs [€/a]	12.312,00 €	20.520,00 €
Rooftop Units	2	2
number of modules per Rooftop	8	11
Number of PV modules in total	184	256
Approx. PV output per Rooftop [kWh/a]	9000	12500
Approx. total PV production [kWh/a]	18000	25000
Netto PV gain minus Rooftop consumption [kWh/a]	11000	18000
electric coverage [%]***	24,12	23,68

[3]

c) Replacement of central heating unit with appropriate local solution

We will examine in which way we could replace or renew the heating system of the host building — taking into account existing market structures in Berlin and looking for a local, sustainable solution.

d) Façade retrofit

At best, the walls should be insulated from the outside. This can simultaneously avoid structural damage and visual defects. The most common materials used as insulation are: composite systems made of polystyrene, mineral wool or polyurethane, wood fibre. Low energy houses need at least 12 cm insulation. Any further cm makes sense to reach a zero energy house. Particular care should be paid to avoiding thermal bridges. In fact, some components or component connections may break through the insulation. For example, it can be effective to demolish a balcony slab and replace it with independent supports, rather than insulate it. At best, the windows should also be changed during this operation.

3 *Source Energieagentur NRW

** Source: Energieagentur NRW (2 persons household without electric water heating)

*** assumption: 100% local consumption of generated PV power

****Source: energiesparmobil.de

The expected saving effect of a façade retrofit is of about 20 to 25% and the cost is 20 to 50 €/m².

e) Windows retrofit

Today insulation windows have a minimum of two panes. They are characterized by a U-value of 1.1 or 1.0 W/m²K for the glass itself. The optimal solution would be three panes windows with a particularly well-insulated frame (in this case, the glass U-value is 0.8 W/m²K). The responsible for wall and windows retrofit should if possible enlarge the openings facing South and reduce the openings facing North. Shutters should be located externally on the window frame or on the wall in order to reduce thermal bridges and leaks. Particular care should be taken in the joints between frame and wall: they should be sealed with adhesive and sealing tapes and pressure tests with blower-door should be performed after completion. As stated before, optimally this operation would take place together with the walls retrofitting.

The expected saving effect is also in this case of about 20 to 25% and the additional costs of a passive house windows if compared to insulating windows are about 50 to 100%.

f) e-mobility

Our goal is to satisfy the demands of the Rooftop Unit inhabitants bearing in mind the needs of society. Therefore, it is necessary to develop a mobility strategy that benefits from the interaction with the Rooftop Unit, satisfies the mobility needs of the inhabitants in the Rooftop Unit and in the host building and pays respect to specific requirements of the transportation system within the city of Berlin.

E-mobilty includes a big chance to increase the electrical usage in the host building would. Using the storage capacity of these e-bikes reducing the grid feed-in to nearly zero. The residents would be able to benefit from the cheap electricity produceed on the host building. See a detailed analysis and concept work in chapter 5.1.4 mobility strategy.

5. DISSEMINATION PHASE

Now, after the project is implemented and phases 1 to 4 have been carried out, it is time for spreading the message. The refurbished house in its entirety acts as a lighthouse, a flagship from which we organise the continuation of the movment. As far as the residents agree, open door days will be carried out, turning the house into a live museum for a ahort while before routine takes over again. Coverage in public television can be supported by actual residents' hands on reviews.

It can not be denied that all projects undergo an optimization process as they develop. Especially when a large number of different interest groups is involved. In the aftermath of the refurbishing, these hurdles are adressed and solutions are developed. Analyse and optimize. A close monitoring of the energy flows within the building can point out the strenghts and weaknesses of the concept after implementation.

The DGS, the German chapter of the International Solar Energy Society, hosts a network for energy- and building-culture. This place presents a voice that reaches far within the community.



5.1.4 MOBILITY

Our goal is to satisfy the demands of the Rooftop Unit inhabitants bearing in mind the needs of society. Therefore, it is necessary to develop a mobility strategy that benefits from the interaction with the Rooftop Unit, satisfies the mobility needs of the inhabitants in the Rooftop Unit and in the host building and pays respect to specific requirements of the transportation system within the city of Berlin.

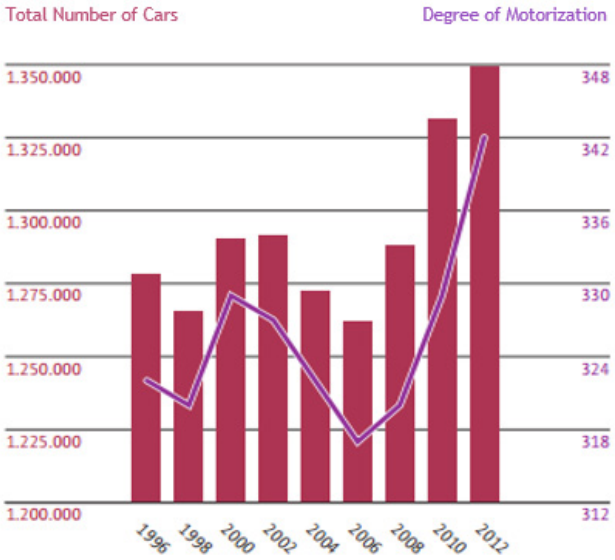


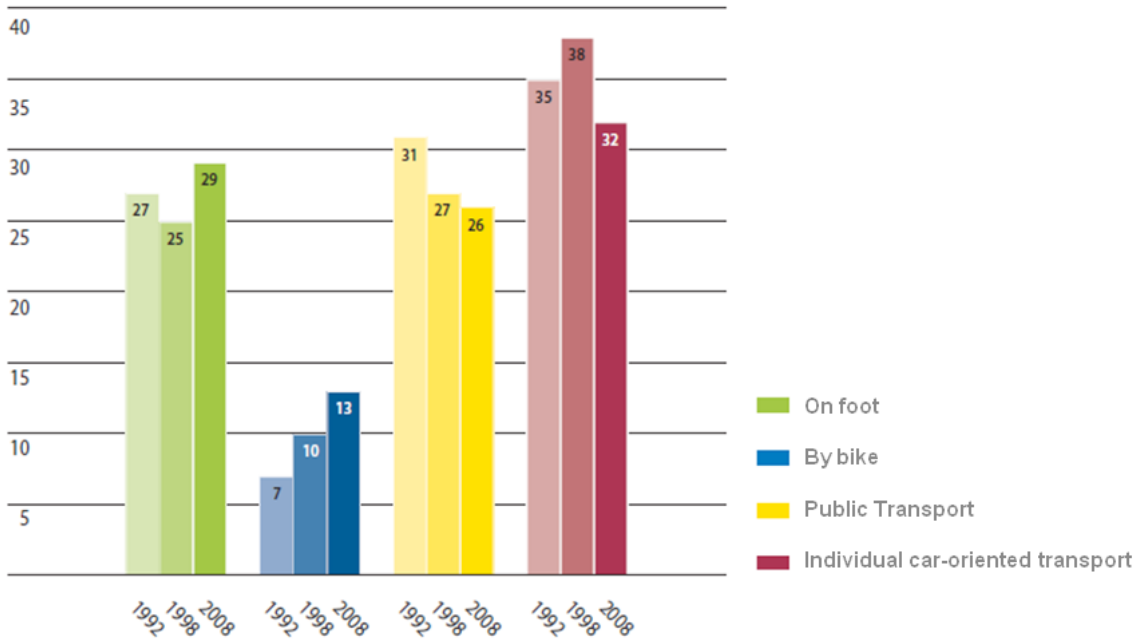
Figure 25: **Development of Motorization**

One of the megatrends influencing mobility is the increasing urbanisation. According to the Frankfurt Future Research Institute there are more people today living in cities than in the countryside[1]. Although this trend is rather moderate in Western Europe and Germany, there is a visible effect on urban development in Berlin as outlined in the previous chapters. The space within the city is getting scarce and the current buzzwords are density, congestion and air pollution. The total number of cars as well as the degree of motorization within our city is steadily increasing.

In combination with an overall growing volume traffic, this leads to the need of a change in the transportation system of the city. Current ways of transportation are still headed by individual car-oriented transport, but its latest relative decrease (see Figure 26) suggests that it is not the correct answer to today's challenging situation. Berlin's existing transportation system is also characterized by a very strong public transport sector, which results in a broad coverage of the city with a well-equipped public transport system.

The most interesting information in Figure 26 is the relative increase in cycling. This development is based on the well-equipped system of cycle ways within the city and its further expansion. Just lately, the federal state government of Berlin announced to increase its budgeted spending for new cycle ways up to 8 million € within the next two years[2].

1 http://www.zukunftsinstitut.de/megatrends
2 http://www.morgenpost.de/berlin-aktuell/article120128984/Berlin-investiert-acht-Millionen-Euro-in-neue-Radwege.html



Source (modified): http://www.stadtentwicklung.berlin.de/verkehr/politik_planung/zahlen_fakten/download/Mobilitaet_dt_Kap-1-2.pdf

Figure 26: **Transportation means usage in percentage**

The advantages of cycling are obvious: It is environmentally friendly and does not exploit the planet's resources, it is good for people's health and it offers an intensive experience of nature within the city. Furthermore, it offers a similar advantage of individual mobility and freedom to the one citizens get by car; in the crowded city space of Berlin the bicycle is actually often the more advantageous alternative.

At Team Rooftop our priority is to improve the living experience of our inhabitants and - at the same time - to contribute to a sustainable and resource-saving interaction with our city. Due to these reasons, our mobility strategy is designed so that our customers profit from the advantages that the Rooftop Unit offers maintaining an interaction with the city's transportation system.

Taken these points into account, we developed a concept suiting the changing needs of transportation of the inhabitants of the Rooftop House and the host building within their local community and with special regards to the requirements given by Berlin’s transportation system. Since Berlin offers a well developed system of public transport and the city is already overcrowded by cars, the mobility concept for our Rooftop House focuses on transportation means that do not include individual car-oriented transportation means.

In order to determine the adequate means of transport for the inhabitants it is necessary to find out more about the actual reason why people are mobile and want to change their physical location within the city. Those reasons are classified by traffic researchers and can also be found in Figure 27. Thus, the main reasons that lead to physical movements of people are living, work, education, shopping, leisure activities.

As Figure 27 shows, the modal split is different for each of the various transportation purposes. While the relative percentage of cycling remains constant around 12 percent, the other transportation means vary widely according to the travel purpose. The individual car-oriented transport plays the most important role in almost all of the travel purposes, probably because people enjoy the comfort and individual privacy cars offer to their passengers. The shown information is important to design the framework of the Rooftop's mobility concept.

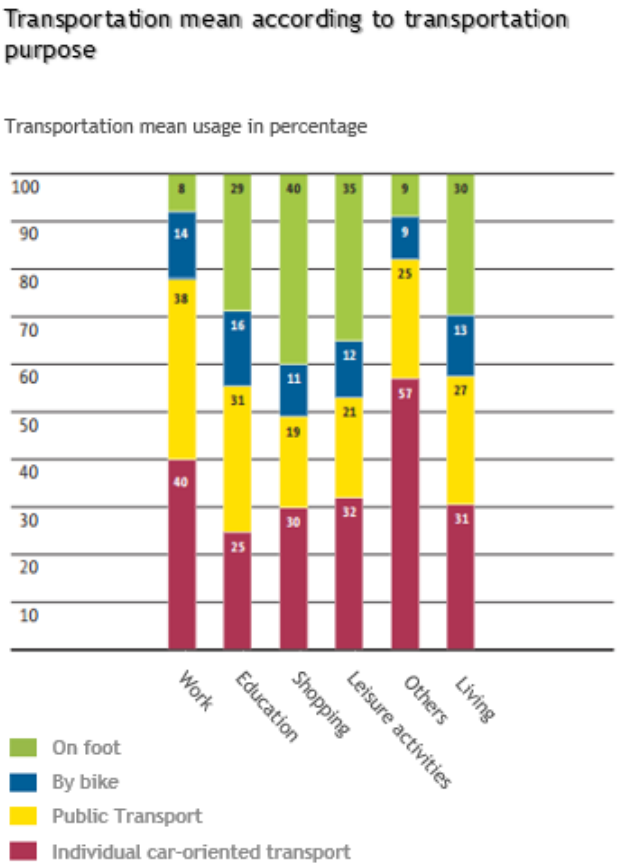


Figure 27: **Transportation means according to transportation purpose in percentage**

Furthermore, Table 1 gives an overview of the current amount of mobility of Berlin's inhabitants. The data gives information about the potential usage of bicycles if they offered similar comfort features to people as they enjoy by their individual car usage. Taking a closer look on going to work as a travel purpose, the disadvantages of cycling with standard bikes are obvious: one is subject to bad weather conditions, it can be phisically tiring and one probably feels like taking a shower afterwards. The Rooftop's idea takes the disadvantages of standard bicycles into account and therefore focuses on bicycles supported by electrical engines. The engines support the cyclists with a speed up to 25 km/h and the battery's capacity lasts for a distance for up to 50 km.

Mobility of inhabitants	
Average number of ways of mobile inhabitant	3.4 ways per person per day
Average time in traffic	70.1 minutes per person per day
Average covered distance	20.2 kilometres per person per day
Average length of ways	6.9 kilometres per person per way
Average duration of ways	24 minutes per person per way

Table 1: **Mobility of inhabitants**

Relating to Table 1, these specifications are enough to cover an average distance of 6.9 km per way, as well as the average distance of 20.2 km/day which a mobile person travels in Berlin.

With a charging time of maximum 4 hours, the battery pack could be easily charged every second night, or if needed every night or even more frequently, e.g. in the office.



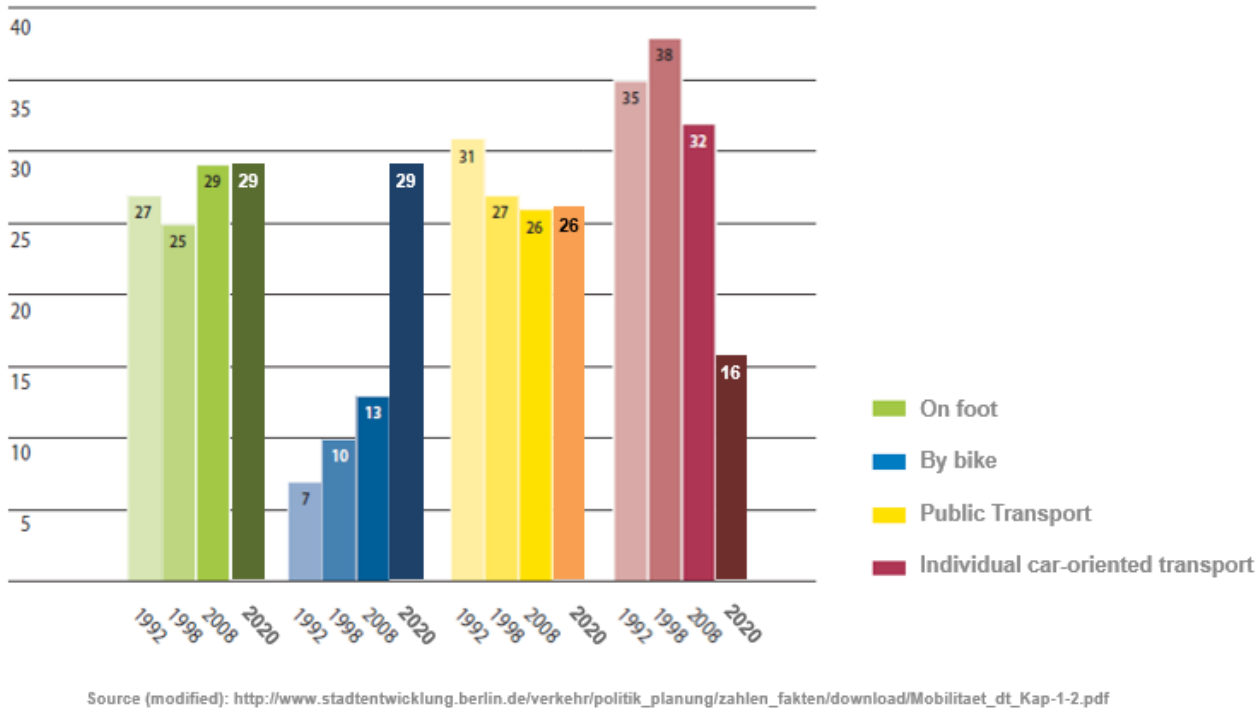
Figure 28: **Copenhagen Wheel**

Therefore, the basic idea of the mobility concept is to equip the inhabitants of the Rooftop House and the host building with an e-bike solution fulfiling the individual needs of the inhabitants. The chosen Copenhagen Wheel manufactured by Superpedestrian offers an easy way to attach an electronic engine to almost any existing bike by simply replacing the rear wheel. Therefore, this bike offers a great way of individual mobility additionally to the well-equipped public transport system in Berlin.

Hence, our mobility strategy is another example for the symbiosis of the Rooftop House and its host building. It focuses on the logical continuation of the innovations the Rooftop Unit provides and the interaction with its host building. We use the peak power generated by the Rooftop's PV panels to charge the batteries of the Copenhagen Wheels of the inhabitants of the Rooftop Unit and the host building.

The Copenhagen Wheel offers a state of the art performance with a power assist that is giving a boost to the pedal instead of using a throttle. This preserves the natural biking experience but still enables the rider to

bike faster and easier. A regenerative braking system enables the Copenhagen Wheel to charge its integrated battery pack when braking or going downhill. The biggest advantage of the Copenhagen Wheel is its smart control that enables the wheel to control all the actuation automatically through sensors. Control algorithms that can be adjusted manually by the user through a complimentary mobile app. This app allows not only to customize the settings of the power assist but also to track the personal usage in statistics including time, distance, calories burned etc. that can be even shared with friends. Last but not least, with the mobile app the user is able to lock and unlock the bike.[3]



Source (modified): http://www.stadtentwicklung.berlin.de/verkehr/politik_planung/zahlen_fakten/download/Mobilitaet_dt_Kap-1-2.pdf

Figure 29: **Predicted choice of transport in 2020**

Hence, this solution provides not only a personal way of experiencing mobility but also the possibility to use the excess energy produced by the PV modules. In combination with the micro grid solution outlined in the collective housing building concept, the users of the Copenhagen Wheels can use the provided Rooftop electricity to charge the batteries of the bikes. The most important benefit for the inhabitants is the individual possibility to upgrade any existing bicycle with the Copenhagen wheel and thereby transform it into an e-bike. The inhabitants who choose to use a Copenhagen Wheel profit from savings through less car usage as well as the Rooftop electricity for a price lower to standard electricity costs. The users will be provided with sockets in the bicycle storage in the basement of the building, where the batteries of their e-bikes will be charged with the excess energy of the Rooftop Unit delivered through the before mentioned micro grid. The detailed calculation of the costs saved for the individual inhabitants are conducted in the following.

3 https://www.superpedestrian.com/

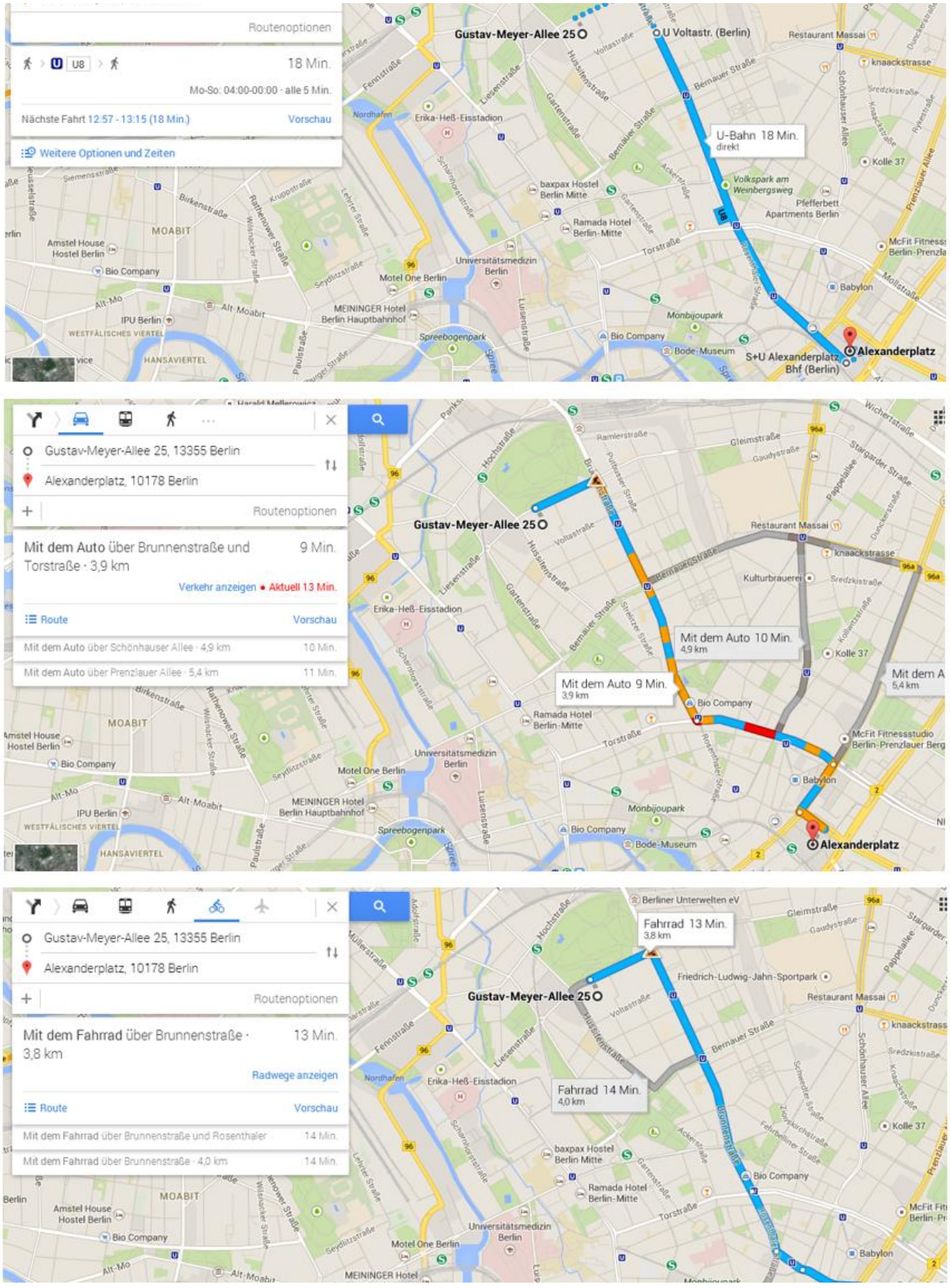


Figure 30: **Selected route with different means of transportation**

Realistically, not every journey that is currently done by car can be replaced by an electric bike. There will still be occasions that require a car or the usage of transportation means (e.g. very bad weather conditions or the transportation of bulky purchases). However, it can be expected that 50 percent of the traffic that is currently provoked by cars can be replaced by assisted cycling. This does not mean that the 50 percent drop is caused by the exclusive 1:1 replacement of car usage by e-bikes; it takes into account the advanced effects of a split travel chain consisting of different transportation means like cycling, public transport and complementing offers like carsharing. This change would mean a drop of individual car-oriented transport from 32 to 16 percent and an equalling increase of cycling from 13 to 29 percent. This predicted outcome can be found in Figure 29.

Monetary savings due to drop in car usage per person			
Car Usage per kilometre	see following figure	0.316 € (0.333 €)	0.65 € (0.76 €)
Distance per day in 2008	32% of 20.2 km	6.46 km	
Distance per day in 2020	16% of 20.2 km	3.23 km	
Expected savings per day	3.23 km * car usage / km	1.02 € (1.08 €)	2.10 € (2.45 €)
Expected savings per year	Savings / d * 365 d	372.55 € (394.20 €)	766.50 € (894.25 €)
Average savings per year	Per unit	633.40 €	
Total Savings	12.4 years	7,854.16 €	
Copenhagen Wheel	Prime Costs + 2 batteries 550 € + 2 * 200 €	950 €	
Rooftop electricity	3.23 km * 365 d * 12.4 a	52 €	
Total Surplus		6,852.16 €	
CO2 Emission avoided	Average: 1.51 g/km	355 kg	

Table 2: **Monetary savings through drop in car usage**

The proof that the usage of a comfortable e-bike is a suitable alternative for the crowded streets within Berlin's city is given in Figure 30. The selected route calculated by Google Maps shows the journey from

our construction facilities in Gustav-Meyer-Allee to one of Berlin's most famous sights: The TV tower in Alexanderplatz. Given the journey times in the three different travel modes, you can see that the travel time is 18 minutes using the public transportation systems, 13 minutes using the car and also 13 minutes with the bicycle. Taken into account that this calculation was done on a weekday at 1pm, when the streets are not

erage costs of car usage per km		Standard[1]	Premium
preciation of car	Average age of cars: 12.4 years (2007); annual kilometres: 18,963; overall kilometres: 235,141; salvage value: 0€	0.085 €	0.255 €
x	2 € / 100 cm³ plus 2 € / g CO2 exceeding 120 g (2011) / 110 g (2012) / 95 g (2014)	0.004 €	0.011 €
surance	Casualty Insurance: NCD 3 – 70% Comprehensive Coverage: NCD 4 – 70%	0.033 €	0.072 €
aintenance / Inspection	Average Maintenance: 288 € / a Average Inspection: 398.75 € / 12.4 a	0.013 €	0.013 €
el Consumption	Average Price per litre Super: 1,592 €	0.108 €	0.151 €
ternal Effects	Accidents, Noise, Infrastructure, CO2 Emissions etc.	0.035 €	0.035 €
puted Interest	Imputed Interest 3% / a	0.038 €	0.113 €
tal (Self-financing)		0.316 €	0.65 €
erest Rate	Interest Rate 6.17% / a Standard Car: 48 months Premium Car: 72 months	0.017 €	0.11 €
tal (financed by loan)		0.333 €	0.76 €
ndard Car: Volkswagen Golf 1.2 l TSI, 85 HP, 1197 cm³, CO2 129 g/km, 7.1 l/100 km, 19995 € emium Car: Mercedes E 300, 252 HP, 3498 cm³, CO2 174 g/km, 9.5 l/100 km, 59995 €			

Table 3: **Average costs of car usage**

as crowded as in the morning or evening, you can assume that the travel time for car usage rises during the rush hours.

The drop in car usage can also be expressed in quantitative savings for individuals. The detailed calculations in (see Table 2) are based on the predicted drop of car usage from 32 to 16 percent and the average mobility data displayed in Table 2. The average cost of one kilometre car usage is explained in detail in (see Table 3). As displayed in (see Table 2), the annual amount saved assuming a drop in car usage of 50 percent sums up to 372.55 € at least for a standard car. This represents only one household inhabitant of the Rooftop House considering that there is still a car which is used. If the car is financed by a loan or a premium car is used,

the annual savings sum up to almost 900 Euros. In fact, this calculation still includes the possession of a car used for 16 percent of the annual transportation volume.

Electricity costs for e-bike usage instead of car usage		
Distance per year	3.23 km * 365 days	1178.95 km
Number of charging processes	Range of battery: 35 km	~ 34
Energy required per year	Battery capacity: 0.5 kWh	17 kWh
Costs for energy per year	0.26 € * 75% (Rooftop Electricity) * 17 kWh (in 2014)	3.32 €
Costs for car replacement	12.4 years; 4% price increase for electricity	52.00 €
Costs for initial bicycle usage	2.63 km * 365 days = 959.95 km ≙ 28 charging processes 14 kWh = 2.73 € in 2014	42.77 €
Total cost for electricity	For 12.4 years	94.77 €

Table 4: **Electricity Costs for e-bikes replacing 50% of car usasge**

As shown in Table 3, the cost per kilometre of car usage is a minimum of 0.316 € calculated with a standard car with an average usage of 12.4 years and cash purchase instead of any loan-based financing. The costs rise according to other ways of financing or the usage of premium cars with higher fuel consumption and higher value.

tal savings due to Rooftop's Mobility Strategy				
tal Savings per unit	12.4 years (avg. lifetime before car gets replaced) avg. car; avg. financing 50 % drop in car usage			6,852.16 €
vings for 14 Units buildings	14 Units in host building + Rooftop unit			102,782.4(
vings for 24 Units buildings	24 Units in host building + Rooftop unit			171,303.7!
2 Emissions saved	14 + 1 units	5.325 t	24 + 1 units	8.875 t

Table 5: **Total savings due to Rooftop's Mobility Strategy**

By replacing 50 percent of car usage by cycling with one the Copenhagen Wheel e-bikes one person per household will save an average 633.40 €/year. This is enough to amortize the prime costs for a Copenhagen Wheel (approximately 550 €) and the electricity provided by Rooftop worth 3.32 € for the first year (see Table 4). Over the timespan of 12.4 years (the average lifetime of a car before it gets replaced) an amount of 6,852.16 € can be saved. This already includes the costs for the electricity provided from Rooftop as well as two replacement battery packs for the Copenhagen Wheel.

Since the calculations are conducted with average values for mobility and kilometres travelled, they can be applied as an average calculation on all households of the Rooftop Units as well as the host buildings. Therefore, the total savings for a Rooftop Unit including the host building with 14 respectively 24 units sum up to more than 100,000 respectively 170,000 Euros for the 12.4 years time horizon. These calculations are - as already mentioned - conducted with average cars and average financing and replacing 50 percent of the initial car usage. If the inhabitants dropped their car usage to a greater extent (or if the replaced car used to be a premium model) the total savings would be even higher.

In addition to the economical advantages of limiting the car usage, the Rooftop mobility concept will contribute to reducing the environmental costs by saving 9 tons of CO_2 emissions for a 24 units building.

Unfortunately, the Copenhagen Wheel development has been delayed past the competition start. Therefore, the idea remains a concept that will be followed together with the developers. We are in close contact and will stay true to the concept. Stay tuned with us for updates on the topic.

5.1.5 AFFORDABILITY

The Rooftop Unit is built on pre-war buildings with a high backlog on restoration in terms of thermal insulation and energy efficiency. This backlog leads us to the current development in the Berlin real estate market, which can be described as follows: house owners cannot afford necessary but expensive renovations. Therefore, they address themselves to investors who buy the house, renovate it and, as a next step, set up new rental agreements with major increases in rent which exceed by far the legitimate increase due to energy savings. This process provokes gentrification as people with lower incomes, and especially the elderly, cannot afford the increased reant and are forced to move out.

Given this highly negative development, we developed a solution focused on social sustainability rather than profit. Due to the penthouse location in the heart of the city, the unit will achieve high prices on the market. By selling the house, we would only be in control of the first selling price - we cannot assure that the first buyers will sell the house if there is a high mark-up possibility. Renting, however, assures us to be in control of the prices. To be able to make our house affordable to the largest amount of people, we decided to rent the Rooftop Unit instead of selling it. This idealistic approach leaves us with the question of how a real estate start-up like Company Rooftop is able to finance new Rooftop Units. This brings us to the main idea of our affordability strategy: an atomization of the real estate market through crowd investments.

We would like to explain and discuss the model based on the parties involved. The short qualitative explanation is followed by a detailed quantitative approach that shows the viability of the business model.

The parties involved and their interactions can be seen in Figure 31 and also easily be derived from the facts that Rooftop Units have to be financed, built, managed and they are always attached to a host building.

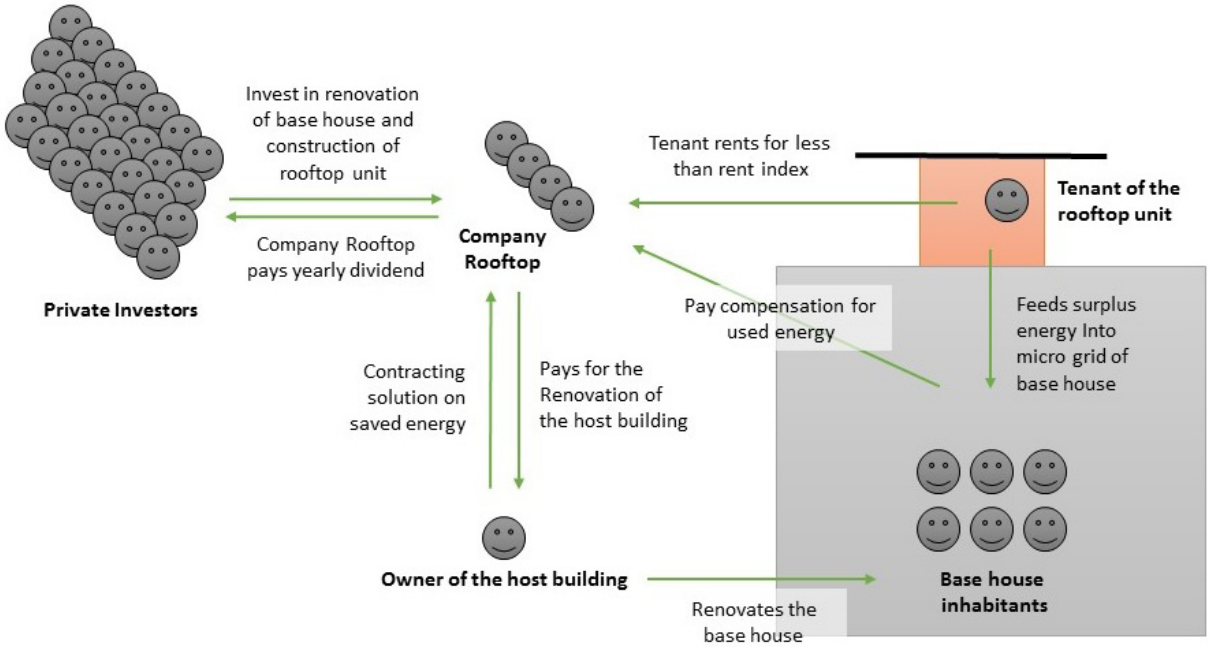


Figure 31: **Involved Parties in Business Model**

Briefly, Company Rooftop is the interface between the private investors, the tenant of the Rooftop Unit, the owner(s) of the host building as well as the tenants of the host building. The private investors are investing in the Rooftop Units as well as in the refurbishment of the existing building in return of a yearly dividend. The owner of the host building allows Company Rooftop to put Rooftop Units onto the roof. Furthermore, he/she agrees to raise the rent at most of an amount correspondent to the costs the tenants save on energy due to the refurbishment. In addition, he agrees to forward the profit from the rent increase to Company Rooftop for a duration of ten years. The tenants of the host building receive the surplus energy that the Rooftop Unit produces for less than the price on the market. The tenant of the Rooftop Unit is paying constantly less than the average rent for the specific location in Berlin (published by the official rent index).

A QUANTITATIVE APPROACH OF THE DESCRIBED AFFORDABILITY STRATEGY

To show the quantitative implications of our costs and revenue streams, it is necessary to keep in mind that the input data for the calculation are not consistent with the SDE Rules & Regulations for the competition. It is important to distinguish between the future Rooftop Unit, which is sold on the market and part of our business model, and the house that takes part in the competition in Versailles. As an example, the amount of produced energy is limited for the competition, while it does not make sense to limit it for the Rooftop Unit in series production. Regarding the input data, it is necessary to mention that the model is based on assumptions. As assumptions are always affected by uncertainty, we will calculate a pessimistic scenario resulting in higher costs and lower revenue streams. In the following passages we will calculate our business development for a 6-year period until 2019 (such scenario was developed in 2013).

Company Rooftop

In contrast to the Rooftop Unit participating at the Solar Decathlon competition, in the future Company Rooftop will not produce and build the house itself. When it comes to the building and retailing of future Rooftop Units, it has to be kept in mind that Company Rooftop will not be a student team anymore. In a realistic scenario, Company Rooftop will start with four team members in autumn 2014, after the SDE-prototype has successfully returned to Berlin. Therefore a buy solution, where the house is built by contractors, is the most realistic scenario.

Company Rooftop's sphere of competence can be divided into two areas: on the one hand, the team has the expertise and knowledge to support the building of the house on a larger scale and in a more standardized way, mainly by giving mandates to construction companies. On the other hand, the team is responsible for finding the suitable host buildings, private investors and tenants and linking them to the planned Rooftop Units. The process starts with looking for pre-war buildings to renovate and on top of which to put a Rooftop Unit, then finding private investors for the specific Rooftop Unit. As a third step, Company Rooftop is managing the renovation of the host building and construction of the Rooftop Unit. When the unit is build, the team acts as a real estate agency by finding a tenant for the unit.

Starting with four team members in 2014, more team members will join Company Rooftop during the first years. A detailed development can be seen in Table 7 and the paid loans in Table 6.

	Gross wage for employee	Wage including all social charges
Loan for Company Rooftop employee [€/month]	2100	2.583
Loan for Company Rooftop managing director [€/month]	2700	3.321
Loan for Team Rooftop student assistant [€/month]	625	769
Labour costs increase per year	1.5%	

Table 6: **Assumptions to calculate Labour expenses**

year	2014	2015	2016	2017	2018	2019
Managing Director				1	1	**1**
Employee	4	4	5	6	7	**9**
Student Assistant				1	2	**2**
Labour expenses	123.984 €	125.844 €	159.664 €	245.790 €	292.166 €	**363.331 €**

Table 7: **Company Rooftop Workforce Development**

Because work-load and labour force do not have a proportional relationship due to productivity gains, we think that a team of 12 persons can manage to set up about 100 Rooftop Units in 2019 (see Figure 32).

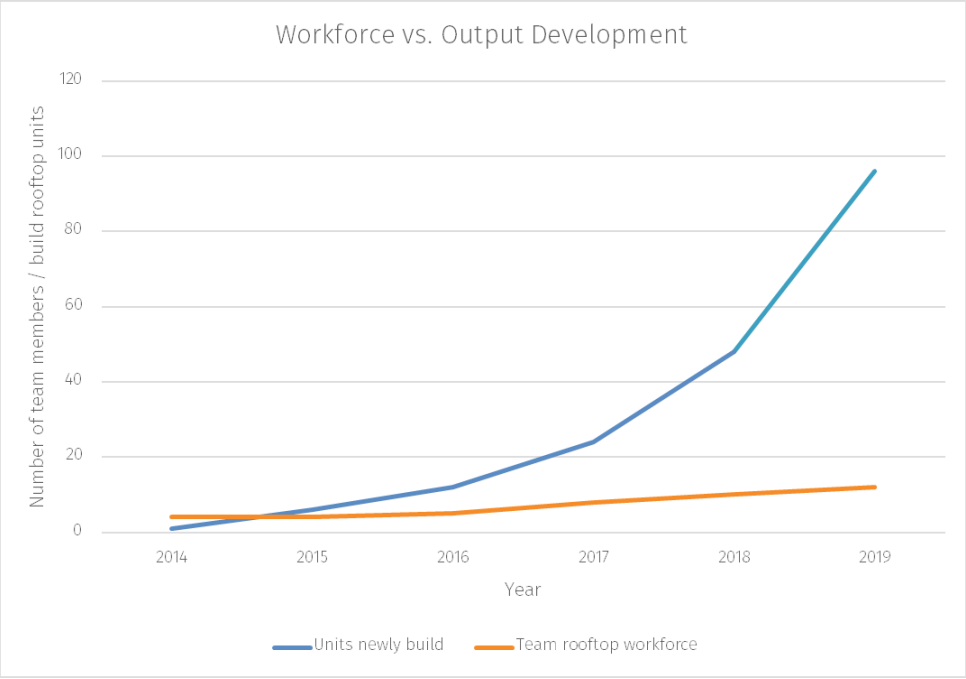


Figure 32: **Company Rooftop workforce vs. build units development**

The Rooftop Unit – Prices and Funding

Besides supporting vertical densification, every built Rooftop Unit is accompanied by a refurbishment of the existing host building. We therefore have to take a closer look on both topics – the refurbishment and the Rooftop Unit.

Prices for refurbishment of host building: every Rooftop Unit is meant to be an impulse to refurbish the host building. The Individual and Collective Housing Building Concept describes in detail which steps we plan to undertake and which parties we involve. From a financial viewpoint, it is clear that Company Rooftop is not able to finance a complete refurbishment of the host building. Our budget for refurbishing the host building sums up to 70000 €. This budget usually suffices for refurbishing the roof structure and the insulation of the top floor plus a variable depending on each house's roof structure. The saving effect to expect by roof retrofit is an average of 15 to 20%. The costs go from 10 to 50 €/m² for the insulation depending if it is positioned between the rafters, on the rafters or under the rafters. In addition, 30-40 €/m² must be planned for the dismantling of the existing roof and another 20-30 €/m² to install a platform roof where our Rooftop Unit can be put on. In a pessimistic scenario, this sums up to 120 €/m² and results in a decrease of 15% in energy consumption. The typical size for the roof of the host building is 250 m² resulting in refurbishment costs of 30000 € leaving a refurbishment budget of 40000 €. This is why we ranked five measures depending on their cost-benefit ratio in terms of financial input and ecological outcome. This ranking determines where the leftover budget is invested in:

- Roof structure refurbishment including insulation of top floor
- Modernization of electrical appliances in host building flats
- Refurbishment of façade
- Financing e-mobility solutions to the host building tenants
- Modernization of windows

Prices for Rooftop Units

The prototype we are currently building will cost approximately 295000 € on material costs (see section 8) . Costs for labour and services cannot be derived from the prototype financial summary as students instead of skilled craftsmen are doing most of the work. For a usual single family house costs can be split into 60% labour and 40% material. In contrast to a highly standardized single family house, the Rooftop Unit features latest technology in combination with state of the art materials. Therefore, material costs make up the biggest cost factor with approximately 70% of the total costs during the low level production (1-5 units/year), leaving 30% (respectively 125000 €) for services. Through economies of scale, gains in productivity and especially standardization we aim to cut service costs by 10% and material costs by 50% when it comes to series production (50-100 units/year). Most of the cost reduction can be achieved in the series production of the façade, window front and the core unit, including kitchen and bath, where the development to build the prototypes made up the biggest cost pool. Although the visible parts can be individually customized, the main technology stays the same for every built house. Furthermore, main parts as the façade are custom build parts because of our goal to maximize our success during the competition having in mind the rules and regulations of the SDE. For series production, we would try to include large-scale produced parts, materials

and equipment. This results in the costs shown in (see section Table 8) Table 8 for one Rooftop Unit depending on the level of production.

Year	Units newly build	Building costs for one Rooftop Unit
2014	2	420000
2015	6	340000
2016	12	300000
2017	24	270000
2018	48	255000
2019	96	250000

Table 8: **Building cost develepment depending on production level**

Funding by Private Investors

Investing money into physical values such as real estate is highly popular in days of volatile markets and fear of inflation. However, houses, apartments and flats are usually part of real estate investment funds leaving investors with no control about the future composition of the fund. We at Company Rooftop want to satisfy the demand for investing in real estate in combination with choosing the exact property by bringing crowd investment into the German real estate sector. In contrast to closed and open property funds, the big advantage for private investors lies in the possibility to choose a specific property to invest in. Investors can control their investment decisions and are able to compile their own portfolio in a specific way; this is something that no real estate investment trust allows. While this concept has never been explored for the German market, crowd investment real estate projects have proved to be successful in the American market during the last few years.

Therefore, we strongly believe that there is a great demand for small investments into real estate. Our aim is to target private people who cannot afford to buy a whole apartment but still like to invest in real estate to profit from the security of physical counter-value and increasing rents. In return, private investors get the typical security of real estate, in comparison e.g. to the stock market. Furthermore, investors know exactly into which building their money is invested and how big their percentage of ownership of the specific Rooftop Unit is.

Moreover, as real estate investments are correlated with increasing rent, the Rooftop Units will always be rented below the rent index. This means we are targeting private investors with an awareness for social sustainability. Real estate investors have a very negative image in the society: they are seen as profit-hungry and are connected with increasing rents. By welcoming small private investors in a real estate business that countervails the problem of rising rents, a whole new group of investors can be targeted. This will enhance the reputation of real estate investors and attract more people with a social and ecological mindset to participate in the business model.

As usual, in return the private investors will receive a yearly dividend on their invested money which is paid by Company Rooftop. As we do not target profit-hungry investors, Company Rooftop pays a yearly dividend of 3.5% of the invested capital.

A crowd-funding model is implemented to finance the Rooftop Unit and the renovation of the host building. We do not envision a high impact of public funding or funding by bank loans in the long term, as our business model is highly capital intensive with little income streams compared to the necessary financial investment. However, the German KfW-bank supports refurbishment projects with monetary subsidies up to 3.750 €.

Tenant of the Rooftop Unit

The tenant of the Rooftop Unit, as described in our market viability section, has an ecological and social mindset. He is renting the unit and proud of the fact that the house is self-sufficient and feeding electricity into the grid. It is also important for the tenant that he does not take part in higher-than-average rising rents and gentrification. In fact, he is paying -on a yearly updated contract with Company Rooftop- always a few percent less than the rent index would suggest for comparable housing in the same area. The rent index is an official index published by the municipality including the average rent for different locations and housings. Furthermore, as the tenant already benefits from the lower-than-rent-index rent, he commits himself to pay an equivalent for the electricity he uses to Company Rooftop.

The tenant of the unit has a renting contract with Team Rooftop, updated on a yearly basis. The amount of monthly rent is based on the rent index for the unit's location and comparable housing standard. We assume that Team Rooftop will rent the units for 95% of the rent index. The price/m² varies a lot throughout Berlin city area. However, an average basic rent of 10.5 €/m² can be taken as a pessimistic value. This results in a monthly rent of 600 € not including the extra expenses for cleaning and lighting the stairway of the base house. Furthermore, the average rent in Berlin increased steadily by 2,5% per year for the last 14 years. Therefore, we assume a rent increase of 2% per year in our business plan. As Team Rooftop will not make a big market share, we assume that our houses – rented to 95% of the index – are not going to influence the increase significantly.

Besides the amount stated in the index, one has to take into consideration that the future inhabitant is decoupled from the energy market and benefits from the self-sufficiency of the house in terms of electricity. Therefore, the tenant has to commit himself to pay an equivalent amount for the consumed electricity on a monthly basis to Company Rooftop. The tenant has to pay the price of the cheapest "green" electricity provider on the market available. We assume a consumption of 3500 kWh per year for the Rooftop inhabitant and a price of 0.26 €/kWh in 2014. According to the long term development, we also assume a 4% increase in the energy price per year.

Owner(s) of the host building

Company Rooftop and private investors are financing the necessary refurbishment of the host building in terms of roof structure refurbishment and, depending on the remaining budget, a modernization of electrical equipment in the host building (for more details see Section 5.1.3 Collective Housing Building Concept). In return for the free refurbishment, the house owner authorizes Company Rooftop to build a unit onto the freshly renovated Rooftop. He also assures not to raise the rent for the host building inhabitants by more than the amount of money the inhabitants will save on energy costs due to the refurbishment. However, as we do not want to finance the owner of the host building with more than the refurbishment budget, he takes part in a 10-year contracting solution with us. The owner of the host building has to sign a contract in which he assures to forward the money resulting from the rent increase to Company Rooftop. Depending on the

condition of the host building the money allows different levels of refurbishment. In a pessimistic scenario, the refurbishment budget of 70000 € will only suffice for the renovation of the roof structure and therefore only results in a 15% decrease of the heating. The typical existing base house consists of 14 flats with 70 m² each and is heated by gas. The average heating costs for the typical, not newly renovated base house is 12 €/m²/year, respectively 117600 €/year. According to the long term development, we also assume a 3% increase in the gas price per year.

Tenants of the host building

Every Rooftop Unit produces a surplus of approximately 5500 kWh per year. The classic way would be to send the surplus energy directly to the grid receiving feed-in compensation from the German government. We decided to discard this solution as the programme is phasing out and there is no opportunity to adapt to the conditions of the energy market. We therefore developed an innovative but simple solution in which a small energy market would be developed by implementing a micro grid. This grid connects the Rooftop Unit with the apartments of the host building (for technical details please see Section 5.3.4 Electrical System Design). Yearly contracts with the consumers in the host building with prices below average electricity tariff (e.g. 75%) and above the feed-in compensation will guarantee a benefit for both users and suppliers of the Rooftop energy. Assuming a consumption of 2850 kWh per year, this leads to a reduction of ca. 25 € for each tenant per year.

Summed up, the tenants of the host building pay even less for the overall rent (including energy and operating costs) due to cheaper electricity. Furthermore, they will live under a freshly renovated roof structure and, depending on the costs for the roof refurbishment, can benefit from a renovated façade including better noise-proof windows.

OUTCOME AND SUMMARY

All assumptions made in this chapter can be seen in the following Table 9.

Percentage of saved heating costs through renovation	15	%
Price per m² for heating the host building before renovation	12	€
Number of flats in host building	14	
Squaremeter per flat	70	m²
Total Squaremeters host building	980	m²
Heating costs per year	11760	€
Saved costs through renovation in 2014	1764	€
Compensation for electricity fed to the host building in 2014	0.195	€
Yearly Increase of rent	2	%
Square meter of living space in Rooftop Unit	60	m²

Percentage of rent index paid by tenant	95	%
Energy consumption of Rooftop tenant per year	3500	kWh
Kwh sold to the host building per year	5500	kWh
Yearly Increase of gas price in %	0,03	%*100
Price per kWh in 2014	0.26	EUR
Yearly Increase kWh price	4	%

Table 9: **Summary of Assumptions**

Based on these assumptions, the following Table 10 shows all revenue streams for a period of ten years one Rooftop Unit build in 2014 achieves. According to our pessimistic assumptions, every Rooftop Unit creates a revenue stream of approximately 11000 - 14000 €, depending on the year it is built.

Year	Revenue out of contracting on saved energy in € (paid by host building owner)	Equivalent Value of used energy in € (paid by Rooftop tenant)	Revenue out of sold kWh in € (paid by host building tenants)	Rent in € (paid by Rooftop tenant)	Revenue stream for Company Rooftop in €
2014	1.764	910	1.115	7.182	**10.971**
2015	1.817	946	1.160	7.326	**11.249**
2016	1.871	984	1.206	7.472	**11.534**
2017	1.928	1.024	1.255	7.622	**11.827**
2018	1.985	1.065	1.305	7.774	**12.129**
2019	2.045	1.107	1.357	7.930	**12.439**
2020	2.106	1.151	1.411	8.088	**12.757**
2021	2.169	1.197	1.468	8.250	**13.085**
2022	2.235	1.245	1.527	8.415	**13.421**
2023	2.302	1.295	1.588	8.583	**13.768**
2024	2.371	1.347	1.651	8.755	**14.124**

Table 10: **Revenue Streams for Company Rooftop for one Rooftop Unit**

The capital streams for the year 2014 are also visualised in Figure 33.

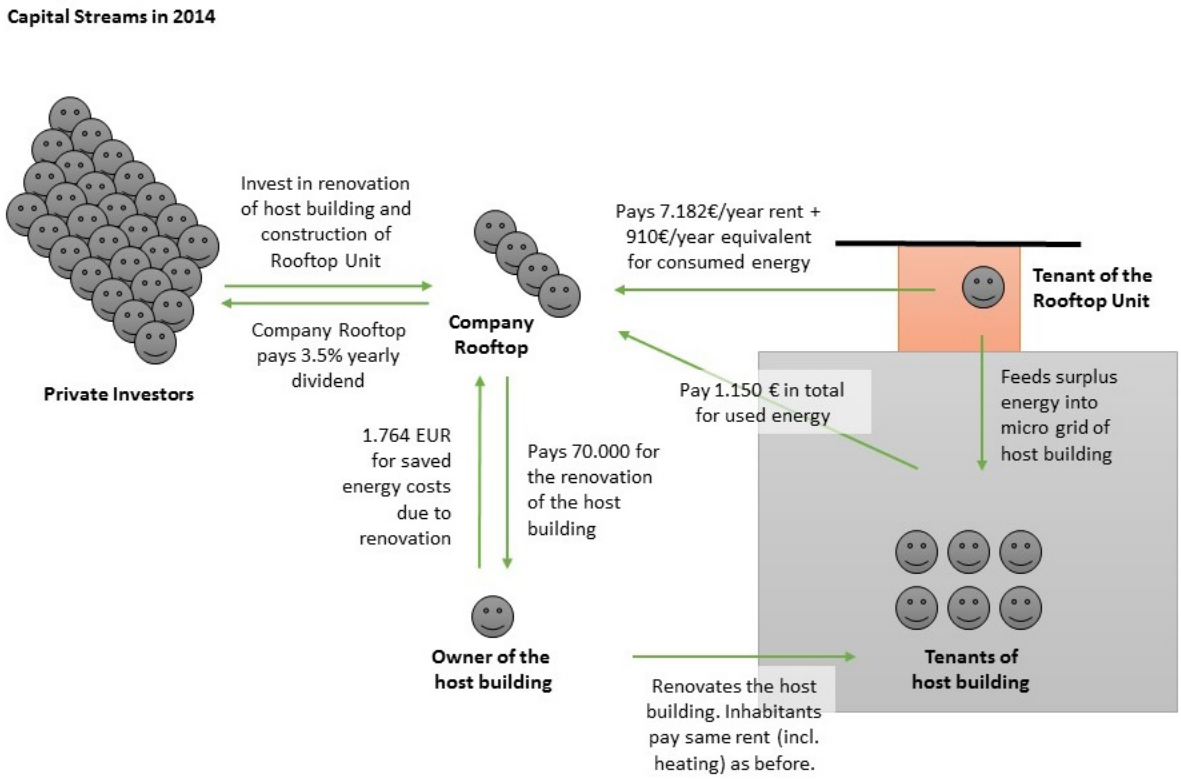


Figure 33: **Financial connections of all parties involved**

To calculate the financial development of Company Rooftop we need to expand the quantitative approach from one Rooftop Unit to much more units. We therefore look at a business case for the following six years. Table 11 and Figure 34 show the viability of our affordability strategy respectively our business idea.

Year	Revenue stream for Team Rooftop in € per unit	Units newly build	Sum of revenue in EUR	Employees	Labour costs in EUR	Total Capital invested	Payed dividend (3.5%)	Loss/Profit in EUR
2014	10.148	2	20.296	4	123.984	972.500	0	**-103.688**
2015	10.401	6	82.703	4	125.844	3.410.000	34.038	**-77.178**
2016	10.661	12	210.634	5	159.664	7.805.000	119.350	**-68.380**
2017	10.928	24	472.904	8	245.790	15.875.000	273.175	**-46.061**
2018	11.202	48	1.010.617	10	292.166	31.295.000	555.625	**162.826**
2019	11.484	96	2.113.115	12	363.331	61.655.000	1.095.325	**654.459**

Table 11: **Business Development on a six year period**



Figure 34: **Loss and Profit Development from 2014 until 2019**

The most important steps to reach profitability are economies of scale, both regarding the building costs and the critical number of Rooftop Units per year.

SUMMARY

We developed a crowd-funding business model to make our house affordable to a large number of people. This model is economically and socially sustainable, leaving the tenant with a monthly rent of about 600€ as well as not increasing the overall rent in the newly renovated base house. We are enabling small private investors to invest in a real estate business model that countervails the problem of rising rents and improves the energy budget of the city. By funding a big part of the refurbishment of the host building, we give an impulse to house owners to bring their Altbau to a new level in terms of energy efficiency.

We pay a constant dividend of 3,5% targeting a new mindset of real estate investors who focus on social and ecological sustainability. The physical counter-value gives security in times of volatile markets and fear of high inflation rates. Furthermore, we should not forget that our assumptions inhabit mainly very pessimistic scenarios – still leaving us with a profit from 2017 on.

5.2. ARCHITECTURE DESIGN NARRATIVE

What is a house without context? The architectural section describes the Rooftop House as part of a whole, at conceptual peace with its context. Rooftop is a part of Berlin, continue to learn why.

5.2.1 ARCHITECTURAL CONCEPTS

PRELUDE

Berlin is a very unusual western metropolis. When it was founded, London, Paris and many other European cities were already thriving, the trade flourished and crowned leaders ruled supreme. It was only quite late, in the 19th century, that Berlin could establish itself among these cities, when it was chosen as the capital of the equally belated German nation. Berlin has always been a young city, a city in the making. An adolescent yearning for extremes. With these ambitions, Berlin grew to become one of the densest cities in Europe before the second world war and became the leading industrial centre on the continent. Everything seemed possible to those within this melting pot. That was until they fell victim to their own ambition and unleashed a war that reduced Berlin to an enormous lithic ruin.



Figure 35: **BW Site Plan 1940**



Figure 36: **BW Site Plan 2013**

It became a fertile soil for two entirely different ideas which prospered: capitalism and communism. These drained from each other in such a fashion that the city bled out slowly. Many citizens decided to leave. Those who stayed turned their backs to the infamous dense tenements and spread onto the many open fields that had been incorporated into the city limits even before the war. Now, in the wake of the Wirtschaftswunder, the 'economic miracle', a large suburban carpet began to form with all its consequences: Wide axis routes for handling the private transport, expansive infrastructures in order to bring the new era into the furthermost homes. And so, the citizens poured out into the new satellite cities also from the eastern historical city centre, with its makeshift-renovated housing blocks. These lured with expansive green open fields and new public transport systems. But meanwhile Berlin's profits dwindled, until it was nothing more than a display of the two systems which so passionately opposed each other. And then the wall fell.



Figure 37: **falling of the Berlin wall**

In one night everything suddenly changed. Suddenly the old prewar tenements were once again in the centre of the republic. Everything seemed possible again. This new freedom drew many young and curious people from all over the world to Berlin. But not the wealthy old industrial entrepreneurs and business executives. More so their creative daughters and sons. People who wished to experiment with new life concepts. People who felt responsible for society and environment. There were so many of them that they in turn created a market. Because with their innovative products and unconventional ideas they understood - and they do until now - how to make money. Money they wish to invest in sustainable personal comfort that at the same time can support the community. Because these people are very realistic and pragmatic, they unite responsibility and good taste, know the value of trained professionals and want to create something really

sustainable. In this mindset, the Rooftop House has been conceived. Quickly, all those involved came to the conclusion that a small single family dwelling with the dimensions set by the Solar Decathlon Rules should not be placed on one of Europe's last precious open areas. Especially not since it should be such an exemplary project. Furthermore, the many fascinating open gap sites that form the unique urban structure and the cultural life of post-war-Berlin do not - in our eyes - apply for infill housing.



Figure 38: **Prinzessinengärten, a community-claimed war gap in Berlin**

In this process we became aware of the many empty attics above our heads. These were, in the late 40s and 50s, often placed on the ruined old buildings with the cheapest methods available in order to prevent complete deterioration. They are therefore called “Notdachstühle”, emergency roof trusses. During the years of the “Wirtschaftswunder”, these wooden umbrellas did not pose a climatic problem, because energy was abundant and there to be wasted. But during the last years, since the rise in oil prices, every house owner should be interested in putting an end to this madness. In order to make such a large investment profitable for the owner, during the past years these roofs have not only been insulated but many times been developed into living space. It has even become a common practice to let others do the development to their wishes. These Dachstuhlrohlinge, or “Attic Blanks”, as they are commonly called, can be bought on the free market in thousands of houses all over Berlin. More often than not, these filet spots on the roofs have been used by the owners as a means of wealth display, and created urban luxury lofts. By doing so, all the base for neighbourly community with the rest of the house is taken away.



Figure 39: **Removal process of an obsolete attic in Berlin**

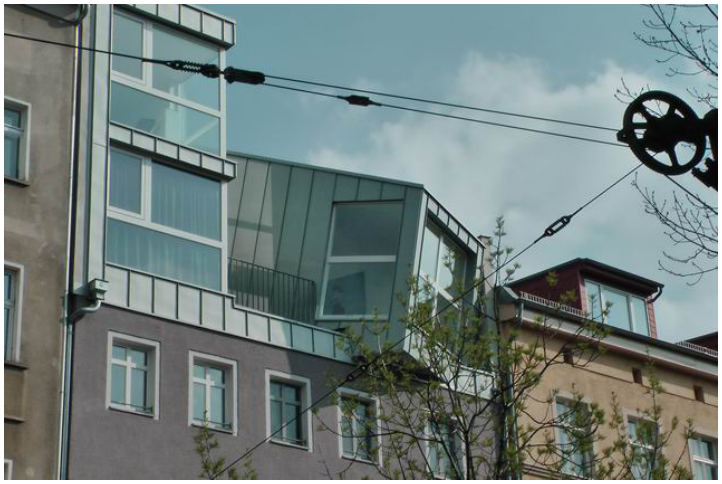


Figure 40: **Attic blanks are regularly used for loft building projects**

ARCHITECTURE

We designed the Rooftop House in accordance to the constitutional principle: "Ownership means commitment". It would be too easy to just profit from others. The strong ones also have the obligation to "carry more". According to the principle of social awareness, it is self-evident that the Rooftop House does not only profit from its elevated position, but it gives something back to its host-house and to the residents within. The goal of the design process was primarily to create a more reserved structure that fits in with the historically grown local order, but at the same time lets the resident experience the exposed location.

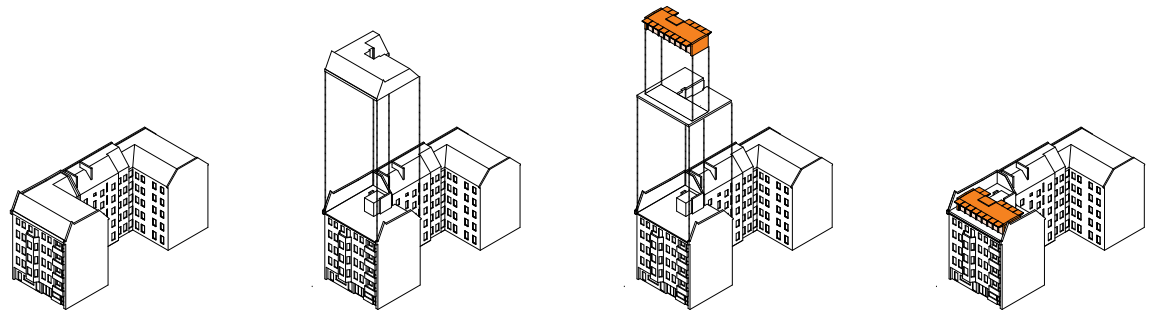


Figure 41: **Exposed location on the Rooftop**

Also, the house should produce more energy than it requires over the course of a yearand feed it to its symbiont, the host-house. In order to reach these goals, the Rooftop House is placed on the lateral axis of a typical Berlin historical prewar house. For this reason, the precarious roof truss is removed and the safety and structural analysis is carried out. Only the stone staircase is preserved as a dry access route and a connection to the neighbo

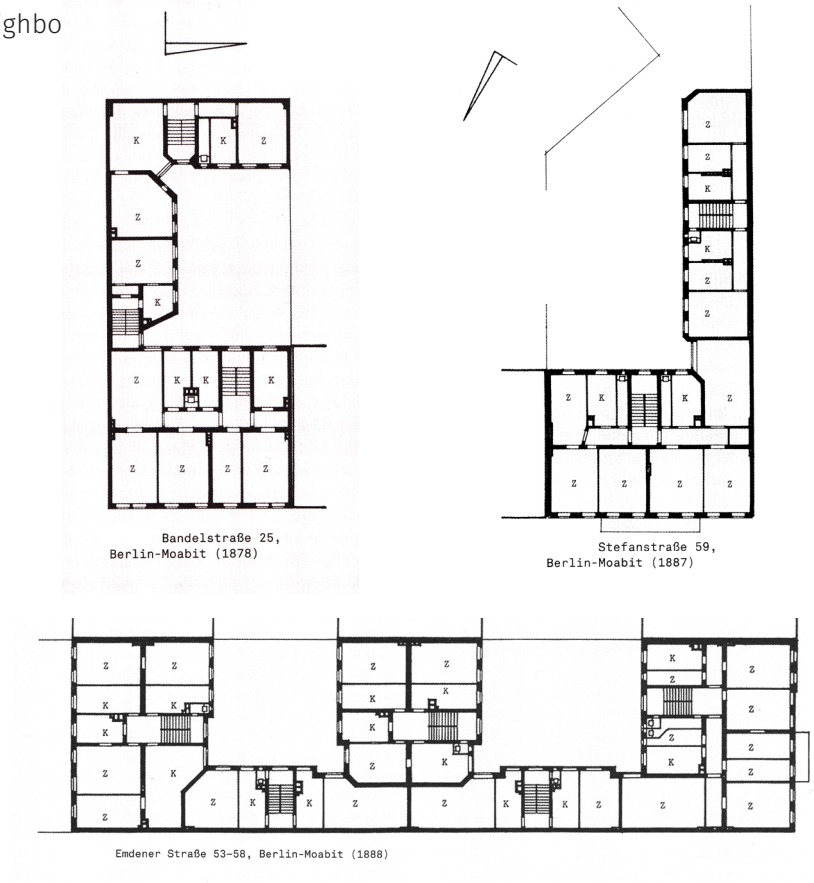


Figure 45: floorplans of typical pre-war tenements

The cubature of the roof pavilion is therefore determined by the two fire walls of the neighbouring buildings, the staircase block, the building law distances to the building edge, and the solar envelope as determined by the SDE rules and a climatically sensible compact shape. The emerging shape is a 15 m long, 4.5 m wide and 3.4 meter high structural body.



Figure 42: **Sunset over the Rooftop House**

In order to maximise the solar intake surface, minimise the energy consumption of the unit and provide an optimum living comfort, the Rooftop House is ideally oriented with its short sides pointing east and west, and the two main façades facing north and south. With its 15 m length, not much space remains between the fire walls of the adjacent buildings. Therefore, the short sides are designed as closed walls and the long sides, with their elaborate glass doors, offer the freedom of interaction with the open roofscape. These long façades can be widely opened towards the roof terrace. Thus, in summer, the borders between inside and outside become blurred. Through the position of the building, the local conditions and the existing fire walls and staircase, three very different terraces are formed. One panorama terrace that faces the street on its full length, opening the view into the city roof landscape. One terrace that offers the use of a roof garden towards the more introvert inner courtyard of the block, and one quiet, clearly separated opening for tranquillity, connected to the more private area of the house.



Figure 43: **Backyard view of the Rooftop House**

Not only cultural-historical extremes have formed the city of Berlin, but also the climate with its continental attributes. In order to react to cold winters and hot summers equally, we implement the Bergmann rule of surface to volume ratio. This means that our pavilion opens up in summer, with its widely overhanging, shading roof elements beset with photovoltaic modules for a maximum solar intake surface. In winter however, when it is cold, these façade elements fold down, creating a preserving shell around the house. This system also reacts to the now very low zenith of the sun path and its indirect influence on the inner climate. A passer-by in the street below would not notice the extraordinary housing unit placed on top of this classical Berlin prewar house. Moreover, the residents of the host building could easily forget about the retrofitting of their edifice, were it not for the devices placed in the ground floor entrance hallway. Here, inside a larger docking station, labelled by name just as the mailboxes, every resident can charge his own portable e-bike battery – free of charge. This charging station is fuelled by a part of the Rooftop's surplus energy. Upon entering the old house, the historic staircase leads directly to the roof level on the fifth floor. To the last flight of stairs, two steps have been added due to the new roof's thermal and acoustic insulation. This thickness of the roof is also partly due to the necessity of rain water drainage across the large terrace surface. Thus, through the staircase in the east, one enters the Rooftop Pavilion. The visitor soon finds himself surrounded by a wooden interior wall with a sophisticated pattern of joints that offers a presentiment of the multiple uses hidden here. Intuitively, he/she opens the swinging door ahead and finds a wardrobe. Shoes can also be stored here and disappear into the module. To the left, passing by the monitoring station on the right, he/she enters the living room, and a new sight awaits. Large glass façades set the view flying into the distance, above the roofscape.



Figure 44: typical Berlin Altbau roofscape, the Berlin "roof-sea"

Interior Design

The first entity defining the space wthin the house is the so calles Core Module: a single element that unites all technical functions of daily life, the kitchen and the bathroom, and humbly lets the owner design the free flowing space around it. The kitchen compartment itself can be shut by a big flap panel, recreating the solid plane gesture which outlines the Core Module's being.

In favour of living up to later residents' expectations, when outlining the interior design profile, we focused on modularity, clarity, flexibility and durability from the beginning on.

Letting one's fingers run along the Core Module surface one can feel the confident, grounding aura of this anchor in the otherwise so exposed pavilion. While circling the volume one reaches the bedroom and finally again the entrance without having opened a single door. The singular living spaces are only defined through the position of the module and the setting of the moveable shelvings.

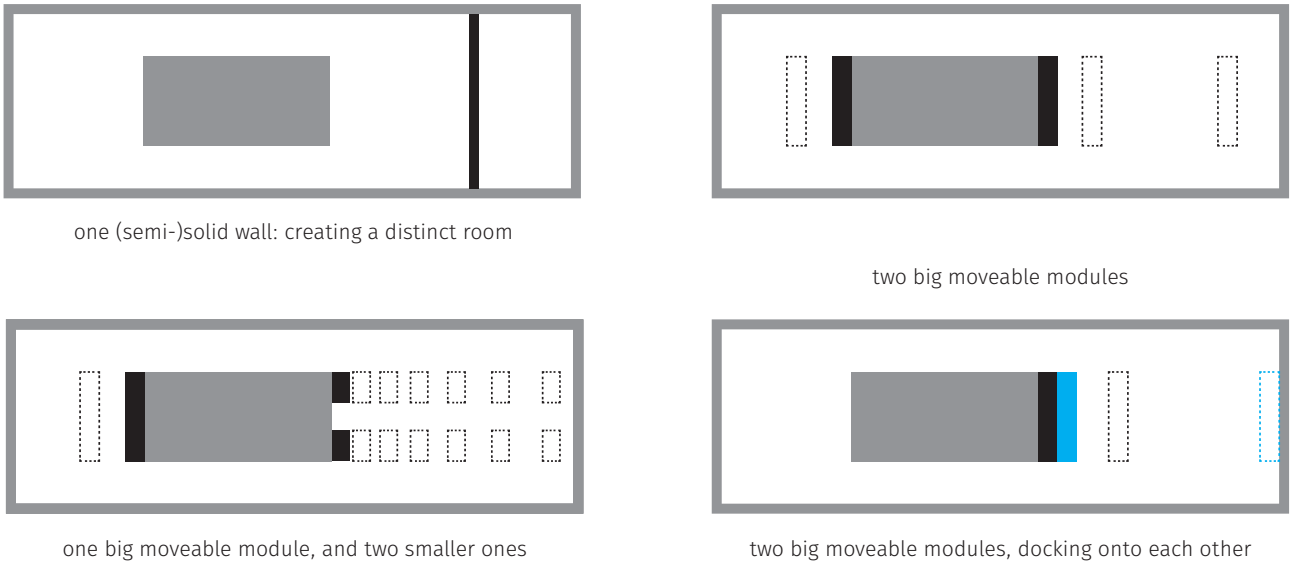
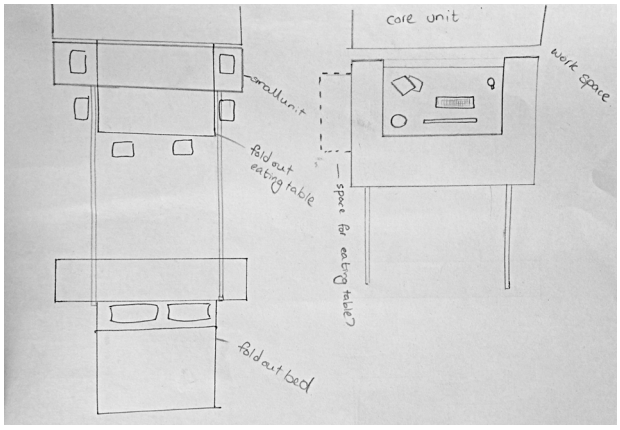


Figure 46: **first ideas on how to divide spatial areas within the house's space**



Dialogue of inside and outside

The elongated building obtains its classic elegance from its clear structural shell. Timber studs on the outside are connected via wooden beams and are sufficiently stiffened by the solid walls at all ends of the building. The bottom of the gently slanted, suspended ceiling is realised in classic white finish, a clea layer on top of the clay based passive phase change cooling components.

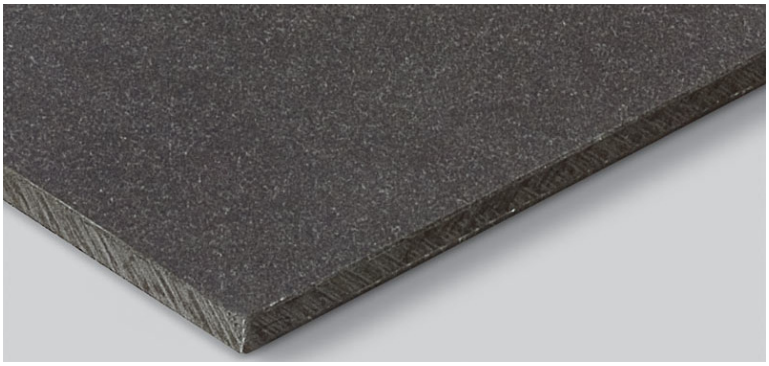
All spacious building components are designed to be modular and pre-fabricated. The flooring components are simply pieced together on site. The solid walls of the house are also prebuilt, with the insulation sound in place. In order to integrate all these ideas into one coherent design, we first establish a hierarchy of the different elements. To lead the design process' dynamic character towards the competition, we decided to focus mainly on the Solar Decathlon and the conditions in Versailles. To bring forth the authentic feel of the house's situation on an “Altbau” in Berlin and recreate the adjoining house walls, would viciously disrespect the given Solar Envelope. On the other hand, to simply erect the Rooftop Unit as a pavillion would stray far from the spacial concept and the clear integration into the roofscape. Therefore we found a compromise: The pedestal, or terrace on which the Rooftop Unit will be placed in Versailles will be coherent with our terrace solution in Berlin in size, shape and design. We will erect a volume representing the existing old house’s staircase, to which the ramp will be connected, allowing all visitors to access our house in the way we intend it in the Berlin roofscape. To covey the natural feeling of the two different terraces, a corner lot has been chosen to allow maximum distance to neighbouring houses. Furthermore, we will erect a part of the representative adjacent house’s walls, just staying inside the solar envelope but cleary defining the outside spaces. Our housing proposition is made accessible from the northern side, so that one can reach the southern, more private and personal terrace after passing through the building.

The Bathroom

Because private sphere is at all times a value, through opening the central double doors of the bathroom, one does not only enter it. Designed in a way the doors' dimensions fit the profile of the hallway, with the same gesture the bathroom can be expanded, using the hallway space and directly connect to the terrace. Additionally, one closes off the bedroom. This way not only the inhabitants can mind their own busineses, but it also offers manifold ways to experience the bathroom. Maybe one wishes to experience a private, quiet space before joining the hectic daily city life downstairs. By opening the large window and façade element, the experience of taking a bath in the vast skyline above the roofs is complete.

A cocoon, surrounding the body with a solid stone-like appaerance, and even while feeling the figurative weight of the anthracite eternit panels, which we are using for the floor, walls and ceiling, the perception of such never becomes oppressive. In our opinion, by straightly acknowledging the material's qualities and supporting it with a dim illumination, with just a few highlights, we achieve a warm, yet heavy, and dark surrounding. Breaking with this stone-like feel of the eternit, we introduce oakwood for the lamp and as a stripe insert in the floor. Furthermore, soft lines and haptic textures are also elements that turn this small room into a protective, relaxing

refuge.



Eternit panel as used in the bathroom

The Kitchen

Going from the living room to the bedroom is not just about changing rooms. You pass the Core Module, the housing unit's heart, and on the façade facing side to the south one of its most important functions besides the technical room and the bathroom – the kitchen.

Standing in front of our kitchen, you might wonder about where all the typical functions are actually placed. In fact, the kitchen does not reveal itself instantly as it is fully integrated in the "Core Module". By the use of the bamboo material for the surface of the module, the kitchen melts into the central unit of our house. Almost every machine and even the whole work space can disappear behind the bamboo skin. You expect a door hiding a storage room? Wrong! That is where our dishwasher could be located. Merely two little hints tell you where the kitchen is. We do not want to get your pasta bake get burned, so we did not cover the oven with our wooden material. The operator control module is also not hidden to facilitate the use of our fully integrated washing machine.

Hence, at a first glance, the kitchen has one smooth surface. But at a second glimpse the fundamental elements of the kitchen reveal themselves. With every grasp you discover more functions and storage spaces in the kitchen. Valuable devices such as dishwasher, washerdryer, freezer and refrigerator are no longer hidden behind the trim. Take out a knife and start cutting you tomatoes!

But where? If you take a look on the small recess that is left for the sink and the stove top you surely wonder where the space to work is. Pull off our removable trim elements and use them as an additional work place. Just place it on the telescopic sub construction between oven and dish washer or use the mobile roll car to create unseen operating range.

Chromed kitchen instruments, the stainless steel sink as well as the aluminum anodized working plate complete the picture of a consistent kitchen without unneeded playfulness.

Starting with the seamless integrated kitchen surfaces, it was for us of upmost importance not to break with the high quality of the materials in terms of technical gear. That is why we are very pleased about the qualities the line of Miele products provide. Having all devices manufactured by Miele, we achieve a optical-technical consistency.

Ring Ring! Guests are coming and your kitchen is still in a mess? No problem. Just wipe over the removable work plate, put it back on the Core Module, and your chaos is not a problem anymore.

Conclusively, you can experience the kitchen as a room that does not impose on the resident but as a place that opens its doors. Furthermore, our relocatable windows transfer the kitchen area to the outside. So in the end, the kitchen is an area where people work, come together and have fun.

The Façade

Eight glass panels, four of which are sliding doors, on each side along the house ensure the maximum daylight intake and openness. They are organised in such a way that all living spaces have access to the different terraces. This way, in summer, inside and outside flow become mutual. Conversations with guests on the terrace while cooking in the kitchen becomes easily possible.

The folded up solar façade elements that wrap themselves around the living space like a protective layer in the winter provide shelter from sun in the summer. This outer layer of the house unites constructive, climatic and energetic concepts. Nine wooden supports send the weight forces onto the constructive walls of the host building. At the same time they form the attachments for the mechanisms that open and close the façade elements. These elements have photovoltaic modules mounted onto them. When they are open, they become an extension of the roof both inside and outside, following the slight angles of the ceiling. The walls transmute and the entire structure turns into a roof, shielding direct sunlight. When the owner is not at home, the automation of the house system adjusts the façade to track the sun. Should the inhabitants be present, then the choice lies with them to adjust each façade element at their will. In order to realise this innovative flexibility, one needs to find a careful balance between technology and design.



mockups about shelvings on guideways

Experimental Process

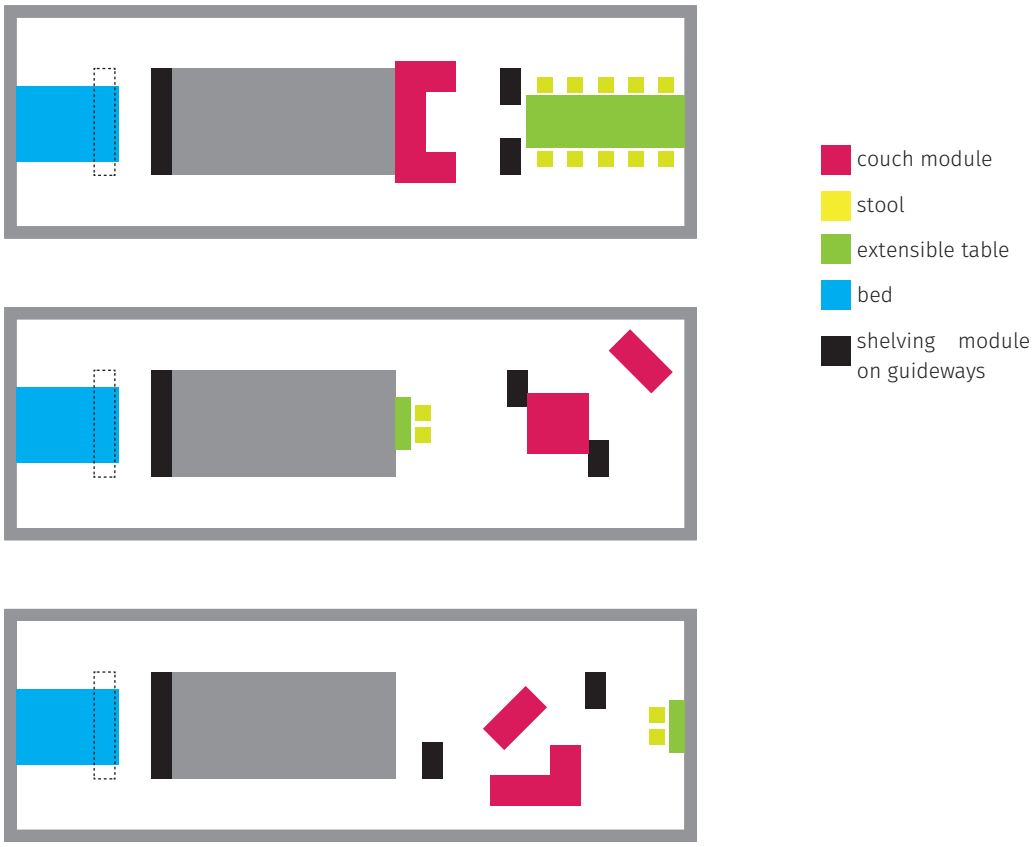
The question of what to fill your living space with is an issue which does not let colours pop up in one's head instantly. Hence, in the thinking process, we started playing around with wall elements on wheels and plane white cubes. We drove them through a room, found constellations we liked, constellations we also liked, and constellation we liked even more. The problem was that all of those solutions interfere with the other ones, at least partly. The only possibility was therefore a concept of freely-arrangeable furniture pieces (shelves, chairs, couches and so on) to allow a maximum flexibility for different users.

Nevertheless, an aspect of moveable furniture concerned us: giving people every possibility arranging the living space does not automatically result in proper setups. Consequently, we decided to literally limit the axis of movement for the two defining shelving structures of the living room and the clothes closet in the bedroom area.

By letting the structures glide on embedded guideways, we provide a smooth, yet fixed movement along the room and also keep visual axes as clear as possible.

With all these measures we hope to accomplish the figurative drawing of the line between obtruding situations and offering possibilities in a most fashionable manner.

Functional Setups



Furnishings and Fixtures

Particulary designed furniture, conveniently stackable, extensible or - on embedded guideways in the parquet - moveable, leaves full freedom in the arrangement of the room layout. The interior is dominated by warm, natural materials. Oak parquet on the floor, clay on the walls, bamboo panels coating the Core Module and light strucures of aluminium shelvings.

We are happy to say that we are cooperating with Ozzio Design, manufacturer of the extensible Golia table, which will equip our living room.



Figure 48: Golia table. fully extended, picture by Ozzio

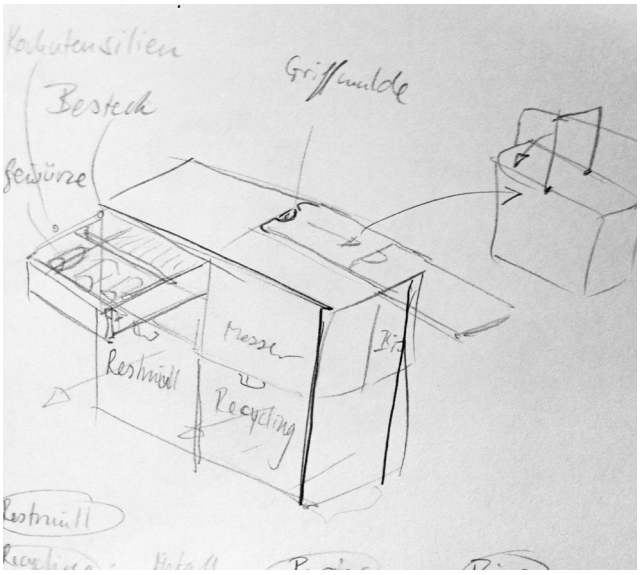


Figure 49: drafts for multifunctional serving cart

The table can be extended from a small console to a dining table for up to 10 people. It is accompanied by a set of stackable stools in a perfect dining and working height. The living room is dominated by tall twin shelvings on guideways which can be moved with ease across the full lenght of the room from the Core Module to the outer wall.

In the bedroom is another piece of movable furniture. The wardrobe can be pushed away from the Core Module, creating a free space which may be used as dressing room. The armoire provides an appropriately sized opening so it may be pushed over the bed. A bench beneath the closest's opening, also on wheels, covers a set of clothes' baskets. The bed is spacious enough for two persons. It can be split up into two parts and pushed to the sides, or onto the terraces. During the Solar Decathlon competition the bed will be split up, respectively pushed to the sides in order to satisfy local emergency regulations.



Figure 47: section of bamboo panel

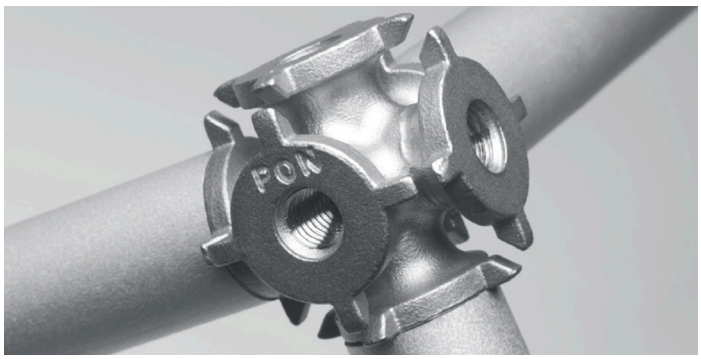


Figure 52: connective joint

PON-system

In terms of durable, yet modular shelving contructions we obtain our material from a good name in exhibition stand construction, Burkhardt Leitner. Standardised nodes, connecting tubes and stabilising elements provide a solid structure, simple and fast to build up. With this so called 'PON'-system, we build the living room shelves, the clothes closet and, of course, the couch elements.



Figure 51: rendering of the clothes closet



Figure 50: rendering of the movable shelvings and couch elements

5.2.2 RECONFIGURABLE FEATURES

Element Name	Abbreviation in Plan
Folding Façade Elements	
	F1-F14
Sliding Windows	
	W2
	W4
	W6
	W8
	W10
	W11
	W14
Exterior Doors	
Entry Door	D1.01
Door to Private Terrace	D1.06
Door to Gardening Terrace	D1.07
Interior Doors	
Door Bathroom	D1.02
Door Bathroom	D1.03
Door Technical Room	D1.04
Door Technical Room	D1.05
Removable Kitchen Faceplate	
	K1
Movable Furniture on Rails	
Closet (clothes)	M1
Shelve	M3
Shelve	M4
Movable furniture free	
Drawer Element	M2
Table	M5
Stools	M6-M7
Couch Elements	M8-M10

5.2.3 LIGHTING DESIGN

Urban conditions

Berlin is an overall very flat city with only very few high peaks. Most building heights still syntonise to the old Prussian eaves height of about 20 meters. This was due to the limited length of fire fighters ladders at the time. For this reason, shading is not a problem in Berlin. Even the low winter sun is not cut off by neighbouring houses, as the streets' widths respond to the increasing heights of houses. During the summer months, the folding façade elements of the Rooftop House are tilted upwards and shade off the glass façade against direct sunlight. By choosing light, wooden flooring for the terrace, the sunshine is unobtrusively reflected into the interior, illuminating it in a comfortable manner.

Use of sunlight

As the house’s ceiling is held in a light, natural clay surface, light is allowed to reach deeply into the interior spaces, more likely floating from the southern to the northern side and vice versa. This bright, cozy atmosphere is further enhanced by the bright walls at both ends of the house.

In wintertime the façade elements will mostly be opened in order to maximise passive solar gains, closing only at nighttime. The sun does not only bring light, but also warmth to the house.

Setting up a sub-network for lighting

In order to keep lights as flexible as the house itself, a distributed sub-net on a 12 V basis is provided at specific plugs around the house. The LED strips allow maximum flexibility: every lamp or lamp construction is made possible. Ranging from long strips over light panels or spots, unique solutions can be built. Another advantage being the safety of such sub-system due to its low voltage. The contacts can even be touched without harm.

Creating a seamless ambient lighting

Our aim is to create a seamless ambient lighting. Although the term 'ambient lighting' is typically associated with dim light situations, by using high power LED strips incorporated in the joints, ambient lighting gains a whole different status. In fact, it becomes not only an attention-seeking object in living spaces, but it also provides light in a most natural, diffused and non-glare manner. Thereby ascending to a comfortable entity one likes to live in.

If the inhabitant wishes to set the ambient lighting back to a subtile setting, this can easily be achieved by dimmer switches which are also connected with the house's automation system. In this way, the light intensity increases at sunset.

The LED strips will provide either ~500 Lumen/m or ~1000 Lumen/m and a energy consumption of ~4,8 W/m and ~14,4 W/m. With the seamless LED strips alone we achieve up to 7000 Lumen in the living room and 5000 Lumen in the bedroom area. Lux levels vary in both areas between 280 Lux and 480 Lux with the LEDs turned up to maximum.

Terrace area lighting

Standing in the bedroom and looking to the north, you can see the private terrace surrounded by the fire wall on the left and the wall of the staircase on the right; both walls are over 7 m long. There are three wall lamps mounted on the fire wall and emphasize the surface structure of it. The expanded metal of the railings on each terrace gets illuminated by LED strips integrated underneath the handrail. At the gardening terrace, facing north, right under the very long bench around the pond for wastewater treatment there will be a LED strip as well.

Additional spot lighting

A more concentrated lighting is realised by single lamps, hanging down from a guideway in the ceiling with visible cables hanging down as well. Thanks to the extra-length, those lamps can be pulled from one side of the room, hanging close together, towards the other end, generating a more distributed light emission. Attention is drawn to the pillars of the house in a similar way; spotlights are flush mounted between each pillar that encourage the skeleton like outer façade structure of the house. Light from below is shone against the curtains and creates a very smooth faint light inside and outside the house. The open façade elements reflect the light additionally at night, naturally illuminating the terrace. The delicate mechanics with their nuts and bolts throw long shadows across the wooden beams, giving the house an almost sacral, mystic scent.

We are looking forward to welcoming you to the Rooftop House and to let you see the lighting design with your own eyes. You will enjoy it, we promise!

5.2.4 ACOUSTIC DESIGN

The following chapter examines the acoustic design from a theoretical point of view. The actual measurable results might vary slightly.

CIRCULATION OF SOUNDS IN THE INDOOR SPACE

Our building consists of three acoustic separate rooms; living room, sleeping room and bathroom. The entrée and the kitchen are, acoustically, forming one unit with the living room, and can therefore be regarded as being included in the calculations done for the sound exchange between living room and sleeping room.

The noise originating from the technical installations room is covered in „Influence of HVAC and active systems on the indoor sound pressure level“ on page 103 later in this Session.

For the calculations of living- and sleeping-room, two different options are taken into consideration, in order to find an optimal compromise solution between acoustics and optical benefits.

The problem originates from the large free space above the doors, caused by the not horizontally levelled ceiling, which allows sounds to be easily transmitted.

In order to solve this issue, the gaps could be filled with additional wooden boards installed at the ceiling. However, this would hinder the free view through the rooms, an important architectural feature. In conclusion, we chose to propose the further wooden boards application as an optional, so that a one-person household may enjoy the best optics without acoustic concerns, while the demanded acoustic comfort can be provided for a multi-persons household.

In the following passage, values for both options are calculated.

a) Optical optimum

The following calculations are performed under the following hypothesis: closed doors, point of view from the living room to the sleeping room, extended bathroom area in between.

The doors are not airtight, but are rather they are characterized by the mentioned free spaces above. Since the interior doors are only lightly sound insulated, while the Core Module walls are relatively highly insulated, we will for this calculation forego the structure-bourne sound through the walls.

Considering

S_f=0.1 m² open spaces above the doors (two doors leading to the bathroom, each with 0.05 m² open space),

A_b= 3.7 m² equivalent absorption area of the bathroom (see attachment **Figure 54**),

A_{sr}= 10.6 m² equivalent absorption area sleeping room (see attachment Figure 55),

L_{lr}= sound pressure level living room,

L_b = Sound level extended bathroom,

R_b= sound reduction index to bathroom,

$$L_b = L_{lr} - 10\log(1 + \frac{A_b}{S_f})$$

([2], p. 505)

and

$$R_b = L_{lr} - L_b = 10\log(1 + \frac{A_b}{S_f})$$

([2] eqn. 8.4)

, follows that R_b=15.8 dB if the sound transmitted through the door leaves is disregarded.

The doors can be estimated to have a sound reduction index of 25 dB ([1], Tab. 5.15). In comparison with the noise reduction index of the free spaces (R_b= 15.8 dB) the disregard is reasonable.

For the sound transmission between the extended bathroom and the sleeping room, the same calculation leads to a resulting R_{sr}=20.3 dB.

This value differs from the first value due to the higher sound absorption in the sleeping room.

Finally,the total reduction index can be obtained as follows:

$$R_{tot}=R_b+R_{sr}=36.1 \text{ dB}$$

Such value enables the sound absorption of a gentle conversation or some quiet music of 60 dB to a level of under 25 dB, as recommended in the German norm DIN 4109. However, it does not grant enough protection against any vivid conversation or louder TV.

b) Acoustic optimum

The open spaces above the doors are in this second scenario reduced to merely 0.01 m², which is approximately the amount needed to ensure an appropriate ventilation rate (it is, in fact, coherent with the area of the ventilation outlets).

The wooden boards at the ceiling are estimated to be characterized by the same sound reduction index as the doors.

In analogy with the calculation above, this would lead to the following results:

$$R_b=25.5 \text{ dB}$$

$$R_{sr}=30.2 \text{ dB}$$

In both cases, these values will actually be lower, because of the sound transmitted through the door leaf. Since the tabular value does not consider the different sound absorption in the rooms, both reduction indices are approximated to have an acoustic value of 25 dB ([1], Tab. 5.15).

Therefore, the final value of the reduction index equals to R_{tot}=50 dB.

In this scenario, even a vivid conversation with a sound pressure level of 75 dB taking place in the living room would arrive at the sleeping room diminished to a level of 25 dB, and thereby comply with the maximum value (25 dB) recommended by the DIN 4109.

As far as it concerns the bathroom and the other rooms, the determining elements for the sound transmis-

sion are the doors. Once more, they can be estimated to have a sound reduction index of 25 dB ([1], Tab. 5.15), since both adjacent walls are considerably thicker due to constructive reasons.

The developing of structure-borne sound is minimized by the acoustic decoupling of the pipes at the contact joints with the walls. Furthermore, due to the central placement of our mechanical room, the water pipes for toilet, sink and shower are placed in the acoustically damped wall towards the mechanical room, which further minimizes the noise originating from the bathroom.

Since the rest of our house represents one acoustic unit when the bathroom doors are closed, the resulting noise reduction is the same for all other rooms. Its value will only slightly vary with the distance from the bathroom.

Circulation of sounds between collective buildings

Since our house is designed to be built on the top of another building, the only noises exchanging between collective housing units will be between our house and the building beneath.

We accounted for that with the best possible elastic support of our technical installations room which is the main acoustic source in the Rooftop House. Moreover, consequent impact sound insulation is used throughout the house.

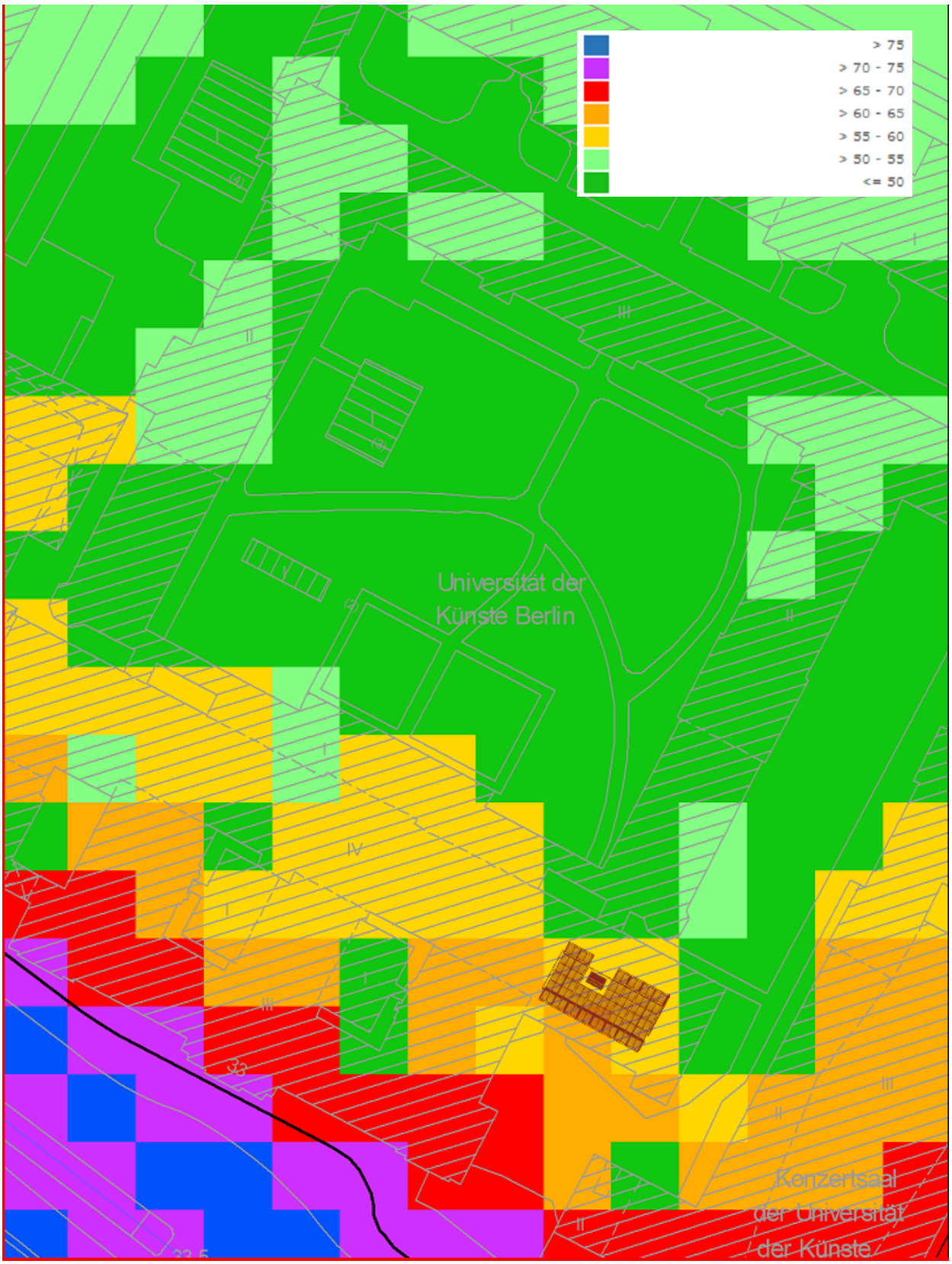
Outside noise levels on local site in Berlin

For an overview of the local sound levels see „noise map of the University of Arts Berlin [9]“. The Rooftop House can be seen in the lower left corner, in the yellow area.

The maximum level of outside noise is 65 dB during the day, and thereby a maximum of 35 dB inside the house (see Chapter „Façade airborne sound insulation“ [9]). This fulfils the recommendations of the German DIN 4109 for living spaces during the day. During the evenings and nights, the sound level can be expected to be considerably lower, due to the decrease in street noise.

On the terrace facing the street side, the noise level will be almost the mentioned value of 65 dB, an average value for balconies and terraces in Berlin [9]. This does not provide good acoustic comfort, but the Rooftop House has three terraces. Two of them face the internal courtyard side away from the street, where the sound pressure level may be up to 20 dB or lower, due to the acoustic barrier formed by the house ([2], p. 334). The result of 45 dB allows a normal conversation at a distance of maximum 3 m between the participants ([13], p. 495).

The noise levels at the façades to the sides will be between the values for the sites facing the street and the courtyard. Further calculation are not needed, since these façades have highly sound insulating properties (see Chapter „Façade airborne sound insulation“ on page 102) and no directly adjacent terraces.



noise map of the University of Arts Berlin [9]

REVERBERATION TIME

The reverberation time is an important characteristic of the acoustic comfort. High values are coherent with a loss of acoustic clarity, higher sound pressure levels (caused by the lack of sound absorbing materials) and may lead to difficulties in understanding spoken language ([2], p. 237).

According to the contest rules, the minimum reverberation time for full points is 0.8 seconds.

Since the acoustic behaviour of a room is only of higher importance for the human comfort in places where activities with an acoustic impact, such as conversations and listening to music, take place, the respective calculations are, in compliance with the contest rules, discussed in detail solely for the living room. Data about the reverberation time in other rooms can be found in the attachments on page 108.

The volume and equivalent absorption surface of the entrée and the kitchen are included in the data given for the living room, since such areas are not acoustically separated from the living room.

By definition the reverberation time is the time in which the sound pressure level in a room has dropped by 60 dB, starting with the end of the sound emission.

It can be calculated using the Sabine's reverberation equation ([1] eqn. 4.55):

$$T = 0,163 \frac{V}{A} \cdot s$$

where

$$A = \sum_i \alpha_i \cdot S_i$$

and

- T reverberation time
- V volume of the room
- A equivalent absorption surface
- α sound absorption coefficient
- S surface area
- s second

This leads for our project to values which are for most frequencies below 0.8 seconds (see Figure 53). The complete data can be found on page 109.

In reality, these values can be expected to be even lower, for reasons such as open doors, additional private items of the inhabitants (we calculated with empty furniture) and also the presence of people in the room.

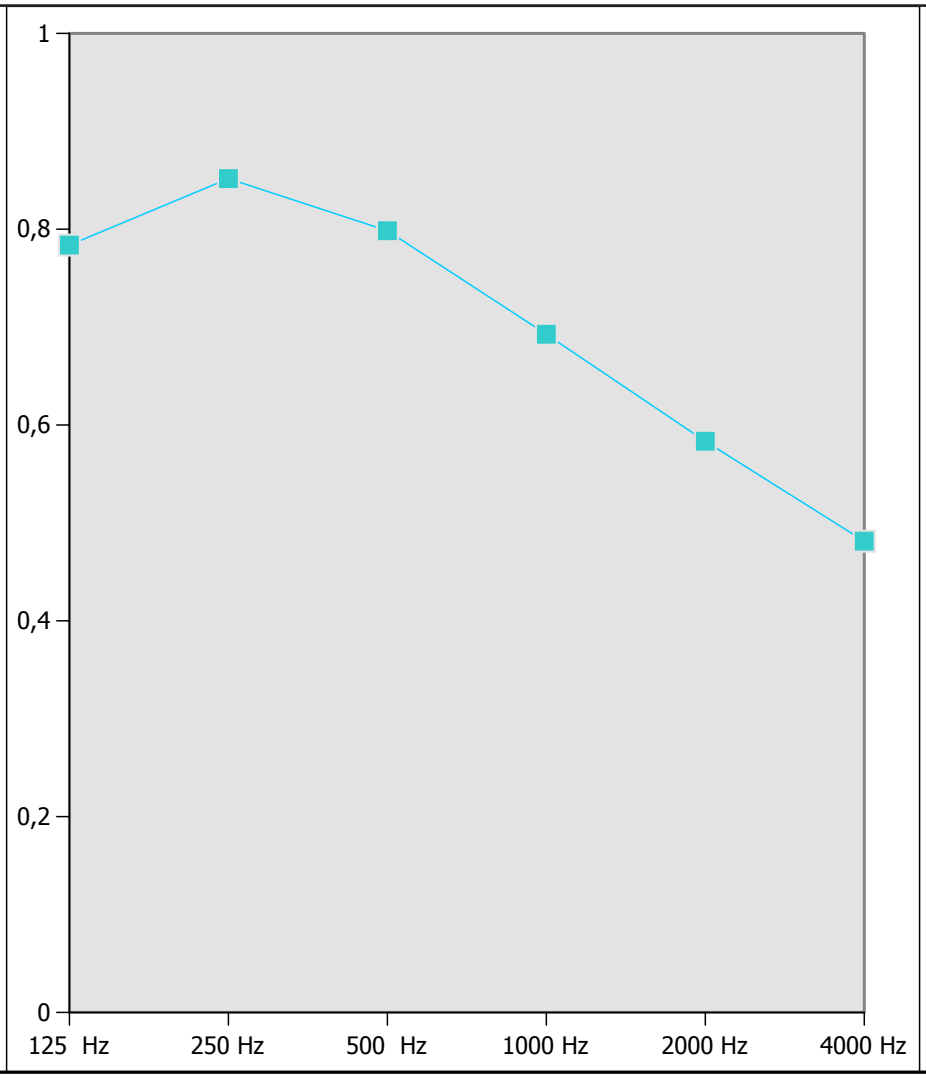


Figure 53: **reverberation time living room**

Façade airborne sound insulation

The walls, roof and floor of our house consist of elements made of wooden materials filled with sound absorbing cellulose.

The thickness of these parts is slightly over 400 mm, leading to good soundproofing qualities with a resonance frequency of 35 Hz and from there an increase in the sound reduction index of 18 dB per octave ([12], page 489).

The determining part for the acoustic insulation is the glass façade, which has a lower noise reduction index and accumulates to a larger surface than the outside walls. Therefore, we will disregard the sound transmitted through the outside walls, since it will have only a very small impact, and we will carry on calculations for the glass façade.

The acoustic value of our glass façade is 30 dB [8]. This will probably not suffice for full points in this contest. Still, we decided not to use especially made sound proofing glass for our façade, since the optimization of the thermal insulation is, in our case, more important.

The Rooftop House will stand in a quieter place (maximum external noise level 65 dB) at the University of Arts Berlin, where windows optimized for thermal insulation will suffice, see chapter „Outside noise levels on local site in Berlin“ on page 98.

The positioning of the house can be seen in „noise map of the University of Arts Berlin [9]“. Our house can be seen in the lower left corner, in the yellow area.

Such values fulfil the recommendation of the German norm DIN 4109. During the evenings and nights, the sound level can be expected to be considerably lower, due to the decrease in street noise (traffic as well as human).

If a more noisy environment is expected on a building site (for example near a heavily trafficked street corner), our design will be optimized by means of sound proofing windows. This choice, however, may lead to a budget-increase. Sound proofing windows can be purchased from our supplier with sound reduction indices of up to 50 dB [11]. Accordingly, a noise level of 75 dB, which is approximately the sound level near a heavily trafficked street corner, could be sufficiently muffled [9].

In cases of temporary extreme noises from the outside, such as construction works or demonstrations, the design of our house allows a further increase of the noise reduction index through the closing of the folding façades.

Inside noise level with open windows

The influence of open windows on the sound pressure level inside is determined by the area of the open window the equivalent absorption area inside and the existing sound pressure level outside of the house.

The equation for rooms with openings to the outside can be given as:

$$L_{inside} = L_{outside} - 10\log(1 + \frac{A}{S})$$

([2], p. 505)

where

- L sound pressure level
- A absorption indoor surface
- S area of openings to the outdoor

The absorption indoor surface of the living room is approximately 16 m², hence with one open window (S=4.17 m²) the difference in noise levels between indoor and outdoor is 6.6 dB.

In acoustically demanding times, the opened windows can be expected to be those facing the courtyard, with lower sound pressure level of about 45 dB during the day (see„Outside noise levels on local site in Berlin“ on page 98). Accordingly, the sound pressure level with one open window will be 38.4 dB.

For the sleeping room, the same calculation results to 39.5 dB.

Influence of HVAC and active systems on the indoor sound pressure level

Our solution for an acoustically nondistribution HVAC system consists of a reduction of the sound pressure level inside the technical installations room, a complete acoustic decoupling of the technical installation room and sound absorbing ventilation outlets.

This is a very important aspect of the Rooftop House, since the heating and cooling demands are supported by an air-water heat pump which generates up to 55 dB of noise inside the technical room.

The acoustic power originating from the heat pump exceeds by far those of other technical installations within the Core Module. Therefore, the heat pump will be the sole acoustic source for the purposes of this calculation.

According to the data given by Stiebel-Eltron, the heat pump produces a sound power level of 56 dB(A) [4] . Highly sound absorbing pyramid foam will be fitted to the inside walls of the technical room to reduce the resulting sound pressure level, resulting in 5 m² of equivalent sound absorbing area.

The sound pressure level is ([2] eqn. 7.25)

$$L_{tr} = L_p - 10\lg\left(\frac{A_{tr}}{m^2}\right) + 6dB = 55dB$$

where

- L_p = 56 dB(A) sound power level
- A_{tr} =5 m² equivalent sound absorbing area

As far as it concerns the sound insulating properties, the walls can be approximated as double walls consisting of two flexible shells covering the insulation material from both sides.

Both shells are connected through wooden beams, which are decoupled from one shell with a layer of mineral wool and acoustic decoupling wall plugs for the connecting screws.

Because of this complete decoupling, we will forego these connections for the following calculations. The effectivity of this construction is determined mainly by the resonance-frequency of the whole wall construction, which leads to a substantial drop of the sound reducing index in this specific frequency ([1] p. 270).

This can be avoided by shifting the resonance frequency to a very low frequency where noises are perceived

as considerably quieter ([1], p. 47).

The walls to the adjacents rooms are not all build in the same way. The focus of our acoustic calculations lays on the wall to the entree, since it is considerably thinner and less noise insulating than the other technical room walls.

The composition is:

Thickness d [m]	Material	Density [kg/m³]	Area density m' [kg/m²]
0.016	Fibre cement (Eternit)		20,8 [5]
0.05	Mineral wool		
0.02	Oriented strand board	600 [6]	12
0,02	Bamboo panels	700	14

With the dynamic stiffness of the mineral wool ([1], eqn. 5.71),

$$s' = \frac{10}{d_{mw}} \frac{MN}{m^3} = 2 \frac{MN}{m^3}$$

where

- d_{mw} thickness mineral wool [cm]

the resonance frequency can be calculated as ([1], eqn. 5.70):

$$f_{0\ m\,o} = 160 \sqrt{s' \left(\frac{1}{m_i'} + \frac{1}{m_o'} \right)} Hz = 66,56 Hz$$

considering

- m'_i area density inner shell (fibre cement)
- m'_o area density outer shell (oriented strand board and bamboo panels).

In an A-weighted sound pressure level, the noise from our technical installations room of 55 dB (see above) would equal 30 dB(A) at this frequency, even with a nonworking insulation nearly reaching the maximum recommended sound pressure level of 25 dB in the living room.

Above the resonance frequency, the sound insulation index rises by 12 dB/octave ([1] p. 271), thus providing sufficient sound insulation. At higher frequencies, further insulation decreasing resonance frequencies are found. These origin from the resonance frequencies of the shells. In our design, the shells have a differing area density and thereby differing resonance frequencies. This means that always just one of the shells has its sound-insulating properties diminished by resonances, hence the whole system still works ([2], p. 247).

The heat pump directly induces solid-bourne sound in the floor.

As for the walls, the main task is shifting the resonance frequency to a very low frequency.

This is achieved through a very low dynamic stiffness of the insulation material and a high mass lasting on it. The high mass is already given through the heat pump and the hot water storage tank, while the low dynamic stiffness is provided by a special rubber material[7].

The applying equation is ([1], p. 306; [1] eqn. 5.77):

$$f_0 = 160\sqrt{\frac{s'}{m'}}Hz = 33,72Hz$$

where

s' 15 MN/m³ [7]

$$m' = \frac{m_{floor} + m_{heatpump} + m_{storageunit}}{A_{floor}} = \frac{130kg + 665kg + 235kg}{3,05m^2} = 337,7\frac{kg}{m^2}$$

[5] [6] [7].

In building acoustics, a frequency of 50 Hz is commonly used as the lowest relevant frequency ([1], p. 16), which results in no negative influences through the resonance frequency in our design. Above the resonance frequency, the sound insulation index rises by 9 dB/octave ([1], eqn. 5.86).

This leads to sufficient sound insulation to suppress flanking transmission to other rooms and direct transmission to collective housing units.

We use doors with the German sound protection class 2, which demands a minimum sound reduction index of 37 dB. With the maximum sound pressure level of 55 dB inside tech technical installations room, the maximum sound pressure level that can be heard outside the technical installations room is 18 dB, and thereby substantially lower than the value of 25 dB demanded by the contest rules.

The existence of a mechanical ventilation system is a big acoustic advantage compared with traditional buildings, because it enables the supply with fresh air during the sleeping time without the need of an open window, which would lead to considerably higher noise levels.

All airstreams do not exceed 5 m/s, which is the maximum allowed in our ventilation system in order not to produce noticeable flow noises [4] .

The noise originating from the heat pump is lowered by silencers in the technical installations room. To absorb the noise which is induced in the air pipes behind the silencers by the sound level in the technical room, the ventilation outlets contain absorbing materials. Therefore, they work also as silencers.

All air pipes are acoustically decoupled from the inner wall of the technical room by a thin layer of rubber so that the structure-borne sound induced by the heat pump is not transmitted to the air pipes.

The ventilation will usually continue working through the night, for fresh air supply and eventually needed cooling or heating. In the following passage, the sound pressure level resulting from the ventilation in the sleeping room will be calculated.

If we assume the same sound intensity of the technical installation room in the air pipes, the sound power level in the air pipe before the ventilation outlet amounts to

$$L_P = 10\log\left(\frac{\left(10^{\frac{L_{tr}}{20}} \cdot p_0\right)^2}{\rho c} \cdot A_{ap}}{W_0}\right) = 34dB$$

where

- L_{tr} =55 dB; sound pressure level technical room
- A_{ap} =66 cm²; cross section area air pipes

([13], eqns. (2-11), (2-23),(2-33), (2-37), table 2-1).

For the absorbing properties of the sound absorbing ventilation outlets we assume a conservative value of 5 dB, since the producing company did not supply measured data. The resulting sound power level of the ventilation outlet is $L_{p,out}$=29 dB.

This leads to a maximum sound pressure level in the sleeping room of

$$L_{sl} = L_{P,out} - 10\log\left(\frac{A_{sl}}{m^2}\right) + 6dB = 24,75dB$$

([2], eqn. 7.25)

whith

- A_{sl} =10.6 m²; sound absorbing area of the sleeping room.

This complies with the maximum sound pressure level of 25 dB in the sleeping room, demanded in the contest rules.

Additionally, this is considerably quieter than the 39.5 dB which might result with an open window.

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ATTACHMENTS

	area [m²]	quantity	total area [m²]	absorption coefficient 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	equivalent sound absorption area [m²] 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
wooden floorboards		1	8,2	0,2	0,15	0,14	0,12	0,1	0,12	1,64	1,23	1,15	0,99	0,82	0,99
plastered ceiling		1	8,2	0,013	0,015	0,02	0,02	0,03	0,05	0,11	0,12	0,16	0,16	0,25	0,41
glass fassade (curtains closed)	4,5	0	0	0,1	0,04	0,03	0,02	0,02	0,02	0	0	0	0	0	0
plastered walls			11,9	0,02	0,02	0,03	0,04	0,05	0,05	0,24	0,24	0,36	0,48	0,59	0,59
openings above doors	0,05	2	0,1	1	1	1	1	1	1	0,1	0,1	0,1	0,1	0,1	0,1
plastered wooden beams	0,5	0	0	0,02	0,02	0,03	0,04	0,05	0,05	0	0	0	0	0	0
wooden doors		2	9,5	0,2	0,15	0,1	0,08	0,09	0,11	1,90	1,43	0,95	0,76	0,85	1,04
mirror	4,5	1	4,5	0,1	0,04	0,03	0,02	0,02	0,02	0,45	0,18	0,135	0,09	0,09	0,09
light curtains	4,5	1	4,5	0,1	0,15	0,2	0,3	0,4	0,5	0,45	0,67	0,9	1,35	1,8	2,25
Σ equivalent sound absorption area[m²]										4,89	3,97	3,76	3,93	4,51	5,48
T [s]										0,69	0,84	0,89	0,85	0,74	0,61
	volume [m³]	21	proportion konstant k					0,163		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz

Figure 54: **reverberation time extended bathroom [10] p.371**

	area [m²]	quantity	area [m²]	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
wooden floorboards		1	30,3	0,2	0,15	0,14	0,12	0,1	0,12	6,06	4,54	4,24	3,63	3,03	3,63
plastered ceiling		1	30,3	0,013	0,015	0,02	0,02	0,03	0,05	0,39	0,45	0,61	0,61	0,91	1,51
glass fassade	4,5	2	9	0,1	0,04	0,03	0,02	0,02	0,02	0,9	0,36	0,27	0,18	0,18	0,18
plastered walls			34,7	0,02	0,02	0,03	0,04	0,05	0,05	0,69	0,69	1,04	1,39	1,73	1,73
openings above doors	0,05	2	0,1	1	1	1	1	1	1	0,1	0,1	0,1	0,1	0,1	0,1
plastered wooden beams	0,5	8	4	0,02	0,02	0,03	0,04	0,05	0,05	0,08	0,08	0,12	0,16	0,2	0,2
wooden doors		5	10,5	0,2	0,15	0,1	0,08	0,09	0,11	2,10	1,57	1,05	0,84	0,94	1,15
upholstered furniture			1,5	0,5	0,6	0,8	0,8	0,8	0,7	0,75	0,9	1,2	1,2	1,2	1,05
light curtains	4,5	7	31,5	0,1	0,15	0,2	0,3	0,4	0,5	3,15	4,72	6,3	9,45	12,6	15,75
wooden wardrobe/ shelfs/table/ kitchen			10	0,2	0,15	0,1	0,08	0,09	0,11	2	1,5	1	0,8	0,9	1,1
Σ equivalent sound absorption area[m²]										16,22	14,93	15,92	18,36	21,79	26,41
T [s]										0,78	0,85	0,80	0,69	0,58	0,48

reverberation time and quivalent sound absorption area; living room **[10] p.371**

	area [m²]	quantity	total area [m²]	absorption coefficient 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	equivalent sound absorption area [m²] 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
wooden floorboards		1	13,8	0,2	0,15	0,14	0,12	0,1	0,12	2,75	2,07	1,93	1,65	1,38	1,65
plastered ceiling		1	13,8	0,013	0,015	0,02	0,02	0,03	0,05	0,18	0,21	0,28	0,28	0,41	0,69
glass fassade (curtains closed)	4,5	0	0	0,1	0,04	0,03	0,02	0,02	0,02	0	0	0	0	0	0
plastered walls			17,3	0,02	0,02	0,03	0,04	0,05	0,05	0,35	0,35	0,52	0,69	0,87	0,87
openings above doors	0,05	2	0,1	1	1	1	1	1	1	0,1	0,1	0,1	0,1	0,1	0,1
plastered wooden beams	0,5	4	2	0,02	0,02	0,03	0,04	0,05	0,05	0,04	0,04	0,06	0,08	0,1	0,1
wooden doors		2	4,9	0,2	0,15	0,1	0,08	0,09	0,11	0,97	0,73	0,49	0,39	0,44	0,53
bed			4	0,5	0,6	0,8	0,8	0,8	0,7	2	2,4	3,2	3,2	3,2	2,8
light curtains	4,5	4	18	0,1	0,15	0,2	0,3	0,4	0,5	1,8	2,70	3,6	5,4	7,2	9
wardrobe/ shelfs			4	0,2	0,15	0,1	0,08	0,09	0,11	0,8	0,6	0,4	0,32	0,36	0,44
Σ equivalent sound absorption area[m²]										8,99	9,19	10,57	12,11	14,05	16,18
T [s]										0,62	0,61	0,53	0,46	0,40	0,35
	volume [m³]	34	proportion konstant k					0,163		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz

Figure 55: **reverberation time sleeping room [10] p.371**

5.3. ENGINEERING AND CONSTRUCTION DESIGN NARRATIVE

Welcome to the royaume of numbers. In the pages that follow, our aspiring engineers outline the main technical aspects of our project. The report begins with the hands-on structural design which assures everything will stay in its place. We explain our construction process strategies and the thermal envelope. After our plumbing and water design we elaborate on the electrical and photovoltaic design. At the end of this narrative the Building Integrated Active Systems, including Solar Thermal Design, our cooling circuit and the movable façade, are explained.

5.3.1 STRUCTURAL DESIGN

INTRODUCTION

Our house follows a clear design. In this section we will point out which challenges arise from the chosen structure. For future reference we essentially define eight parts of the house:

- 1: Roof — including the ceiling and all installations on top of our house
- 2: Bracing walls — including the exterior walls to the west and east and the interior wall between kitchen and technical room
- 3: Façades and pillars — made up of two long sides to the south and north
- 4: Floor plates — all floor plates of the house
- 5: Core Module — the kitchen and the technical room which are shipped as one unit
- 6: Footings
- 7: Terrace — the space around our house, including grey water and flower banks
- 8: Surroundings — the mock-up elements of the Berlin Altbau: both Brandwände (fire walls) and the Treppenhaus (staircase)

The geometrically simple and appealing idea of a cube poses less of a structural challenge. It could be said, that solutions to support a roof on four walls can be found in most textbooks. We have found a straightforward solution that we will outline later on — which is not copied from a textbook.

A thoroughly thought through structure is one of our main central challenges as the construction capacities and the timeframe in Versailles are limited. We try to find sensible solutions to make our house easy to construct, deconstruct and reconstruct throughout all three assembly and disassembly phases: test in Berlin, competition in Versailles, long-term dwelling in Berlin. The goal was to find a system that facilitates very quick and efficient on-site construction, mainly through prefabrication of modules and intelligent connections of the different parts.

Apart from smart construction solutions we focus on our movable façade. While this is what makes the house aesthetically exceptional it is also structurally difficult. When opened to 90° it adds an additonal 1.50m by 1.75m that wind forces attack. The bearing of the arising loads from the movable façade is another main structural challenge of our house. We keep the future flexibility of our concept in mind, especially in terms of sustainability and market appeal. In order to comply with these goals we conceptually think about our house on top of a roof in Berlin, even though it will be built for the competition. In Versailles the loads would be lower – meaning, though, that our house would not safely stand where it should eventually be built. This is not what we understand as viable for practical purposes and thus our structural calculations are carried out for Rooftops in Berlin (as long as all requirements of a safe and proper construction in Versailles are met).

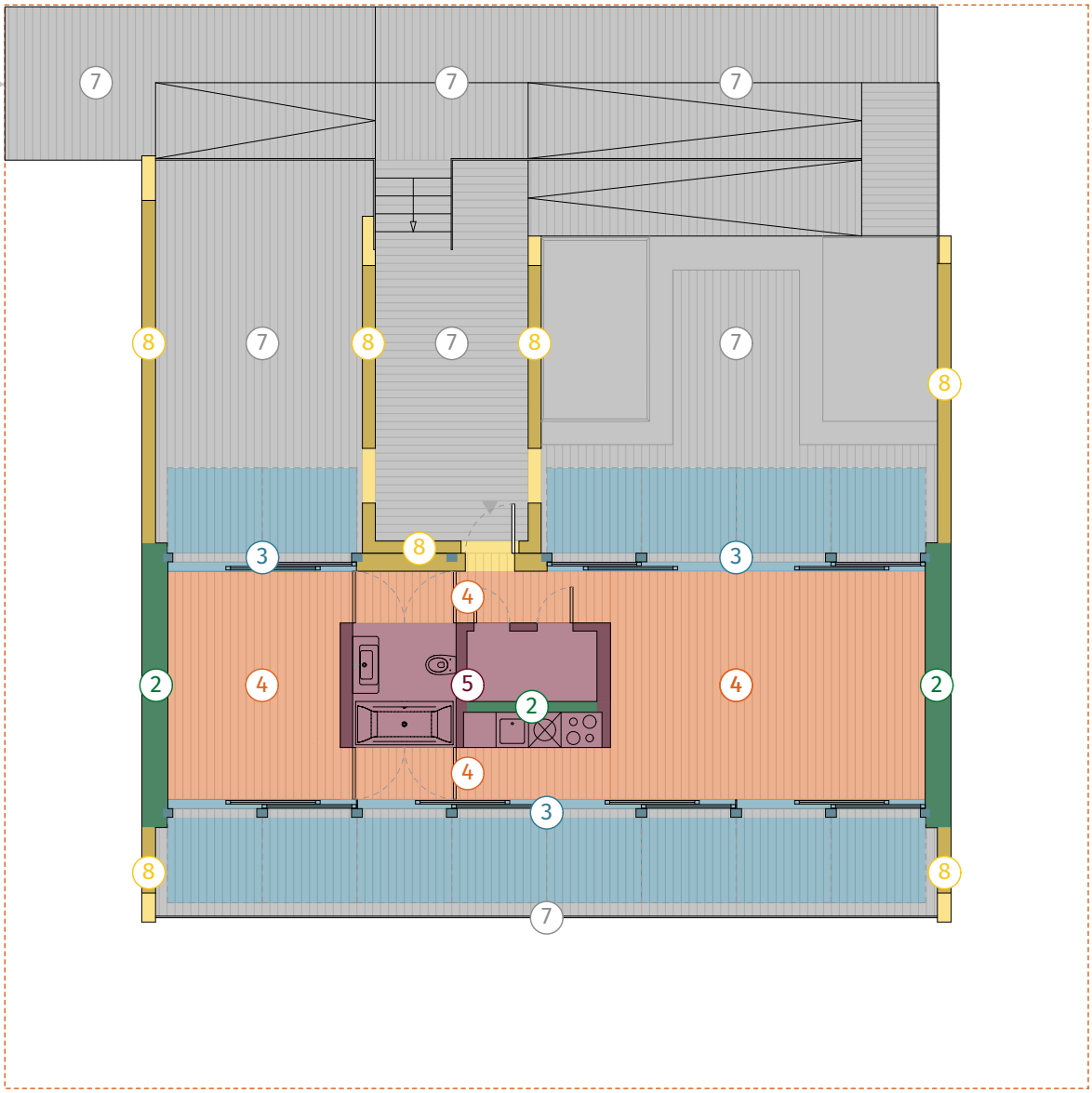


Figure 58: **structurally relevant parts**

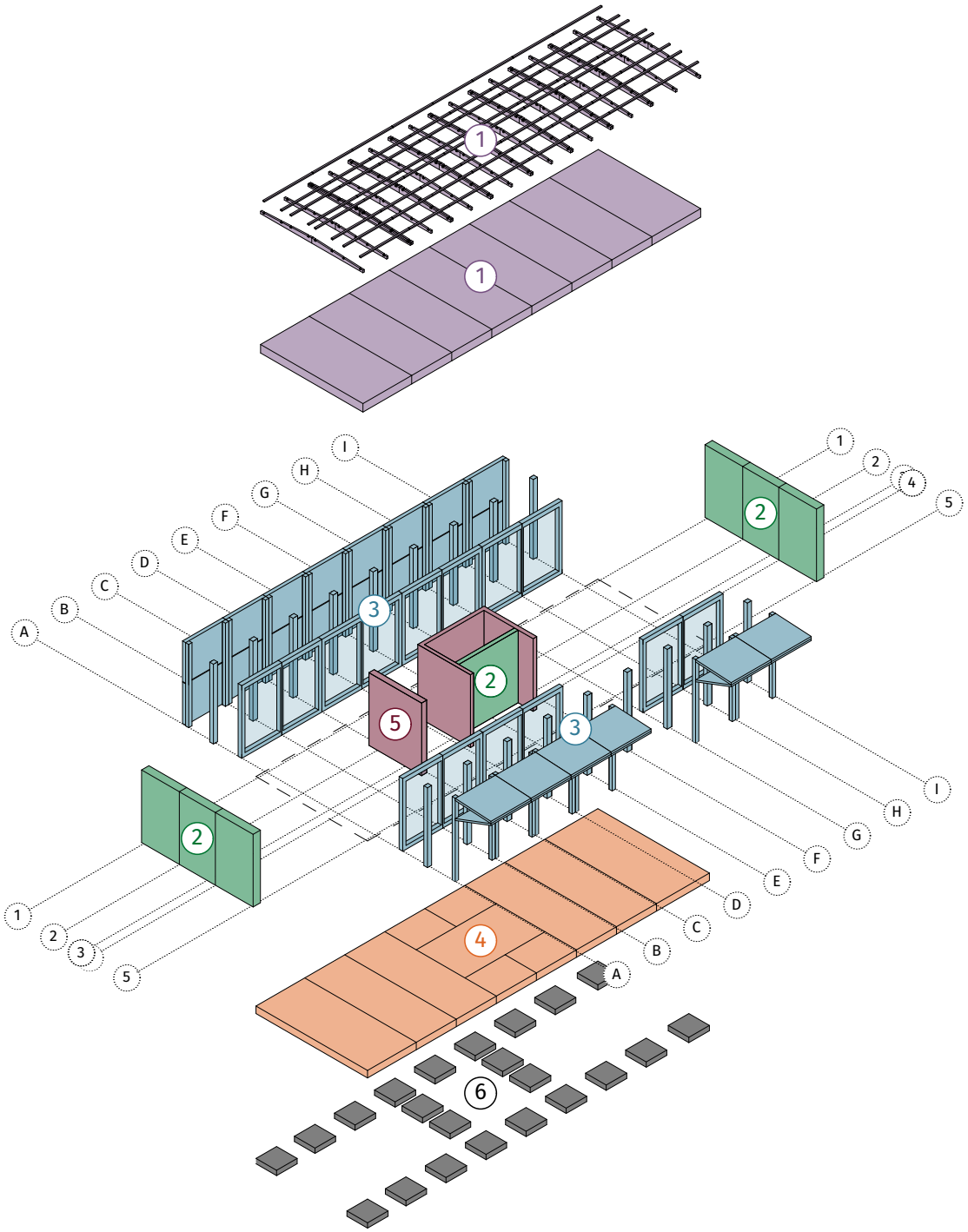


Figure 59: **Structural Blow up, indicating the parts used for calculation.**

When looking for materials we naturally checked their sustainability (more in Section 5.6.4) and, although as civil engineers we prefer to stay on the safe side, we look for innovative solutions, construction methods and materials (see section 5.5.2) .

LOADS

The calculations of the loads are to be found in Section 13 of this project manual. In order to understand these results we will outline a short synopsis of the main challenges.

Our house, whose components are mentioned in the particular constructive part, has to be able to bear its own weight. In addition, when relevant, the house has to be able to bear live loads like snow, wind suction, wind pressure and use loads.

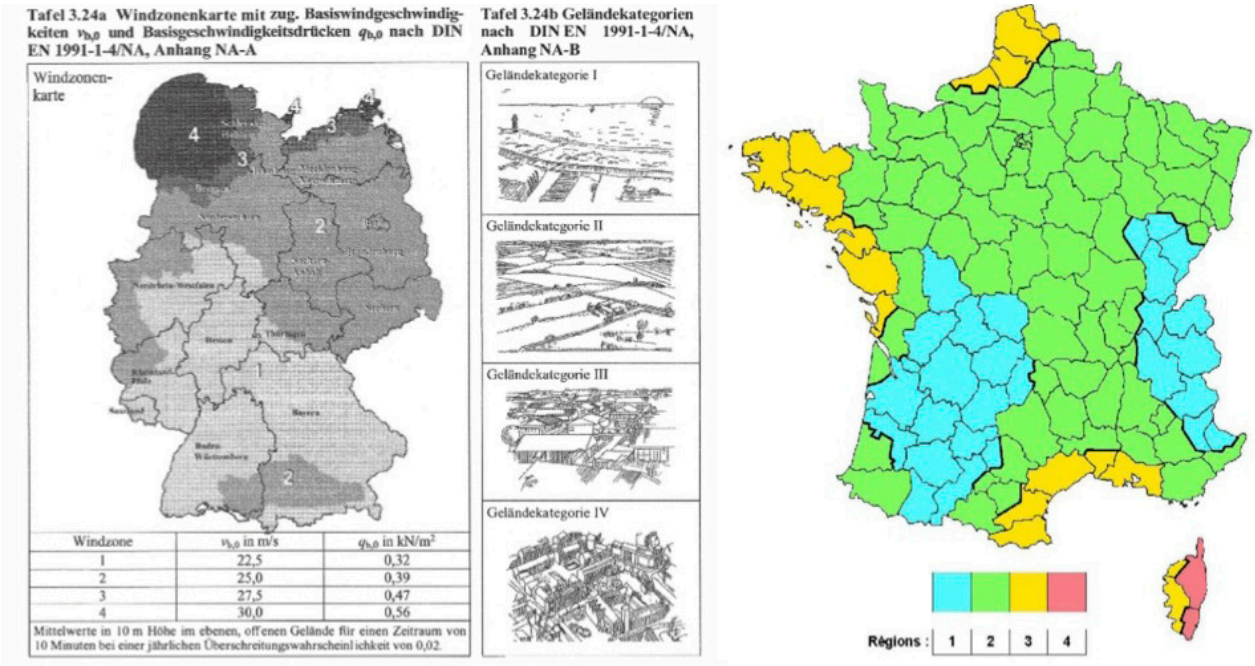


Figure 56: **Wind zones in Germany and France**

A word on the difference between Berlin and Versailles: while the weight of the house remains unchanged, the live loads differ. According to Eurocode's national appendices the characteristic snow load on the ground in Versailles (EN1991-1-3 NA:2009, région de neige A1[1]) is 0.45 kN/sqm whilst it is 0.85 kN/sqm (see section 13) on the roof in Berlin. The loads in Berlin are thus the normative case: we might over-design for Versailles but want our house to eventually stand safely in Berlin. As far as wind loads are concerned, Berlin[2] and Versailles[3] are in the same wind zones respectively (see Figure 56). The loads are slightly higher in the German national appendixes – the construction in Versailles is safe if the house is designed for Berlin. In terms of use loads there obviously are no differences between Berlin and Versailles.

1 http://www.icab.fr/guide/eurocode/en1991-1-3/ (2013-06-22)
2 Alfons Goris (ed.): Schneider Bautabellen, 20. Auflage, Werner Verlag, Köln, 2012 (page 3.24)
3 http://www.icab.fr/guide/eurocode/en1991-1-4/index.htm (2013-06-22)

Concept

We propose a clear design that is easy to construct and physically sound. Our bearing system subsists of a beam-purlin-roof that introduces its forces into the pillars, nine on each side of the house. The walls on the short side do not take any of the roof's vertical loads, but are only responsible for taking horizontal bracing loads. The façade‘s horizontal and vertical loads are also carried by the pillars. The floor takes the loads from the inner house, the floor construction is connected to the pillars sidewise for horizontal forces and otherwise rests on the foundations. Particular attention is paid to the bracing concept which is outlined below: wind loads from the longer side are taken by the walls, wind loads from the short side are taken by one braced wall in the core module.

The mainly wooden bearing system is located in the same layer as the main insulation. This concept allows for easier construction (see section 5.3.2) as we can first construct the entire bearing structure and then add all other installations. Challenges, such as the smart and efficient connection between the two outer walls, the sliding doors, the inner core module with the bearing structure, are met with innovative and sustainable connections. In the following section we outline which loads this static system has to be designed for and what dimensions result for each particular part of the bearing structure.

1: Roof

The critical loads for the roof construction result from own weight, snow and wind. Considering the dimensions of the roof (15 m by 4.50 m) and the fact that vertical pillars will be placed to carry the resulting loads to the foundations, we decided to place two horizontal beams across the short side of the house (4.50 m) every 1.75 m. That is where two opposing pillars are situated. The width between the axes is 1.75 m. In total we have nine beans every 1.75 m. On each edge an exterior wall with a thickness of 40 cm is built – thus 8 times 1.75 m plus 0.40 m on each end make a total length of 14.80 m for the house.

Across these main support purlins a lathing runs across the long side of the house, ten in total. Additionally, on the long side of the house we connect the pillars by bridging the 1.75 m space between a pair with another beam. The pillars rise all the way to the top of the roof because an element of the opening façade has to be fixed on top of them.

In order to facilitate the assembly process ,the roof comes in ten modules : six middle ones that are 1.75 m long, and the end pieces with a length of 2.15 m.

2: Bracing walls

The exterior walls on the north and south side are essential to the bracing concept. They carry their own weight but are not responsible for carrying any vertical loads from the roof. The bracing loads are taken by one OSB plank on the inner side of the wood frame.

The wall between kitchen and technical room is used for the bracing concept, bracing the house from wind loads in north-south-direction (long side of the house) by using two OSB boards on each side to which the forces are transported over the floor and across the roof.

3: Façade

For the opening panels on the long side of the house we looked at several mechanisms to open and close

the panels that comply with structural and mechanical requirements. The design has been finalised with a specialised manufacturer called 'BeLuTec'. For an example of their work please s (see Figure 57).

Each of the 14 movable modules has two parts: the upper part equipped with solar panels and the lower part with a wooden shuttering. The structural frame is made out of steel, which is necessary due to the small tolerances of the precise mechanics.



Figure 57: **Rooftop House in Versailles, Facade built by BeLuTec.**

The dimensions of each module are: 1.75 m wide and 3.15 m high with a depth of 84 mm for the upper panel and 72 mm for the lower. The lower end (0.00 m high) moves freely on a railing, while the upper end (3.15 m) is firmly fixed to a shaft which induces the upward/downward motion. The two panels are connected by a hinge in the middle.

Another important detail about our calculation is the decision of not including snow loads into the design of the façade frames. After consulting Professor Geißler of Fachgebiet Stahlbau, Technische Universität Berlin[4], we assumed that the panels will be closed in case of falling snow. In fact, this is only sensible: if there is a snowstorm, the sun is most likely not shining and the photovoltaic receptors are covered anyway.

For the wind load, we noted that the façade corresponds to a projecting roof (canopy) and not a free-standing roof. This is because windows and doors do not count as open. As the panels are not to be opened constantly, we assume their's is a "transitional state". Thus, according to DIN EN 1991-1-4/NA, NA-BB, the

4 Chair for structural steel engineering, Technical University of Berlin [own translation]

peak velocity pressure can be reduced by half as the state will not last more than 3 days (they will be closed in case of extraordinary storms) and as we have no additional security. The pillars are mainly restricted not by critical loads introduced by the roof and the façade, but rather by the connection with the opening façade and the deformation tolerances of the same. When choosing a pillar we might over-design for the loads introduced into it. However, deformations have to be carefully considered. The deformations occur naturally within the wood and may cause the mechanical design of the façade to fail. Thus, it is better to choose a profile that is not utilized to capacity but will not deform beyond repair.

The enclosing rooms are a straightforward construction entirely sheltered from outside forces. There are no special structural elements incorporated in it. We decided against using the windows on the façade for structural support because this will add an additional layer of complexity to the calculations. Additionally, it cannot be guaranteed that assumptions we make about their structural capacity are met in the final construction.

4: Floor plates

The floor is designed to take the dead loads and use loads from the interior house, i.e. the loads of the core module and the enclosing rooms. As a commercial solution will be used, it will withstand these forces with ease. We will precisely check this again.

We will connect the structural parts of the floor, beams, to the pillars in order to translate bracing forces. How the floor is used in the bracing system is outlined below.

5: Core Module

The core module is a straightforward construction entirely sheltered from outside forces. No special structural elements are incorporated in it, except for the one short bracing wall between kitchen and technical room.

6: Footings

Our proposal is to build the Rooftop Unit on top of an existing house "Altbau" in Berlin. As pointed out, this fact is taken into account for all structural calculations. We present a house in Versailles that could be built on top of an Berliner "Altbau". At the moment where this implementation becomes realistic a crucial challenge arises: for the competition we calculate with foundations that can take loads of 50 kN/m^2. In case of a construction on top of an existing building the foundations will look entirely different – there is probably no homogenous flooring but rather a couple of bearing walls whose locations differ — if only slightly from house to house. In this case, we would look at the building on top of which we will build, and design an underlying structure which may consist of additional beams. This structure will be able to take forces from the pillar footings to the existing bearing structure of the house. This way our design can stay untouched and as easy to build as in Versailles once the necessary underlying structure is provided.

7: Terrace

The terrace is made up of modules that can be carried by hand, allowing for easy construction. In terms of structural concept, we use wooden plankings on top of wooden counter-beams which are supported by light and recycable plastic footings. The railing on each side of the terrace is necessary as our floor will be more

than 40cm high and comes in handy because we want visitors to feel on top of a roof.

8: Surroundings

By surroundings we mean the Berlin Altbau mock-up buildings that abstractely represent the existing building. There is the staircase, our Treppenhaus, in which the accessibility ramp and small staircase arrive. Another part of the sourroundings is the ramp, which consists of the same material as the terrace. The Treppenhaus and both walls on the sides ('Brandwände') are made up of wooden frames planked with OSB on both sides, a very simple construction.

CONNECTIONS AND DETAILS

A crucial challenge for us is the designing and dimensioning of the connections between the different structural parts of the house. There are connections between:

- roof – pillar
- façade – pillar
- pillar – foundations
- floor – pillar
- floor – foundations
- massive walls – roof – floor
- core module wall – roof – floor

The pillar is the central bearing element of our structure that connects roof (1), façade (3), floor (4) and foundations (6); while the bracing walls (2) are connected to roof and floor.

The detailed constructive solutions can be found under Section 13.

It can generally be said that we keep in mind simple construction methods and modularity while designing the connections. We have found connections that work well and bear the necessary loads. Our goal is to look for space-saving connection methods that decrease the need for material and waste.

MODULARITY

We try to integrate structural elements as efficiently as possible with the rest of the construction. A huge challenge when building a house, is that, unlike machinery, it cannot be simply be fabricated in a factory but is constructed where it will stand for most of its lifetime: the open, prey to changing weather conditions. This results not only in deterioration during the lifecycle (as with all goods but also poses difficulties for the engineers and designers during the construction phase.

We aim to avoid these challenges using a system of modular elements, 1.75 meters wide and 4.50 meters long – eight of them on the roof, on the floor. The core module will be designed as an integral closed part that can be transported apart from others so that it would fit in any house similar to the Rooftop Unit. This modularity will allow for a quick and easy and reproducible construction method.

Smaller modules are easier to pre-fabricate, this in turn will allow us to do the hard work in Berlin and ease transportation challenges. As economies of scale apply to prefabricated elements, we are confident that a smart fabrication method will increase the chances of future implementations. Maybe one day we will see a couple of Rooftop Units on top of buildings all over the world.

5.3.2 CONSTRUCTIVE DESIGN

Motivation & Requirements for Material Selections

Houses such as our rofotop building ,that are conceived to be inhabited, must create a comofortable ambience. While technical building systems can help meet comfort criteria, such technology is also prone to errors, produces a steady power consumption, requires space and causes noise. The thermal envelope on the other side is able to reduce the power consumption to a minimum by passively controlling energy and mass flows to and from the environment.

Comfort conditions include temperature, humidity, air quality, natural light and sound levels (rule 19 contest 5). This translates to certain requirements for the thermal envelope:

- In summer, during the day, thermal energy should not be able to enter the building. Meanwhile,in the evenings, the thermal enery should be able to leave the building
- Analogue requirements apply to the glass façade. Additionally as much visible light as possible should be gathered. In summer radiation energy from the sun should not enter the building, in winter it should serve as additional heat source
- Components bordering the interior should be able to absorb and release moisture as this prevents uncomfortable humidity levels
- Furthermore, the absorption of sound should be high in order to achieve pleasant noise levels. In addition, due to thermal duties, the walls serve as a barrier for undesirable noise from the outside
- For safety reasons various measures to prevent harm and damages from fires have to be included
- Moreover, every element has to be designed to create conditions for building technologies like underfloor heating, ventilation, electrical installations etc.

Construction - Floor

The largest amount of material on the floor is wood. This is to achive as sustainable a construction as possibe. The other materials are the plasterboard layer and the screed layer. The plasterboard layer is necessary to meet the fire protection requirements. The screed layer is required to install the underfloor heating correctly and to distribute the heating energy uniformly.

The lightweight construction is essential for the planned modular design as the building will be re-constructed thrice. Because of this, wooden beams as carrying structure show to be more suitable than heavier constructions like concrete floors. As a comparison: wooden beams combined with a cellulose insulation board have a mass per area of 21,8 kg/m² and concrete 480 kg/m².

To achieve the requirements of a modular design, the installation system of the underfloor heating consists of dry systems, which can be installed, uninstalled and reinstalled without great afford. To achieve the requirements of modular design, the installation system of the underfloor heating consists of several dry systems. These systems can be removed and re-installed numerous times without much effort. umm i may have got it wrong with the numerout times bit. The underfloor heating pipes will be installed into expanded polystyrene lay plates (uponor siccus). For the specific pipe routing, cavities are milled into the lay plates. The tubing is constructed as a metal layer composite pipe, because it is flexible and resistant to corrosion.

As heat distributing layer screed will be used. Because the casting and the drying process of normal screed takes ten days at a minimum, it has been decided to use dry screed panels.

The composition of the floor can be seen in Figure 60, dimension details in Table 12. The specific values of each layer are given in .

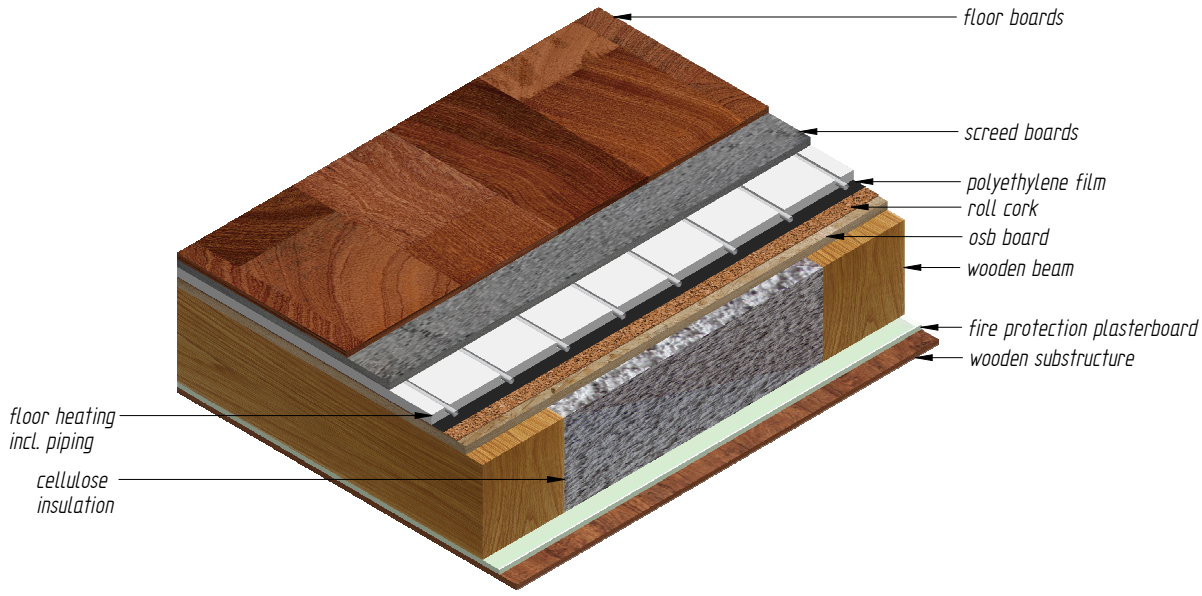


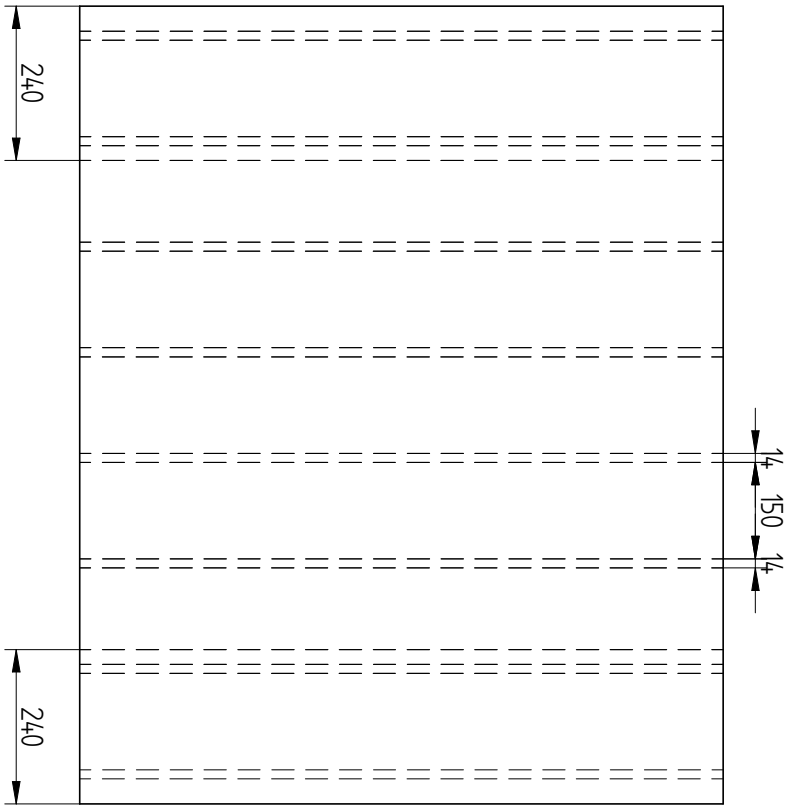
Figure 60: **floor construction**

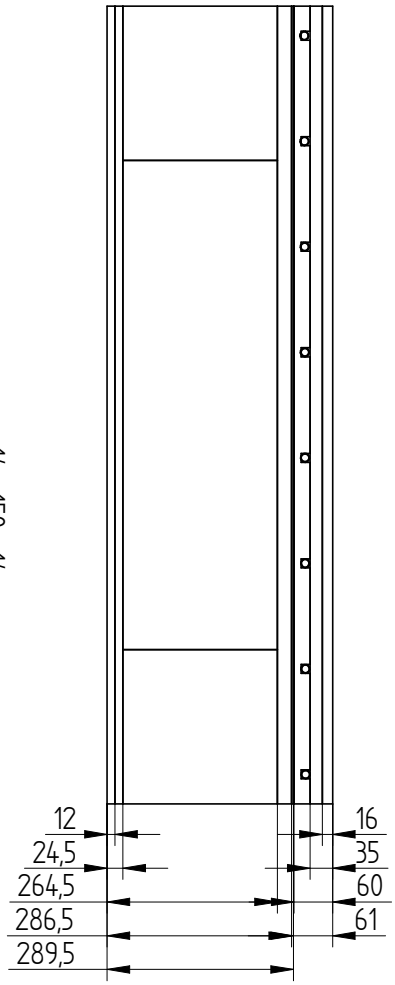
nr	material	thickness d	density ρ	thermal conductivity λ	heat capacity c_p
		mm	kg/m³	W/(mK)	J/(kgK)
1	floor boards, or corc, or acoustic insulation board (rubber)	16 3 17	500 140 600	0130 0,500 0,160	1600 2200 1600
2	dry screed panels	19	1300	0,400	1000
3	expanded polystyrene lay plate incl. underfloor heating pipes	25	938	0,035	550
4	polyethylene film	1	1900	0,400	930
5	roll corc	3	140	0,400	2200
6	OSB board	22	620	0,130	2100
7	cellulose construction wood	240 240	65 460	0,040 0,130	2100 1600
8	fire protection plasterboard	12,5	1400	0,250	1000
9	wooden substructure	12	460	0,130	1600
total					
	floor boards	350,5		0,134	
	cork	337,5		0,135	
	acoustic ins. boards	351,5		0,135	

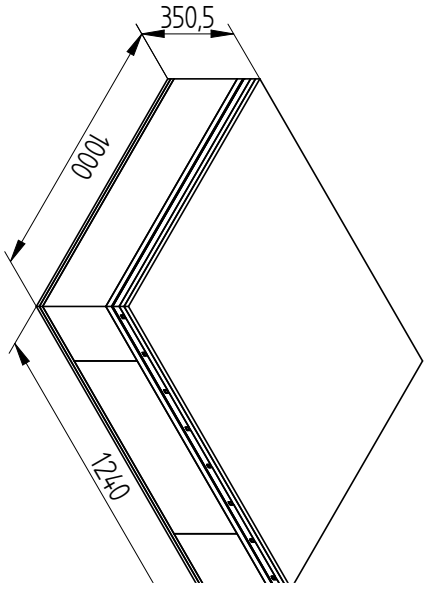
Table 12: **material dimensions of the floor, incl. three types of floor boards (wood, corc, rubber)**

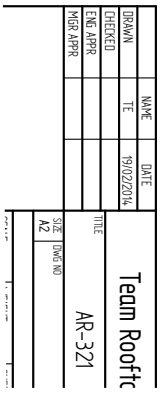
The layer on top of the structure varies in the different areas of use inside the house. For the upper layer of the living room, sleeping room, hallway and kitchen, floor boards will be used. Inside the technical room the upper layer is created with acoustic insulating boards consisting mainly of rubber based material. The floor of the bathroom will be sealed with a cork layer.

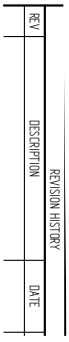
The thermal transmittance of the floor can be therefore calculated three times, using the method described in EnEV2014. As a result, the value is calculated to U=0,134 W/(m²K) for timber boards and for acoustic insulation as well as for cork panels to U=0,135 W/(m²K). Thus, the requirement of German law EnEV2014, which sets a maximum value of U=0,350 W/(m²K) for floors and ceilings adjoining not heated rooms, is easily met [EnEV2014, appendix]. Furthermore, this complies with the requirements to reach the passive house standard value which is determined between 0,10 and 0,15 W/(m²K).











sectional view, floor

Floor Realization in Versailles

The realization of the floor for the competition in Versailles will be different from the planned execution in Berlin. This is because of the foundation differences on top of the host building in Versailles. It is planned to install the house on an existing floor ceiling or an existing flat roof. In this plan, the fire protection can be provided by a fire protection plasterboard. In Versailles, as the house is placed on foundation squares, the use of plasterboard and a wooden substructure using wooden battens is not possible. Therefore, the lowest layer is another osb board. The thermal transmittance of the floor in Versailles does not differ from the planned floor in Berlin.

The floor construction in Versailles is as follows:

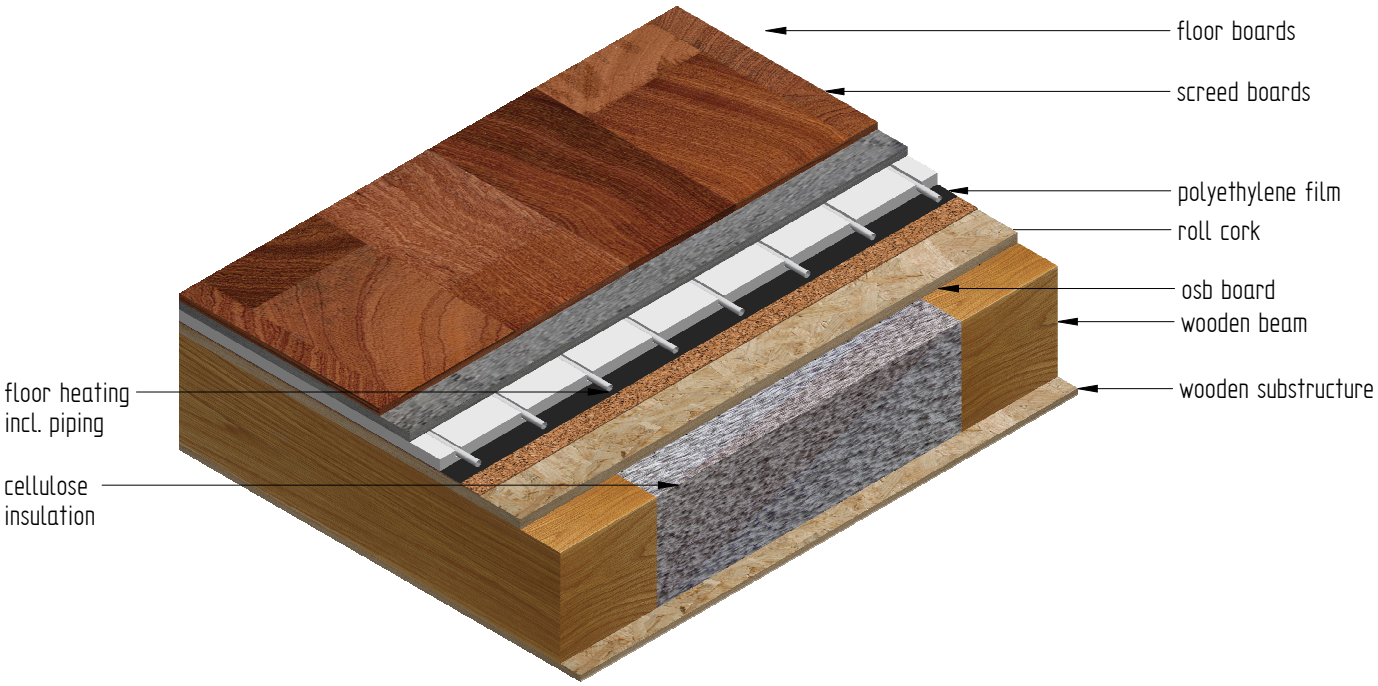


Figure 61: **floor construction in Versailles**

The following table shows the changes in the layer structure:

nr	material	thickness d	density ρ	thermal conductivity λ	heat capacity c_p
		mm	kg/m³	W/(mK)	J/(kgK)
1	floor boards, or	16	500	0130	1600
	corc, or	3	140	0,500	2200
	acoustic insulation board (rubber)	17	600	0,160	1600
2	dry screed panels	19	1300	0,400	1000
3	expanded polystyrene lay plate incl. underfloor heating pipes	25	938	0,035	550
4	polyethylene film	1	1900	0,400	930
5	roll corc	3	140	0,400	2200
6	OSB board	22	620	0,130	2100
7	cellulose	240	65	0,040	2100
	construction wood	240	460	0,130	1600
8	OSB board	22	620	0,130	2100
total					
	floor boards	348		0,134	
	cork	335		0,135	
	acoustic ins. boards	349		0,134	

Table 13: **material dimensions of the floor in Versailles, incl. three types of floor boards (wood, corc, rubber)**

Construction – Ventilated Flat Roof

The roof is planned as a flat roof as this is the most space efficient solution. The carrying structure of the roof subsists of wooden beams. With wooden beams, the risk of introducing a heat bridge is very low, insulation between the beams is space saving and sufficient.

As a lightweight building, the house is lacking thermal mass to slow down the temperature rise when the sun is heating up the large roof area. Two measures are considered in the roof design to reduce the heat load in summer and therefore cut down the amount of cooling energy demand needed to improve comfort.

Common flat roofs conduct the heat caused by the radiation energy from the sun directly into the building with insulation slowing down the heat flow. The first provided concept improves this heat protection by integrating a ventilated layer. This design element dissipates an immense part of the radiation energy before it reaches inner layer of the roof. An air stream, positioned directly underneath the heated surface, is able to take away a great part of this energy flow and releases it to the building surrounding air. As shown below (see Figure 62), the principle air flow inside the ventilated flat roof.

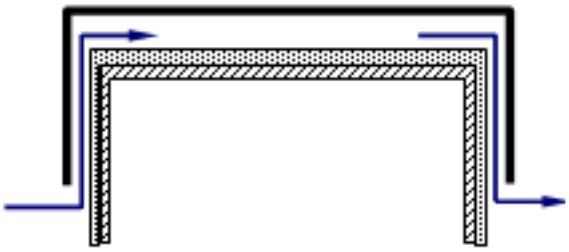


Figure 62: **flow principle of the ventilated Roof [PW-Internet]**

This concept intents to slow down the outer heat flow of summer day amplitudes and preventing it from reaching the inside of the building before being cooled down by the night air. Therefore, this requirements only can be achieved by choosing the optimal insulation. Renewable insulation elements commonly have the ability to store the energy more effectively than petrochemical insulation materials while maintaining a high resistance to heat flows. Hence, the chosen insulation material is cellulose. The positive results of this decision can be observed in Figure 62. Before the temperature rise can reach layers beneath, the roof is cooled down at night.

The composition of the roof can be seen in the three dimensional image (see Figure 63), dimension details in the sectional view (see Figure 64). The specific values of each layer are given in Table 14.

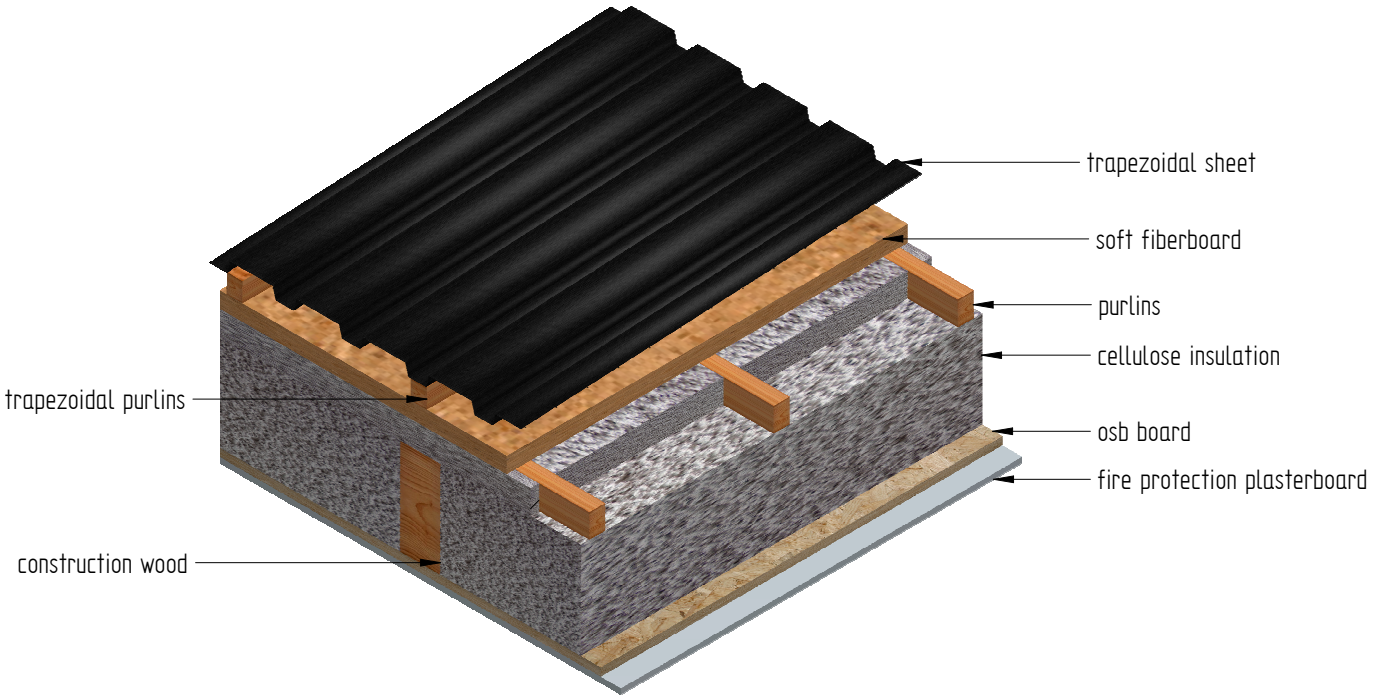


Figure 63: **construction of ventilated roof**

nr	material	thickness d	density ρ	thermal conductivity λ	heat capacity c_p
		mm	kg/m³	W/(mK)	J/(kgK)
1	fire protection plasterboard	12,5	1400	0,250	1000
2	osb board	20	620	0,130	2100
3	cellulose insulation	240	65	0,040	2100
3	construction wood	240	450	0,130	1600
4	cellulose insulation	60	65	0,040	2100
4	purlins	60	450	0,130	1600
5	soft fibreboard	40	300	0,038	1,0526
6	trapezoidal purlins	40 to 100	345	0,500	2000
6	ventilation		-	-	-
7	trapezoidal sheet	0,5	1050	0,130	1000
total					
		373 to 433		0,112	

Table 14: **material dimensions roof**

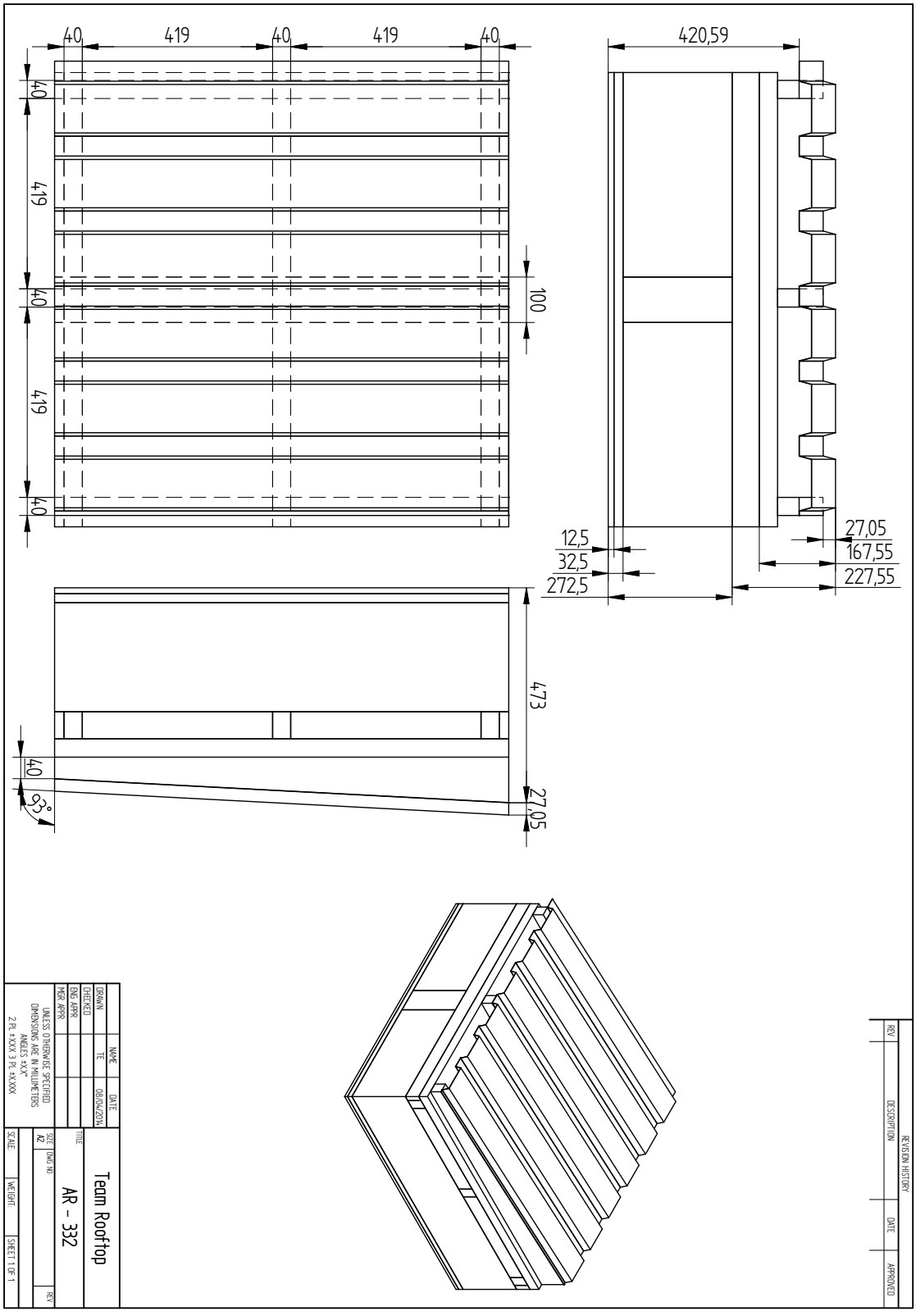


Figure 64: **sectional view of ventilated roof**

Construction - Solid Walls (E/W)

Due to sustainability and light-weight requirements the construction of the solid walls has to be well insulated to reduce heating demand. A high percentage of renewable and recyclable raw materials is also required. Furthermore, a stable design has to be guaranteed and superfluous costs have to be avoided.

As described before, wood is the optimal material that meets all of these requirements. Except the fire protection plasterboard, the PCM plates and the fixing materials such as screws, all chosen materials for the construction of the solid walls are based on wood.

The composition of the solid walls (see Figure 65), dimension details in the sectional view (see Figure 66) and the specific values of each layer are given in Table 15.

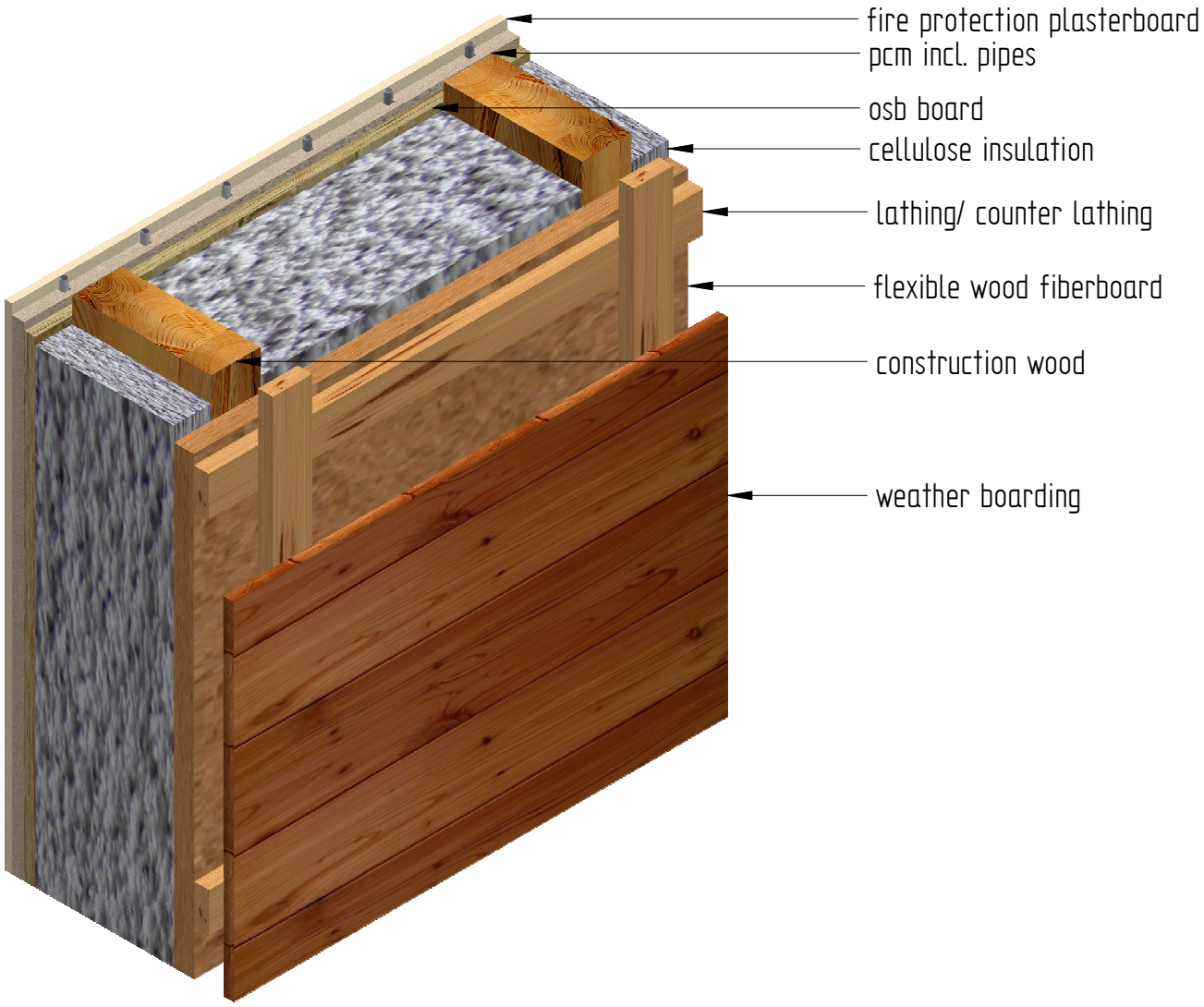


Figure 65: **construction of the solid walls (e/w)**

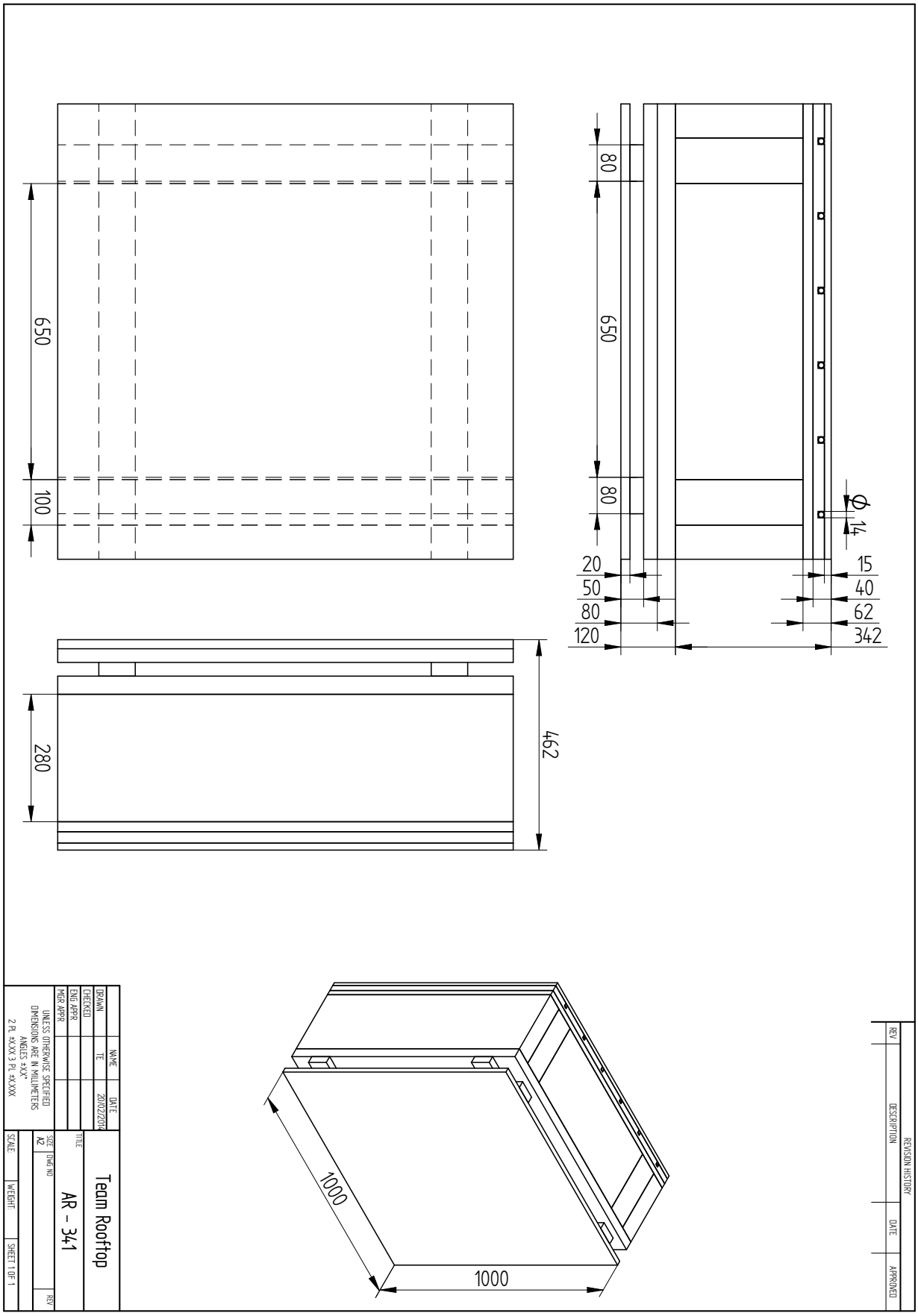


Figure 66: **sectional view of the solid wall (e/w)**

nr	material	thickness d	density ρ	thermal conductivity λ	heat capacity c_p
		mm	kg/m³	W/(mK)	J/(kgK)
1	fire protection plasterboard	12,5	1400	0,250	1000
2	active pcm boards (incl. aluminum pipes)	25	110	0,039	2100
3	osb board	22	620	0,13	2100
4	cellulose insulation panel	280	50	0,040	2100
4	construction wood	280	460	0,130	1600
5	soft fibreboard	18	140	0,042	2100
6	ventilation layer	60	1,2	0,026	1,01
6	lathing	30	520	0,13	1600
6	counter lathing	30	520	0,13	1600
7	osb board	22	620	0,13	2100
total					
		437,5		0,126	

Table 15: **material dimensions of the solid wall (e/w)**

As the table shows, the thermal transmittance of the solid walls can be calculated to U=0,126W/(m²K) and therefore meets the requirements of EnEV2014 which sets the maximum value U=0,28W/(m²K) for exterior walls. [appendix 1 of EnEV2014,]

Construction Ventilation Layer

According to DIN 1856-1 part 4.2.3 the minimum size of air inlet and outlet on the bottom and the top of the walls has to amount to 50cm²=0,5dm² per meter wall length. The designed wall thickness amounts to 60mm. The size of the air inlet and outlet per meter length of wall can be calculated as below:

$$A_{bottom} + A_{top} = 1000mm \cdot 60mm \cdot 2 = 12dm^2 > 0{,}5dm^2$$

The ventilation principle inside the façade can be seen below (see Figure 67) (see Figure 68).

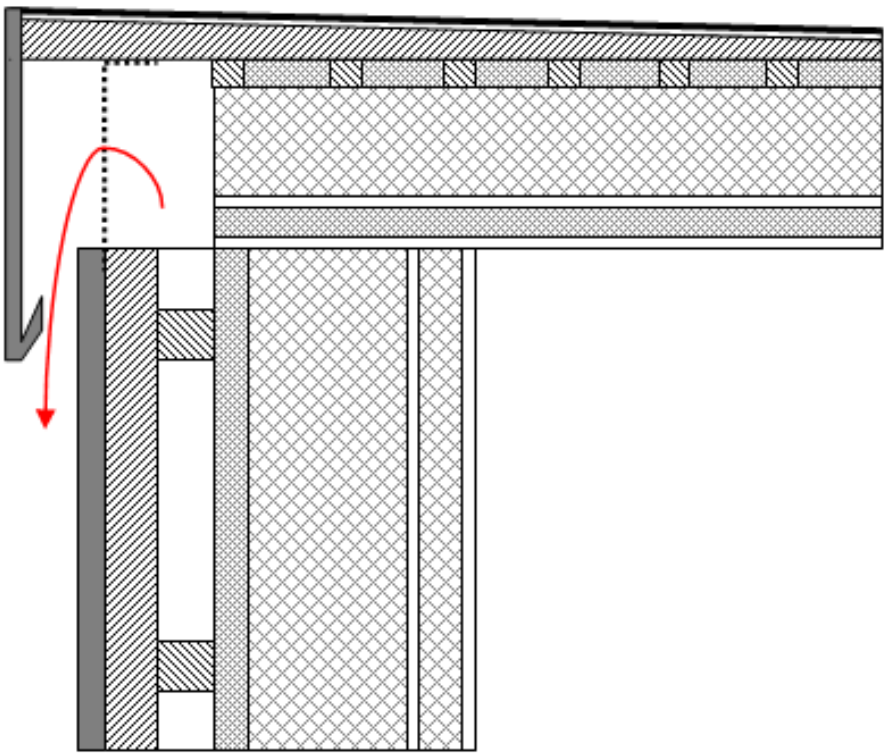


Figure 67: **roof connection, according to [ÖFHF 2011]**

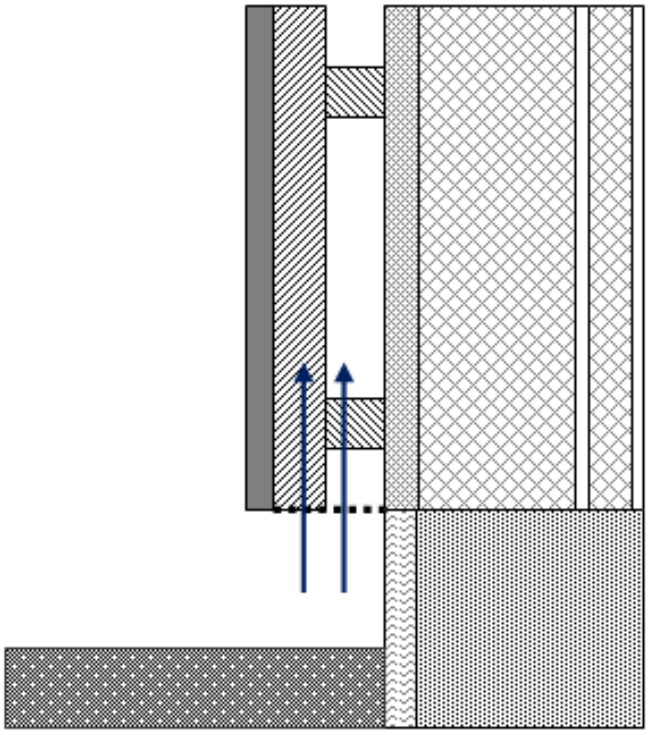


Figure 68: **ground connection, according to [ÖFHF 2011]**

Construction - Wall to Staircase

In compliance with the composition of the solid walls on the west and east side of the house, the wall to stairwell is structured mainly with wooden beams and cellulose insulation boards. As the new build wall on the north side of the house will be build on the existing wall of the existing staircase of the building below, this wall will only be planned as an additional insulation to guarantee and support the thermal balance of the whole Rooftop House.

The composition of the wall to the stairwell (without door) can be seen in the table below (see Table 16).

nr	material	thickness d	density ρ	thermal conductivity λ	heat capacity c_p
		mm	kg/m³	W/(mK)	J/(kgK)
1	fire protection plasterboard	12,5	1400	0,250	1000
2	soft fibreboard	20	140	0,042	2100
5	cellulose insulation board	280	50	0,038	2100
5	construction wood	280	460	0,13	1600
total					
		312,5		0,129	

Table 16: **material dimensions of the wall to the staircase**

The calculated thermal transmittance shows a value of U=0,129W/(m²K), which meets the EnEV 2014 requirements of a maximum value of U=0,348W/(m²K) for walls adjoining to not heated rooms. [appendix 1 of EnEV 2014]

Construction - Glass Façade (n/s)

Basically the glass façade system consists of fixed glazing in aluminum profile frames and sliding glazing on aluminum rails. The variable elements open the building to the environment and enable the inhabitants to step out on the terrace. Additionally, to guarantee accessibility, the rails will be realized at ground level.

The following table shows the dimensions of the selected glazing (see Table 17).

nr	material	thickness [mm]	thermal conductivity [W/m²K]
1	float glass	6	0,800
2	argon	16	0,018
3	float glass	4	0,800
4	argon	16	0,018
5	float glass	6	0,800
6	aluminum profile frame	160	1,500
total		**48/160**	**1,1**

Table 17: **material dimensions of selected glazing**

The figures below show the principle of the chosen aluminum lift-sliding system Schüco ASS 70.HI (see Figure 69). All figures shown below are given by the producer and include a doubble glazing. In contrast, it has to be recognized that the executed glazing will include triple glazing.

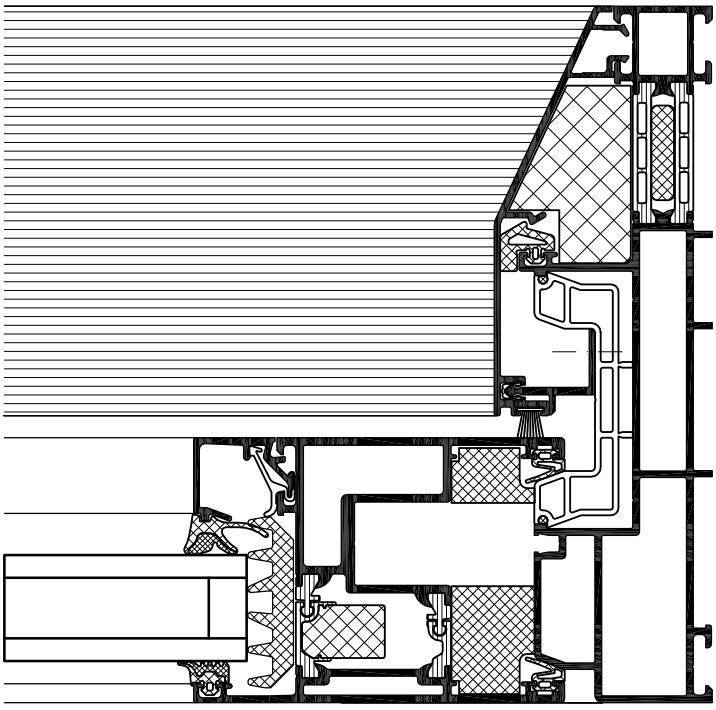


Figure 69: **lateral intersection, product: Schüco ASS 70.HI [SCHÜCO 2011]**

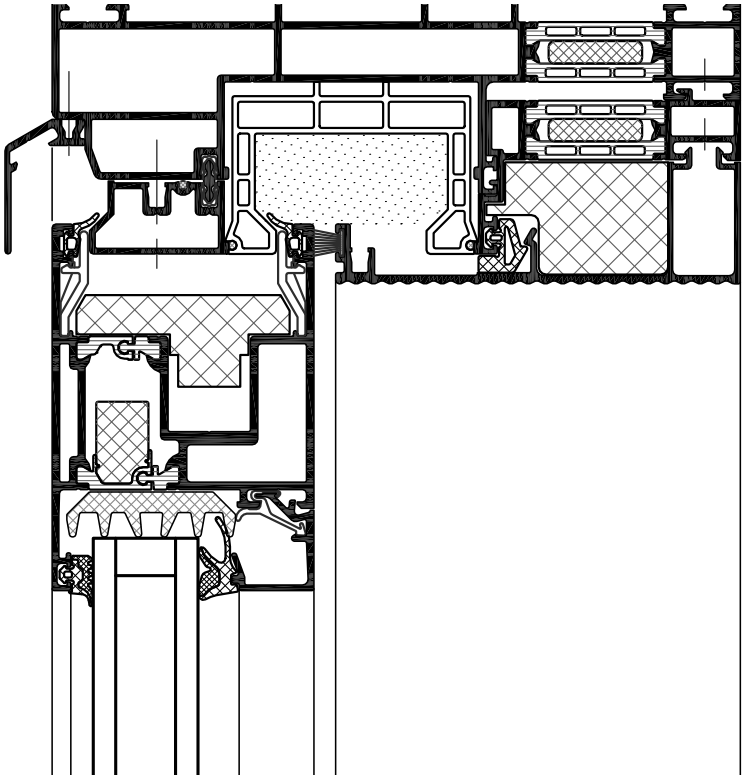


Figure 70: **upper intersection, product: Schüco ASS 70.HI [SCHÜCO 2011]**

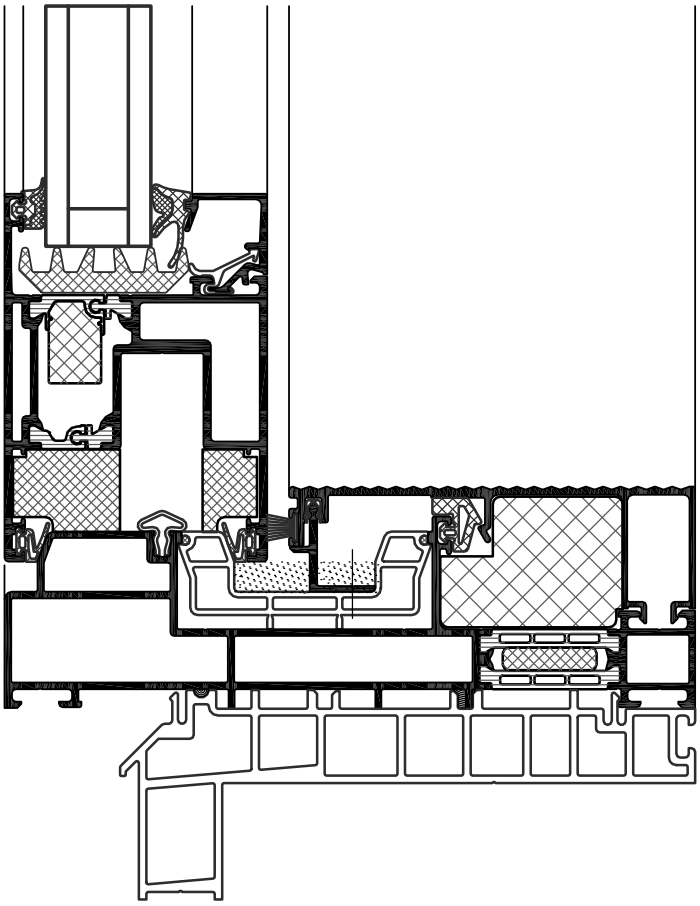


Figure 71: **upper intersection, product: Schüco ASS 70.HI [SCHÜCO 2011]**

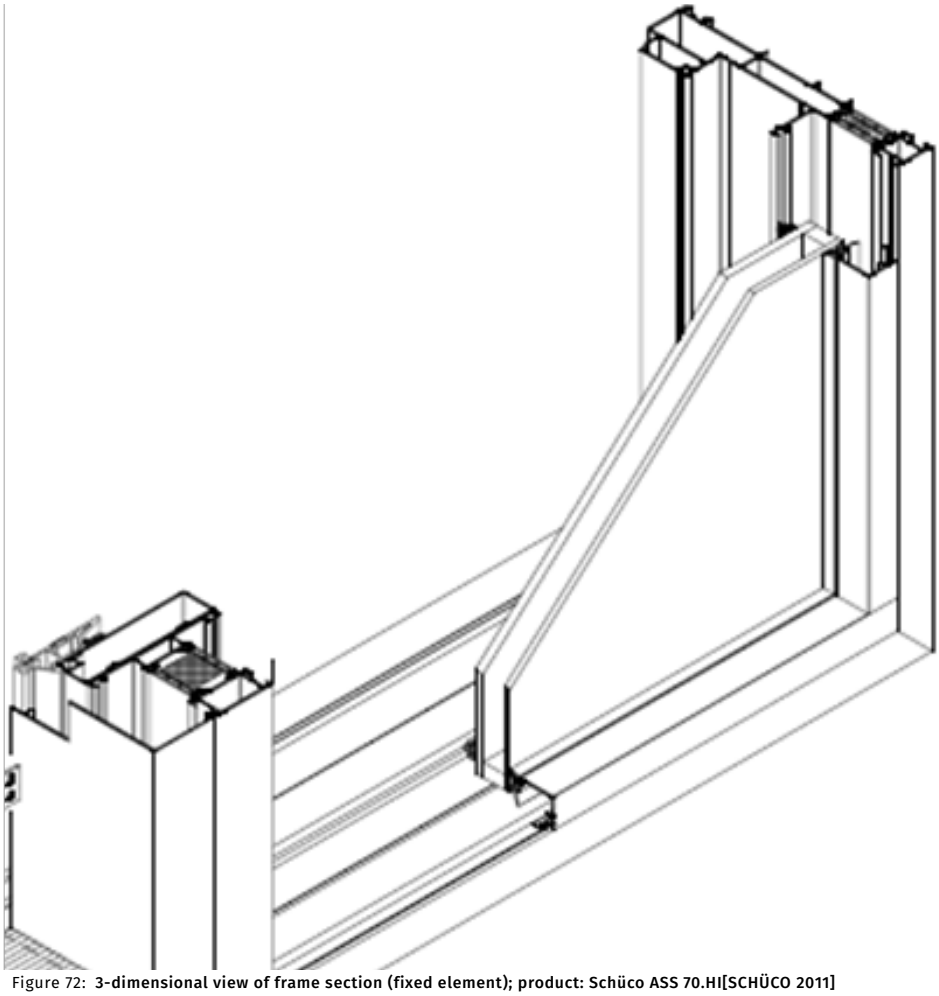


Figure 72: **3-dimensional view of frame section (fixed element); product: Schüco ASS 70.HI[SCHÜCO 2011]**

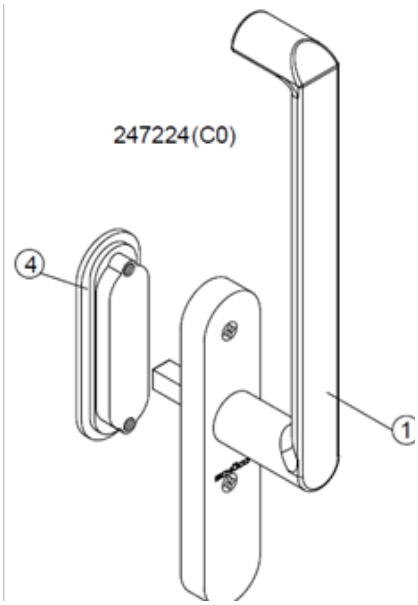


Figure 73: **handhold of moveable elements; product: Schüco ASS 70.HI[SCHÜCO 2011]**

Description: Properties & Advantages of Layers

Wooden Structure With Cellulose Insulation

Energy Efficiency of a building is strongly dependent on the heat flow that leaves in winter and enters in summer. The thermal envelope enclosing the living area acts as a resistor to the heat flow. Wood as a carrying structure already is a well-chosen material for the purpose of increasing the resistance to heat flow. The substructure of the weather boarding and the roof covering consists of lathing (and counter lathing) which creates space for the ventilation and supports the outer covering. Additionally, another advantage is the reduction of thermal bridges on small impact areas.

In this case, the gaps between the wooden beams are filled by cellulose. For those components that do not need to be disassembled for re-establishing, the cellulose insulation is injected under pressure. The advantage of an injected insulation to insulation boards is the seamlessness. This is because the grooves between the insulation and construction wood or between the insulation boards leads to loss of energy. All removable components are filled with cellose insulation boards. Filling empty spaces with cellulose insulation contributes the largest part to the resistance of the surrounding walls in a space saving way.

An additional rigid cellolose insulation inside of the vapor barrier serves many purposes:

- improves the acoustic properties of the walls
- reduces influence of heat bridges
- installation level
- regulates humidity

Moisture Protection Inside: OSB-Boards

A wooden construction requires a moisture protection of the inner layers to prevent rotting. Humidity from inside the building must not enter the wall structure as water can condensate on colder parts. A vapor barrier is often carried out as a non-permeable film. This design is prone to leaks in tightness because of poorly executed installations or accidental punctures. The way OSB-boards are produced results in a resistance to water diffusion and the ability to replace vapor barrier films. That means less waste, an installation less prone to errors and a more rigid wall construction.

Roof & Walls: Separating Layer & Ventilated Layer

One of the challenges when using wooden structures is the effects of humidity on the wood. To avoid mold formation and liquid accumulation inside the structure elements, separating and ventilated layers are planned. In combination with the lathing and counter lanthing as well as the weather boarding an optimal protection against weather impact can be achieved. The ventilated layer releases summer heat and moisture inside the wall layers by transporting diffusing moisture of inner layers to the building surrounding air. Additionally, the substructure of the covering and the ventilated layer surrounding elements are dried by the flowing air. An optimized design with short flow routes and less pressure loss will retain a sufficient air flow to achieve these properties.

Pitched Roofs are commonly built with a ventilation layer that is able to reduce damageing moisture inside

the roof structure [SEDLBAUER et. al 2010; DACHDECKER 2011]. Possible sources of moisture are people living inside the building, weather impact or the roof components. Besides the goal of moisture reduction, a constant air flow inside the roof can cool down the outer roof temperature to shadow the air level when the sun heats up the roof surface [DACHDECKER 2011]. While a steep slope in many roofs allows a mainly thermally driven air flow, flat roofs with this building technique need to rely on wind driven air flow and are therefore hardly executed in a ventilated design.

The separating layer, commonly a permeable film, acts between ventilation gap and insulation. Inside the solid walls this function also can be fulfiled by soft wood fibre boards and OSB-boards. Placed between the ventilation layer and the main insulation layer the soft wood fibre board protects the insulation from moisture and cold wind while being open to diffusion from the inside to the outside. The OSB-Boards will be mounted directly behind the plasterboard on the inside wall to prevent moisture diffusion from rooms into the inside of the wall.

Using this type of construction, combining separating and ventilated layer, gives the advantage of natural creation of a comfortable room climate without additional components of the ventilation system such as humidifiers or dehumidifiers.

Installation Level

Like the separating layer the installation levels inside the roof and the solid walls consist of a rigid cellulose insulation board or injected cellulose insulation. It prevents further heat loss and offers the possibility of installations inside the walls and roof without damageing the main insulation layers. Damage of the insulation would create thermal bridges and great heat loss. In contrary the additional layer improves thermal properties and, if installed directly behind the plasterboard regulates humidity.

Inside the floor the click system of the underfloor heating serves as installation level. The dry screed panels have to feature with routed cut outs for the underfloor heating. As a supporting plate an EPS-board is installed between screed and OSB-board.

Outer Layer: Paneling/ Parquet/ Trapezoidal Sheet

The outer layer of the solid walls is a wooden weather boarding for protection from external impact (wind suction, humidity, UV-radiation, fire) and sealing the air layer beneath. The substructure as well as the covering panels consist of woods and are exposed to humid weather conditions. For that reason all wooden building materials used have to be lubricated with wood preservatives. Also all screws, nails and anchor fittings have to be concerted to prevent rust formation and compromise carrying capacity. [ENERGIEBERATUNG 2013]

Outer material of the floor is parquet. It protects the layers beneath from external influences such as walking people or furniture. The sealing layer of a flat roof is one of the most critical parts. Contrary to pitched roofs, the sealing layer of a flat roof has to be completely waterproof as gravity is not pulling the water off the roof fast enough. Therefore, the planned trapezoidal sheet suits as water sealing [PW-INTERNET].

Roof: Upper Carrying Layer

The Layer directly underneath the sealing must be able to create a very straight surface to allow the rain to flow off. It also carries the weight of installations on the Rooftop and people must be able to walk on the

roof. German laws require a minimum thickness of 22mm [SEDLBAUER et. al 2010, p. 42].

Glass Façade: Glass Layers and Argon Insulation

The challenge of selecting a glass type for an energy efficient building is to minimize heat emission in the winter and reduce cooling demand in the summer while preventing the room from darkening because of thick glass layers and coatings. As a façade, the carrying properties of glass and frame have to be similar to those of solid walls. The chosen glass type for the realization of the glass façade, is a high insulating, low emissive glazing, that strikes a balance between the mentioned requirements. Combined with an aluminum profile frame the constructional requisites can also be met.

The outer and inner glass layers are coated; on the one hand to reflect a greater part of the sun radiation and on the other hand to allow necessary daylight to brighten the inside. Thereby, the heat loss in winter and the heating because of solar radiation in summer can be minimized. This way heating as well as cooling energy and costs can be spared. [SEMCO 2013a, p.10] Filled into the gaps between the glass layers of the glazing, argon acts like an effective insulation. Compared to Krypton the gaps between the glass layers have to be greater, but Argon creates significant lower costs [BRIGLA 2013]

A proof for the minimized energy impact are the low values of energy transmittance (g-value) and thermal transmittance (u-value) as shown in the table below (see Table 18). [SEMCO 2013b]

properties	
visible transmittance (D65)	0,60
light reflection (outside)	0,16
colour reproduction	0,95
u-value [W/m²K]	0,70
g-value (dT=15K)	0,34
shading coefficient	0,43
noese reduction index [dB]	30
weight [kg/m²]	35
frame material	aluminum

Table 18: **properties of glass chosen**

Glass Façade: Aluminum Profile Frame

To guarantee stability and the ability to sustain wind suction, humidity or further weather impact, the chosen profile frame has to be constructed of aluminum. Compared to wooden frames, the advantages of this selection are reflected in an increased security for inhabitants and greater structural load capacity. [GLALUM 2012]

Thermally efficient profile frames are constructed with an edge seal; it keeps the distance between the glass plates and avoids leaking gas. Additionally it prevents from penetrating moisture and wind suction. An edge seal is realized in several layers such as sealing as bonds between the glass plates, or close-up after filling in the gas. Protection from condensation of moisture between the glass plates is accomplished by the use of a desiccant. [GLASTRÖSCH 2013]

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5.3.3 PLUMBING SYSTEM DESIGN

GENERAL DESIGN DESCRIPTION

The plumbing system is an essential part of a building, which has to meet high hygienic requirements in order to avoid health risks for the inhabitants. Elements of the plumbing system are components of water supply and drainage, gas supply and exhaust gas removal. The latter two elements are not part of the Rooftop project. Hot and cold drinking water (or fresh water) have to meet high quality priorities in all stages of the process, starting with the transport from providers and ending with the extraction inside buildings. Quality factors to evaluate the water supply are piping materials, the dwell time of water inside pipelines, pureness and purification of water.

Water supply systems of a building consist of all pipelines and machines that transport, save, treat or extract drinking water. Drainage systems unite drains for wastewater and rainwater, wastewater pipes including ventilation lines and restraint systems for filtration of pollutants, purification or discharging into the sewerage system.

To design one of the above mentioned water systems, rules and regulations that may differ between different locations or countries have to be considered. The design for the Rooftop House complies with European Regulations for installation of drinking water systems (DIN EN 806) and wastewater systems (DIN EN 12056).

Additionally, drinking water and energy consumption have to be minimized. To achieve this goal, each pipeline will be constructed as short as possible and the water consumption of all selected sanitary objects as low as possible. Furthermore, the treatment and reuse of greywaters is part of the project strategy.

Description of the Plumbing Cycles

The planned water systems are:

- cold water system
- domestic hot water system
- blackwaters system
- greywaters system

In the following each cycle will be described in detail.

To support the description and understanding of the concept, the scheme PL- 101, supply and removal drawing PL- 001, drain drawing PL- 021 and greywaters drawing PL- 011 from the project drawings will be of help.

Cold Water Supply

First of all, the drinking water system of Rooftop is installed as a series system. This means that all water draws are connected to one pipeline. For this reason, it is necessary to use more material, but advantageously in every part of the system flows water, if the last water drawn will be used. We chose the toilet flush as one of the last water removal, because it is often in use. If the water is in movement, forming of legionella

(bacteria) is prevented; an important priority in Germany.

The fresh water reaches the Rooftop House over a central water supply system. To install a water meter for determining water consumption, the drinking water pipeline has to be installed at a good visual height. Therefore, the pipe will not be installed inside the module wall to simplify maintenance and so will not damage walls, which would cause negative acoustic effects.

In front of and behind the water meter a shut-off valve is installed to prevent water leakage during maintenance e.g. changing of the water meter. The valve behind the water meter is combined with a backflow preventer and has an emptying possibility.

After that a filter should follow. An automatically reversible filter is a good choice, because it allows a regular maintenance every two months without human support.

But it is not integrated in the water pipes of Rooftop. The reason is, that the pipes of Rooftop are connected with the plumbing system of the old building, which should already have a filter.

The drink water system goes in the direction of the heat pump; to the first water draw to prepare domestic hot water. Above the heat pump is a safety group, which includes a membrane security valve (or conservator). It protects from exceeding the pressure limit and helps by saving water. This component has to be maintained annually by a specialist and the valves between the conservator help to stop the water flow.

As a next step, the drinking water flows to the kitchen. The first water draw in the kitchen is the sink fitting, than a water supply for dishwasher and washing machine. After that, water goes through the core module to the bathroom. The first station here is the bathtub fitting, then the basin fitting and then the cistern of the toilet. With this solution the pipes cannot be seen, as they run in the shuttering of the bathtub. The last stop is an automatic hygiene-flush inside the wall.

Domestic hot water supply

The domestic hot water is also installed as series-system and starts from the heat pump, which contains a 235 liter water tank. From this point, the pipes run to the sink fitting, then to the thermostat of the bathtub and at last to the basin.

All pipelines used for domestic hot water and for circulation are, because of the reduced space, installed close to the pipes for drinking water. Thus, insulation is obligatory referring to EnEV 2009. For good acoustic safety and in order to minimize the heat exchange, we insulate all pipes with 20 mm thick thermal insulation coating. The material also complies with the fire protection requirements. In order to prevent the formation of legionaires' disease bacteria, the water is heated up to 60 to 70°C weekly.

Circulation system

For small houses, a circulation system is usually not necessary. But in our network we use the heat pump as a heater. Thus, the domestic hot water temperature is in normal operation not so high and because of the series installation the length of the water draws is a bit longer. If the hot water stands still in the pipes, than it loses heat and the heat pump must consume more energy to heat again. The circulation is coupled with the cold and hot water system. The basin connects to the hot water pipe and also to the cold water pipe near the heat pump supply. So the hot water circulates to the basin, then it goes back to heat pump and it flows

from the drink water pipe in the domestic hot water tank in the heat pump. And the cycle begins again. A circulation pump is responsible for the movement in the cycle.

Black- and Greywater

Each supplied sanitary object has to be connected to the drainage system. Washing machine, dishwasher (connected to sink), toilet, bathtub and wash basin include a siphon (drain trap) which connects to the drainage system.

All horizontal positioned pipelines are drained using a natural slope; in this case 1%.

During drainage a high amount of air reaches the pipelines. Therefore, a ventilation line has to be considered. To reduce space consumption and breakthrough in the roof, the ventilation of black and grey water is combined to one line. Simultaneously the mixing of black and grey water streams is avoided by arranging the ventilation lines of the grey water above the black water pipelines.

Additionally, to avoid excess pressure, no pipeline is narrowed in flow direction.

Changes of the direction of basic and collecting lines are realized using branches with connections of 45° angle. The angles between down coming lines are 87° to 88,5°. Exclusively connection lines of nominal diameter DN 80 or higher are connected below 45° angles. The stated angles could not be included perfectly into the three dimensional plot.

A direct contact between all pipelines and the building structure is excluded to avoid vibration transfer, which causes noise emissions. Therefore, we tried to install all pipelines inside the insulation layer of the module wall or we insulated (not the waste water pipes) them and fixed with special clamp against noise and vibration.

Greywaters pipelines lead the water over a collecting line to the garden as irrigation and for cleaning. Greywaters are domestic wastewaters from wash basin, shower or bathtub and washing machine. In the Rooftop House, the greywaters also include the condensation of the heat pump and the waste water of the hygiene-flush. A pump is required (see chapters grey and storm water system and reuse) to lead the greywaters into the sewage treatment plant (wetland). The other function of the wetland is very innovative. In fact, it serves also as a heat exchanger for the cooling system of the Rooftop House. The heated water from the PCM ceiling flows to the wetland, which is cooler by night, and gives off his heat. (See for more information: 5.3.8 Building Integrated Active Systems, cooling).

Detailed Description of the Plumbing System

One sanitary area and a kitchen will be realized inside the Rooftop House. The sanitary equipment contains the sink, washing machine, small dishwasher, toilet, washbasin and bathtub. To define the distance between the sanitary objects, guidelines for lateral distance and minimal maneuvering area such as DIN 18022 have to be regarded.

Washing machine, sink and dishwasher are located in the kitchen. The dishwasher is connected with the siphon and the drinking water pipe of the sink. Volume flow and dimensions of pipelines (normal size DN) can be calculated using DIN 1988 - 3 and the number of installed sanitary objects. Considered parameters are the maximal flow velocity of the water influx from suppliers, which differs locally, pressure drop depending

on intrinsic material properties, length of pipelines, junctions, bends, resistors and pipe diameters.

For calculations the selected method is the simplified procedure of the European rule DIN EN 806-3. Because of the European standard, this method complies with German and French regulations. The simplified method considers pressure and flow velocity conditions. The given values are based on velocities of maximum 2m/s inside collecting lines, risers and of 4m/s inside single pipes.

The selected system is a normal-installation. In the following schemes the pipeline network including drinking water and hot water with stages can be seen (see pictures 18 and 19). The calculated values for drinking water are shown in table 20 and for hot water in table 21.

Improving insensibility of the ducting to chemical, thermal, acoustic or harmful hygienic influence, can be achieved by defining the pipe diameter precisely.

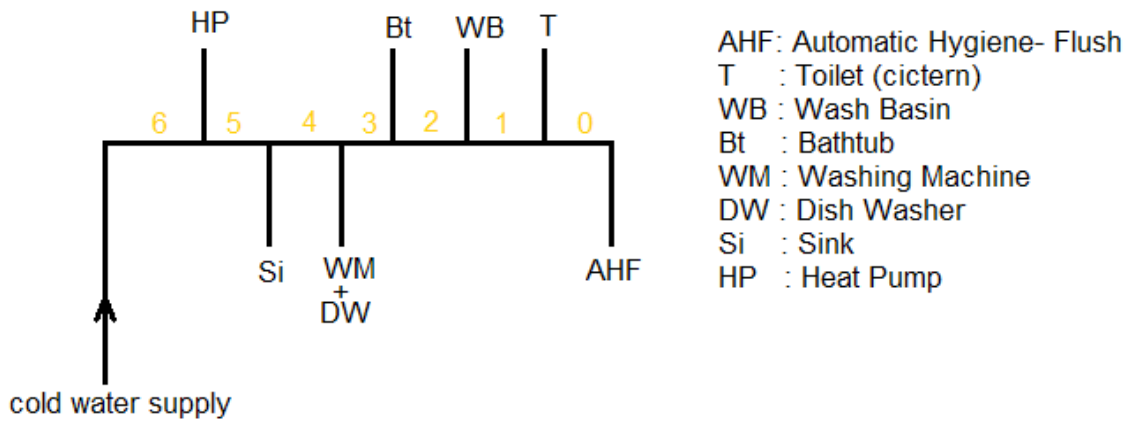


Figure 74: **drinking water pipeline network**

The part PS 0 is not often in use and it does not need a high volume flow. Therefore it is not in the calculation. Moreover, the material and length of the pipes is crucial for the nominal diameters. In this case we have flexible polybutylene pipes.

Part System Number	Object	Volume flow [l/s]	Loading Unit [LU]	Nominal Diameter [DN]	Inside Diameter [mm]	Outside Diameter [mm]
PS 1	T	+0,1	1	12	12	16
PS 2	PS 1 (T)	0,1	1			
	WB	0,1	1			
	Σ	+0,2	2	12	12	16

Part System Number	Object	Volume flow [l/s]	Loading Unit [LU]	Nominal Diameter [DN]	Inside Diameter [mm]	Outside Diameter [mm]
PS 3	PS 2	0,2	2			
	Bt	0,4	2			
	Σ	+0,6	6	15	14	20
PS 4	PS 3	0,6	6			
	WM+DW	0,2+0,2	4			
	Σ	+1,0	10	15	14	20
PS 5	PS 4	1,0	10			
	Si	0,2	2			
	Σ	+1,2	12	15	14	20
PS 6	PS c	0,7	7			
	PS 5	1,2	12			
	Σ	+1,9	19	20	20	26

Table 19: **nominal value of drinking water pipelines according to DIN EN 806-3**

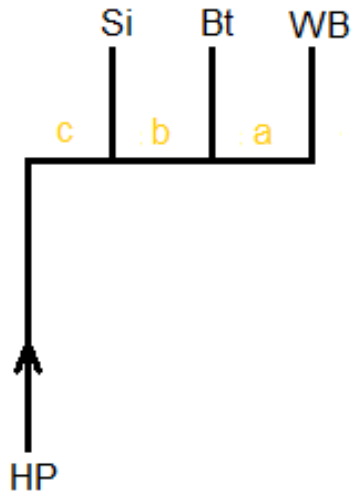


Figure 75: **domestic hot water pipeline network**

Part System Number	Object	Volume flow [l/s]	Loading Unit [LU]	Nominal Diameter [DN]	Inside Diameter [mm]	Outside Diameter [mm]
PS a	WB	+0,1	1	12	12	16
PS b	PS a (WB)	0,1	1			
	Bt	0,4	4			
	Σ	+0,5	5	15	14	20
PS c	PS b	0,5	5			
	Si	0,2	2			
	Σ	+0,7	7	15	14	20

Table 20: **nominal value of domestic hot water pipelines according to DIN EN 806-3**

According to the calculation, the heat pump needs a pipe connection with DN 15, but for installation it should be DN 20 for Drink water supply and hot water tapping. This is a recommendation of the heat pump manufacturer Stiebel Eltron.

A reference of SDE explains that the toilet is not considered a piece of the plumbing ystem in the competition. In the calculations from the dimensions of the drink water system there is no changes. But for the computation of the greywaters reuse system and black water system dimensions it makes a difference. But we design the wastewater pipes for the project in the local context. In the calculations, the condensate for the heat pump has a minimal effect and is thus not factored.

Solar Decathlon Rule 58.3.1 refers to rule NF 12056-2 for dimensioning the wastewater pipelines. The considered German rule DIN EN 12056-2 is equal to

NF 12056-2. Referring to the German requirements, the designed system consists of two separate pipelines for each type: wastewater, black water and grey water. This correlates in Germany to system I of DIN EN 12056-2.

The following calculation of the design unit is parted into two sections: black and greywaters objects.

Black water

- Kitchen sink – DU(Design Unit): 0,8
- Dish washer –DU: 0,8
- Toilet – DU: 2,0

Grey water

- Wash basin – DU: 0,5
- Bathtub – DU: 0,6
- Washing machine (until 6 kg) – DU: 0,8

The expected maximum outflow quantity is calculated for residential buildings. That means that the compensation value K is 0,5:

Maximum Outflow Quantity

- Black water: $Q_{wwB} = K\sqrt{\sum(DU)} = 0{,}5\sqrt{0{,}8 + 0{,}8 + 2{,}0} = 0{,}949\ l/s$
- Grey water: $Q_{wwG} = K\sqrt{\sum(DU)} = 0{,}5\sqrt{0{,}5 + 0{,}6 + 0{,}8} = 0{,}689\ l/s$

Nominal Diameter DN

- Black water: $Q_{wwB} = Q_{maxB} = 0{,}949\ l/s \Rightarrow \boldsymbol{DN\ 80}$
- Grey water: $Q_{wwG} = Q_{maxG} = 0{,}689\ l/s \Rightarrow \boldsymbol{DN\ 50}$

Toilets, connected to downpipes installed on 4 to 6 liter flush volume, have to cover a minimum nominal diameter of DN 80. To reduce drinking water consumption at the use of the toilet flush, the selected cistern uses 3 liter flush volume per flushing (see chapter 3.2.3).

In the Rooftop House is the pipe for ventilation a fusion of the grey and black water plumbing system. So the house needs only one opening on the roof. To get the dimension of the main ventilation pipe, the sum of the two maximum outflow quantities is formed.

$$Q_{tot} = Q_{wwB} + Q_{wwG} = 0{,}949\frac{l}{s} + 0{,}689\frac{l}{s} = 1{,}713\frac{l}{s} \Rightarrow \boldsymbol{DN\ 80}$$

That means or main ventilation pipe should be minimal DN 80. But the product we choose has a DN 90 version.

Product Description

Pipe System

As drink water pipes for cold and hot water we use the PushFit system of Geberit. It is a flexible pipe and easy to install for the beginner. The steps required are simply to cut the pipe to desired length, deburring (entgraden), calibrating with the same device for three different pipe dimensions, and finally to push the pipe into the fitting. The fitting is very robust and an indicator changes to green, when the pipe plugged safely and sealed into the PushFitFitting. The system can be used till a pressure of 10 bar and temperatures up to 70°C. . Advantages of this material are resistance against high temperatures, flexibility, noise absorption, low expansion at influence of heat and high structural stability.



Figure 76: **work steps of the PushFit- system**

The material is polybutylene, a thermoplastic. According to the LCA of the Geberit drink water systems (see Figure) is the Geberit PushFit PB- pipe the ecological. The metal pipes have the worst values.

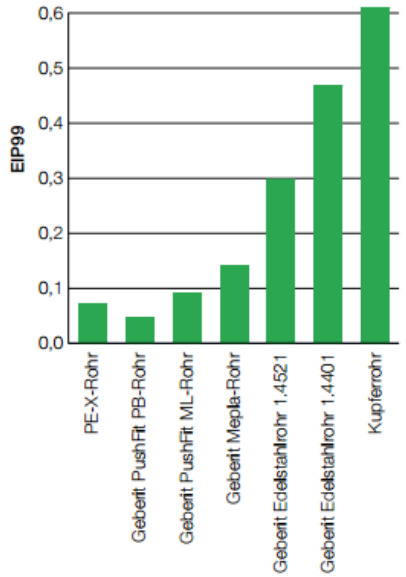


Figure 77: **LCA of Geberit pipes**[1]

For the waste water we choose Geberit- Silent- db20. Piping material is a noise absorbing plastic pipe (Geberit - Silent - db20), because of the hydraulic optimization of all branches of typical piping dimensions. This allows usage at higher loads and partly smaller dimensions. Also it is very practical by installation. The connection rings are easy to close and reopen with a cordless screwdriver.

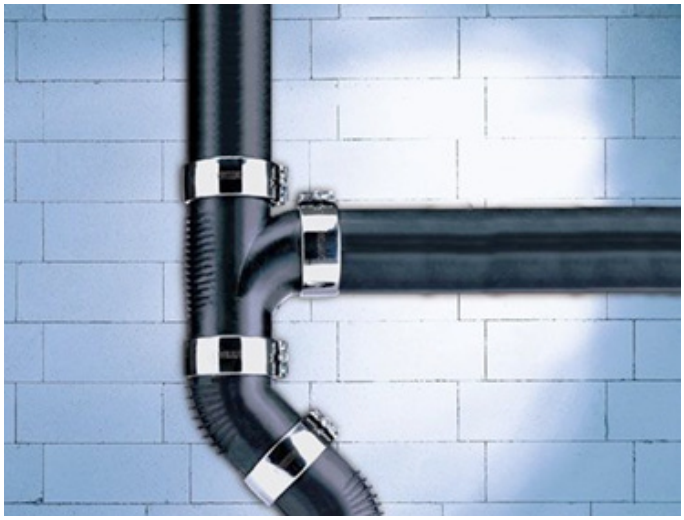


Figure 78: **Waste water pipelines; Geberit Silent db-20 [http://www.haustechnikdialogue.de/News/Images/geberit_db20.jpg]**

Water Containers

Based on the calculations in “Detailed Water Budget”, Rooftop gets the drinking water from two connected 600 liter tanks. For blackwaters, the same is chosen. The selected manufacturer is Osculati. They sell 18,000 articles for boats and also manufacture some of the articles. We prefer the containers from Osculati, because they have different options and sizes to connect the plumbing. The connection with the drink water plump-

1 **http://www.geberit.de/master/content/media/global_media/group/unternehmen/nachhaltigkeit/life_cycle_assessment_supply_pipes.pdf**

ing ,waste water plumbing ,the diameter of openings and clearance above the tanks are shown in the PD. Furthermore they are tasteless and odorless, manufactured in compliance with RINA and ASIR standards and have an inspection plug. One tank is shown in the following figure, which is taken from the Osculati- website [www.osculati.com] of the company.

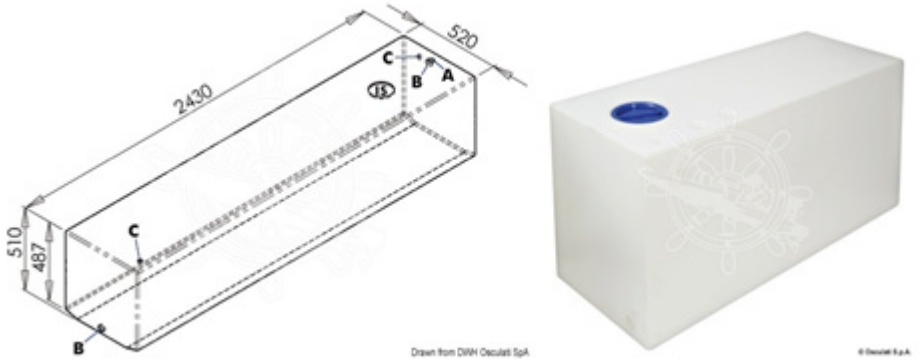


Figure 79: **600 l tank from Osculati [www.osculati.com]**

The containers will be under a long bench on the terrace. The top of the bench can be opened easily and so you can reach the tanks well.

Pumps

For transportation of the fresh water to our house system there will be a water pump at the beginning of fresh water pipe near to the container (see previous figure). It is a selfpriming water pump of Wilo.

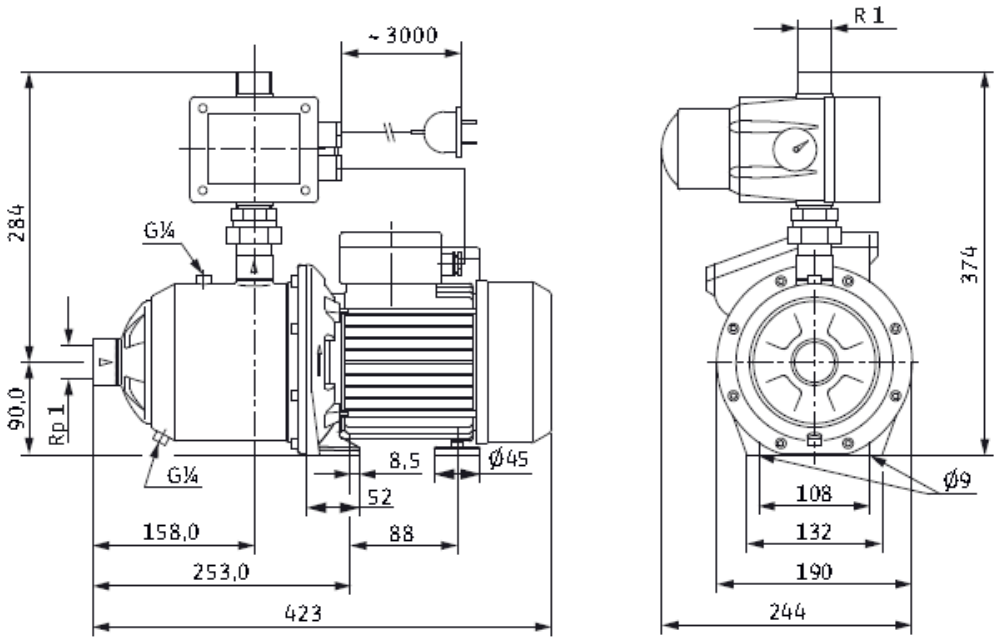


Figure 80: **Units of measurement of Wilo-MultiCargo FMC 604 (1~230 V) water pump**

To save electricity, the black water container will be lowered a bit into the earth. So the waste water pipe of black water could integrate in a high position to the container. The height is adjusted to the gradient descent of the container.

For the circulation we have also a Wilo pump. Series' name is Wilo-Star-Z Nova and have the specials: Extremely low power consumption: 2 to 4,5 W with new synchronous motor; high-quality materials; quick replacement of all common types of pumps; version integrated with ball valve and non-return valve.



Figure 81: **Circulation pump- Wilo- Star-Z Nova (DN 15)**

Water Flow Meter

Because our drink water pipe goes straight up, we bought a water meter in rise design (see figure on left side). The dimension of the vertical water pipe is DN20 and therefore the upstream and downstream ends of the water meter are also DN 20. In the Competition we use a water meter with DN 15 ends. Therefore we provide the required connection fittings to perform the adaption. For easy changing, are upstream and downstream valves before and after the meter. These valves will allow closing of the water flow. Additionally, it stands at the right entry of the core module, where a easy reading is guaranteed.



Figure 82: **right: http://artikelwelten.de/Wasserzaehler-Einbaugarnitur-komplett-1-x-1-fuer-Wasserzaehler-3-4-25-Qn-montagefertig**

Pre-Wall-Installation

The installation of the wash basin and the toilet is realized by a structure supporting pre-wall installation. Advantages of this method are low space consumption, invisibility, noise control, easy design and installation as well as a high accessibility for maintenance.

The toilet flush is sponsored by Geberit and forms part of the Doufix line. The special properties of this toilet flush are the self-supporting construction and especially the rinse. The flush cistern has a thermal insulation to avoid the cultivation of living organisms that normally ensues when the flush is out of use for a longer period. Most importantly, it has an option to adjust the flush volume – you can select between two quantities, the first with 3 liters and the second with 6 liters. While the toilet is flushing you can hold the rinse to save water.

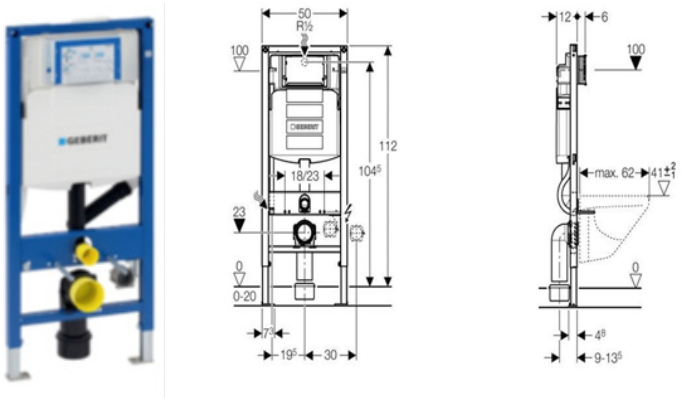


Figure 83: **Toilet flush Geberit Duofix Wand-WC UP320**

Another wall-installation we need for our washbasin in the bathroom. It is a special installation for fittings, which are fixed at the wall and not on the ceramic. It is also sponsored from Geberit.

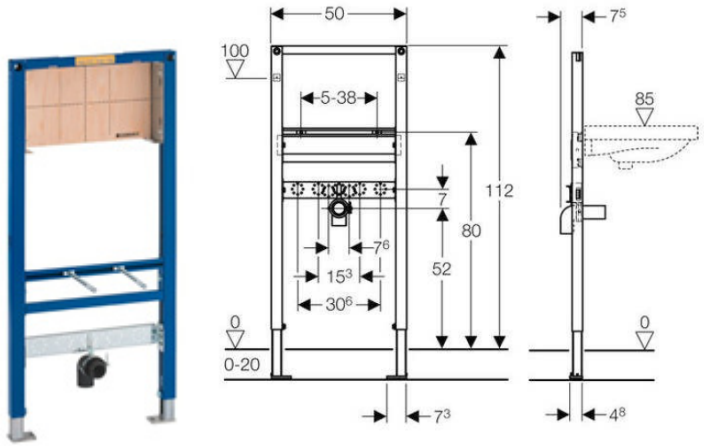


Figure 84: **Duofix washbasin- wall- installation from Geberit**

Fittings

We are going to use fittings that are sponsored by the German enterprise Hansgrohe and belong to the Axor Strack Organic line. This line focuses on high quality and low water consumption. The design is elegant and is inspired by organic shapes, aiming to be minimalistic and to let handles and fittings merge. The beam former from showerhead has got 90 small openings. As a result the jet shower is soft, voluminous and has a wide beam; while having a flow limitation of 3.5 l/min for normal flow. The design tries to help saving energy. It has a special temperature regulation that is separate from the water flow regulation.

This makes it easy to default to a personal comfort temperature or energy-saving cold position without the need to touch the regulation every time you want to open the water flow. Because of the infrequently operated default-handle you avoid drops and water wastage. Also, the handle doesn't need to be cleaned as frequently. The water flow regulation is operated directly at the outlet, increasing cleanliness and comfort.

The normal position is at 3.5 l/min and has a click position so you won't fail it, but it also has a booster option for increased flow at 5 l/min. The demand for materials for the valves' walls is minimized using hollow bodies. This way the need for brass is reduced by approximately a third compared with conventional products.



Figure 85: **Shower fitting Axor Starck Organic**



Shower temperature regulation Axor Starck Organic Thermostat

Automatic Hygiene Flush

Irregular water supply can lead to stagnation in the drinking water pipes. This results in hygenic problems caused by contamination of drinking water with dangerou bacteria. The Geberit sanitary flushing renewas the water in the pipes at regular intervals. Flow volumes and flushing intervals can be individually adjusted and adapted at any time afterwards. Thus, the intended operation of the drinking water system can always be ensured. A vandal-proof stainless steel cover plate in the bathroom makes a fast access for maintenance work possible.

CONTAINER FOR WATER DELIVERY AND WATER REMOVAL

Based on the water budget (see section 11) per day the Rooftop House gets the non-portable water from a water container with a volume for 600 liters. This quantity of water is designed for 8 to 8,5 days, if the amount of water need is 58 liters per day. The waste container is sufficient for 10 competition days. It can store 165 liters. We calculate these after the information from SDE. They inform that the fresh water container will be filled two times during competition phase. Once at the beginning and again at the middle of competition phase. For the waste water tank is the regulation, that during competition phase, tanks will be drained two times: once at the middle of the competition phase, and again at the end of the competition.

The containers dimensions are chosen to provide enough volume for the water delivery and water removal. They do not have the capacity to cover the buffer and the plumping´s for fresh water at the beginning of the competition.

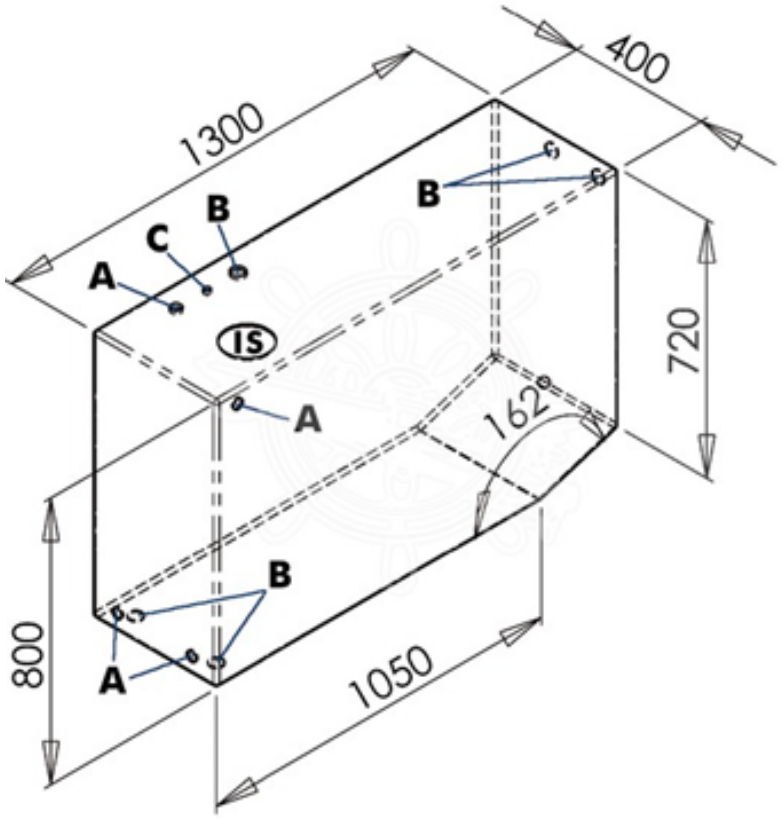


Figure 86: **Sketch of Water Container from Osculati**

Two water tanks from an Italian trading company called Osculati were chosen. They sell 18.000 articles for boats and some of them they manufacture themself. We prefer the containers from Osculati, because they have different options and sizes to connect the plumbing. The connection with the drink water plumping or waste water plumbing and the diameter of openings and clearance above the tanks are shown in the PL- Drawings. Some other points are that the containers have an angled corner, so the water flows to one side. This way the water flow in the fresh water plumbing is improved. Furthermore they are tasteless and odorless, manufactured in compliance with RINA and ASIR standards and have an inspection plug. One tank is shown in illustration Figure 86, which is taken from the Osculati- website [www.osculati.com] side of the company. In Table 21 are the dimensions of the two tanks.

For transportation of the fresh water to our house system there will be a water pump at the beginning of fresh water pipe near to the container. To save electricity, the black water container will be lowered a bit into the earth. So the waste water pipe of black water could integrate in a high position to the container. The height is adjusted to the gradient descent of the container.

Capacity l	Length x width	Height mm
600	2430x520	509
165	900x600	400

Table 21: **Dimensions of the fresh water tank and waste water tank.**

In rule 8.1 is written that the container shall be located outside of the measurable area and that they shall be fully shaded from the light. To protect the containers they will stand under the beet plant. The illustration (see Figure 86) gives you an idea of the dimensions of the container.

Another drawing about the dimensions you can find in the PL Drawings called PL-103 Water Container Dimensions.

To reach the openings for filling and emptying there are inspection-openings (IS) on the top of the containers. They are intended to control the water inside the tanks and also to fill the fresh water and to remove the waste water. It is also possible to put an opening below the black water container to empty it. But maybe the waste can clog the plumbing. Additionally the pipe would need an extra valve. That means more costs. The waste water pipe from the side of the house is above the container, so the water cannot flow back. And the pipe for liquids supply is below the container to fully exploit the water.

5.3.4 ELECTRICAL SYSTEM DESIGN

SYSTEM DESCRIPTION

Connection to the monitoring box and SDE contribution box

The main cable will be duct from the SDE official contribution box to the mainboard in the core module in a short and straight way. Cables will be duct through cable pipes and fixed if possible to prevent accidents and failures. We will duct the cable below the terrace to the cable conduct in the floor of the core module. See the latest routing of this cable in drawing EL-001. The monitoring box will be connected to the power grid and ethernet grid in the same route.

System overview

This chapter considers the electric distribution and systems beside the photovoltaic energy generation. The latter is in fact explained in the chapter PV system narrative. We created the one line diagram and did the electrical distribution planning using a software called epINSTROM, which allows a grid simulation with detailed choices of cable types, cross sections, security devices and consumers. Our electrical distribution planning and installation is being developed in tight cooperation with the electric department of the Knobelsdorffschule, a vocational college in Berlin. Hence, we can profit from their experience in system designing. Mr. Puls, teacher at the Knobelsdorffschule, is going to sign the final acceptance of the electrical system. Our distribution design is planned according to DIN VDE 0100-410, the German regulations for lower voltage and supply network installations. Considering special requirements of the Frensh regulations for save installations in the TT-grid.

Figure 87 shows a figurative overview of the Rooftop House's electrical system. We are going to use a combination of DC and AC power supply. To understand the more detailed structure of the system see especially EL-501 in the project drawings. The final devices we are going to use will be shown after the end of the announcement process. As this is a public funded construction project, we have to provide electricity using the most cost efficient products allowed by the system configuration.

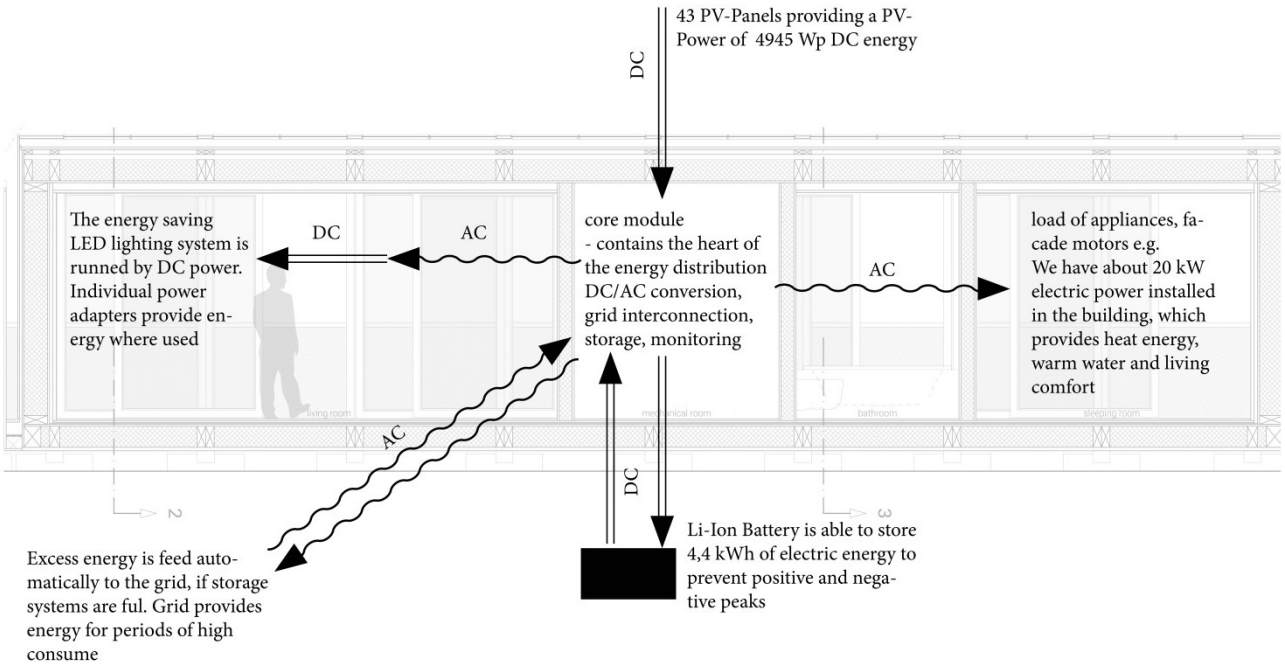


Figure 87: **General system overview**

Wiring

We will only use double insulated, copper cables with a minimum voltage of 450/750 V according to the requirements of the PV checklist. To reduce the harm caused by fire we use halogen-free cables whenever possible. This bans the formation of toxic hydrogen fluoride and hydrogen chloride in case of fire. For exterior wiring we provide UV-resistant cables.

To prevent interferences between communication cables and electrical cables due to induction processes we will duct these cables with a maximum distance. We make sure that these cables will not career along side by side. If possible, we will use shielded cables for sensor, monitoring and communication cables in order to prevent interferences and transcription errors.

The cables will be duct direct to the place of the sockets or the lighting transformers. To decrease the risk of accidently damageing the cables during e.g. drilling works, we duct cables according to DIN 18015-3 standards. For example, we duct the cables vertically and horizontally using curves in angles of 90°.

The electrical calculation for the cable and wiring system will be done by epINSTROM (see Figure 88). The software enables us to choose cross sections, cable lengths and cable types to calculate losses etc.

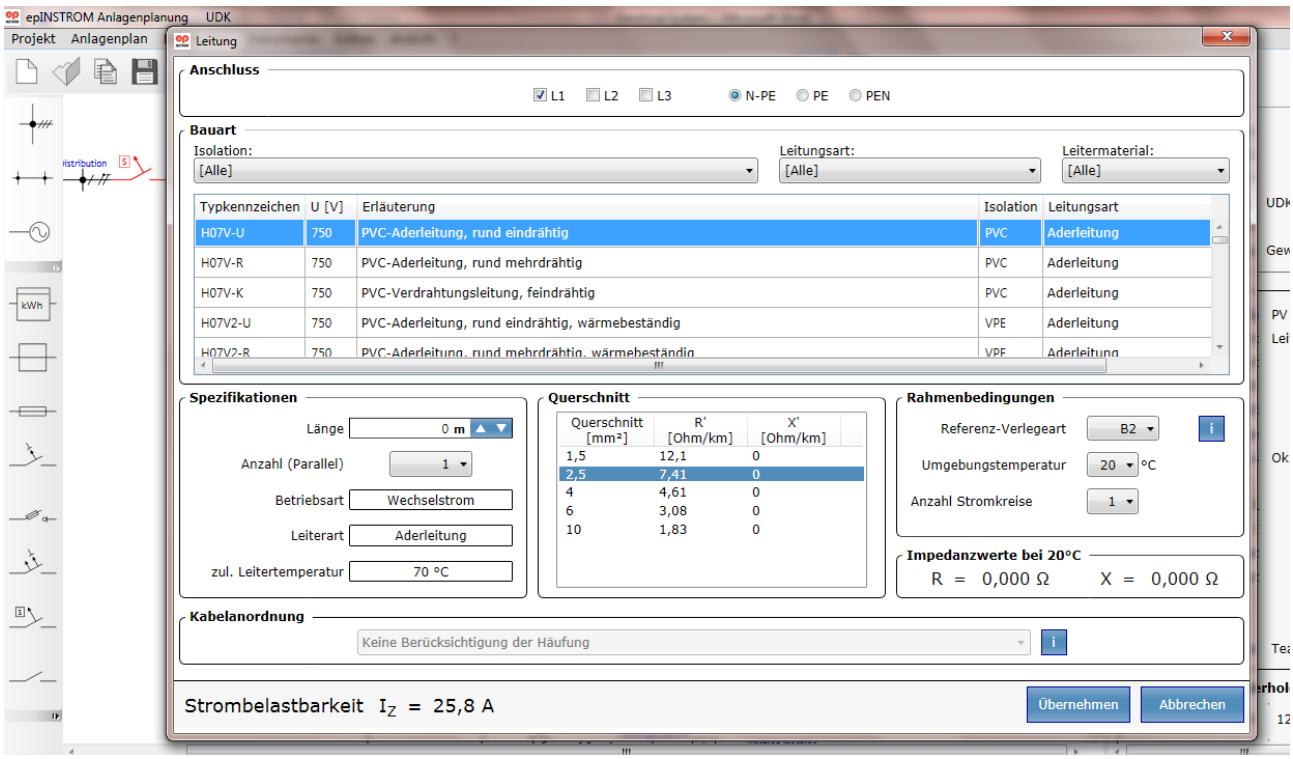


Figure 88: **Extract of the calculation tool for electric distributionsystems epINSTROM**

Sockets

The sockets in the Rooftop Building will be equipped with a children protection device to make them as safe as possible. We will place as many sockets as possible at the central core module. Here we can forestall the installation process to reduce the effort in Versailles as much as possible. We will provide the Electric-Checklist regulations that a maximum of 8 sockets can be installed using a 2.5 mm² cable and 5 sockets can be installed using a 1.5 mm² cable.

Our latest plan contains these 6 socket circuits:

- Living room: 8 sockets
- Sleeping room: 4 sockets
- Kitchen: 4 sockets
- Outdoor terrace: 4 sockets (IP65)
- Technical room: 2 sockets
- Bathroom: 1 socket (IP44) integrated to the lighting circuits

LIGHTING SYSTEM

Our lighting system is created to have a maximum of efficiency. We use innovative LED stripes and LED lamps for a user-friendly and energy-saving installation. For DC wiring see EL-201.

Electrical System Design for Lighting

During the development of the Rooftop Building, several ideas for an adequate illumination were discussed and dropped. The house was continually changing and it became more and more evident that the house will not only change during the development phase but continues to change after its completion. In fact, as the furniture is not fixed to one place, the house needs a very flexible illumination. For example, it shall be possible to place the dining table at different positions in the living room, every day.

As described in „5.2.3 Lighting Design“ on page 94 the whole lighting runs on LEDs. A basic illumination will be created by the lighted shadow gaps around the core module and the exterior walls. We will lighten the shadow gap all around the core Module with LED strips of 600 Lumen/m. This will deliver for the both slim corridors an installed intensity of 314 lux (necessary referred to DIN 5035 Teil 2: 10–50 lux). Furthermore, the gaps to the massive exterior walls will be lighted up by LED strips with a light intensity of 960 Lumen/m. In the bathroom a false ceiling will be installed. The false ceiling also creates shadow gaps on the sides which will not be opened, namely the wall with the toilet and the wall with the sink. Also in this case, LED strips of 600 Lumen/m will illuminate the gaps, resulting in an installed intensity of 685 lux (necessary referred to DIN 5035 Teil 2: 300-1000 lux).

A more concentrated lighting is installed right at the middle-point of the ceiling dividing the room with a straight line, in accordance with the functions of the house. The three movable bulbs will hang down from a gap in the middle, which is created by the PCM modules coming together in an obtuse angle. In the bedroom there will be only one lamp. The fabric cable runs over a roll which slides on a rail. The user will then be able to grab a lamp, simply swing it to the location where he wants the light (always along the straight line) and adjust the height. The lamp has two 5 W LED chips facing to the ceiling and illuminates it, so that we have an overall installed illumination including the LED strips of 310 lux in the bedroom (necessary referred to DIN 5035 Teil 2: 50-300 lux). As far as it concerns the living room, an illumination of 303 lux is forecasted (necessary referred to DIN 5035 Teil 2: 50-300 lux). The three lamps additionally have one chip facing downwards to the ground or to a work desk. The safety rules demand a minimum illumination level of 20 lux for exterior areas and 200 lux for interior areas. We will not fall below these values. The main terrace, facing south, gets illuminated from the downside of the railing by LED strips (300 Lumen/m). At the gardening terrace, facing north, right under the very long bench around the pond for wastewater treatment there will be a LED strip (300 Lumen/m) as well. The private terrace has six wall lights, three on each wall side and each with a 6 W LED chip.

The LED Stripes are connected to a circuit of transformers which deliver the needed 12 V DC and specific Power of each LED stripe.

Distribution board

The distribution board is located in the technical room of the Core Module in front of the heat pump's buffer tank. To provide enough space for installation, maintenance and testing work, there is a door in front of the distribution board. Thus, we are able to supply 1.2 meters constriction distance as it is demanded in the TAB ("Technische Anschlussbestimmungen" – technical guidelines for grid connection). We will use a power distribution cabinet with a size of 800 × 1200 × 210 (W × H × D) with space for three meter and fuse fields. Field 1 is for the fuses, field 2 for Metering and the last field is for controlling and regulation as shown in Figure 89. The upper rail of the terminal block is reserved for the official SDE metering. The electrical cabinet is built by a professional manufacturer for distirbution boxes to gurantee a maximum of security. Thus we can provide thermal simulations and further certification.

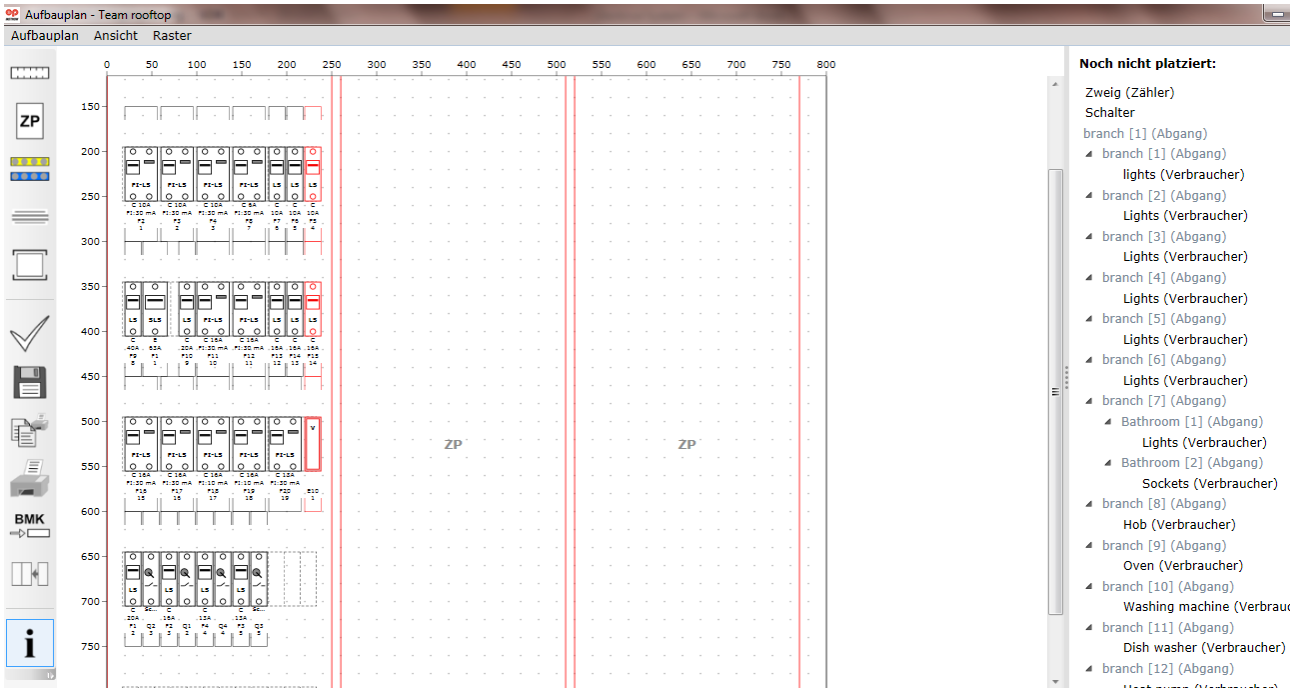


Figure 89: **Distribution prototype creation with epINSTROM**

The power distribution cabinet is mounted on a detached and floor mounted metal frame, to provide a safe position.

Bathroom installations

Our bathroom installations are according to the German standards of current-carrying installations in Bathrooms defined in the TAB. The mains adapter for the DC lighting circuit is equipped with a transformer and it guarantees a protection class III and a SELV (Safety Extra Low Voltage) installation. All current-carrying systems are outside a clearance space of minimum 2.25 m height and 0.6 m width next to the shower tray (see Figure 90). The light circuit in the bathroom runs with a power of 12 V and represents thus no harm for the resident's health due to the LED-belt.

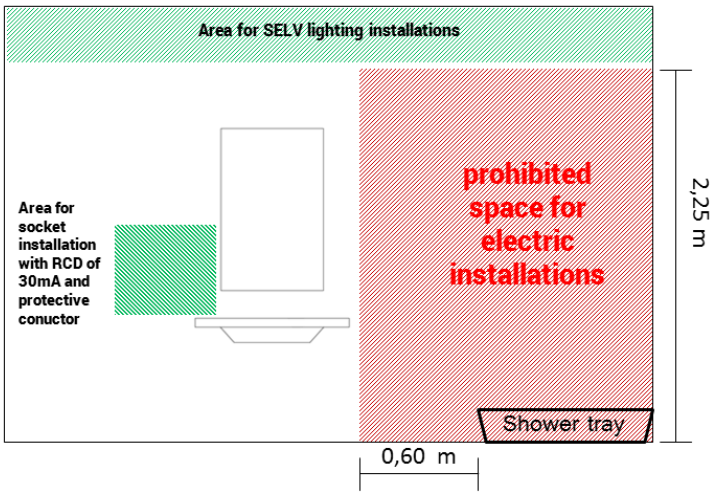


Figure 90: **Requirements for electric installations in the bathroom**

The bathroom's electric circuit is protected by a RCBO with a sensitivity of 30 mA (compare Figure 91) and the socket is provided with a protective conductor connecting the earthing-pins in the bathroom socket with IP44. The sockets will be placed on the washbasin's side averted to the shower tray, to maximize the distance between 230 V electric Systems and water carrying systems.

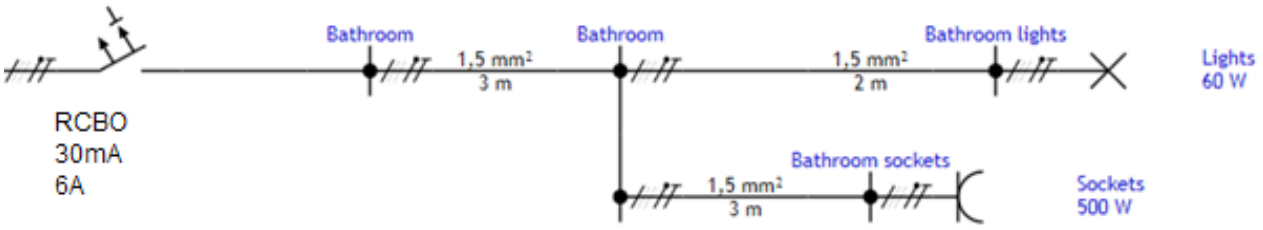


Figure 91: **The combined bathroom circuit for lights and socket is protected by RCBO device with a sensitivity of 30 mA**

Needs and Expected Contribution

Using the data from the energy balance chapter we have to provide an average day maximum load of about 4.2 kW. We have in total a maximum load current of 71.1 A due to the calculation software epINSTROM. This amount will be never reached because the probability that all our active devices are running at the same time is almost zero.

For detailed information see the section „Figure 92: Overloadprotection of the MCB devices integrated in the RCBOs“and Section 12.2.4.

Circuit	Consumer	Gain/load
Lights outside 1	LED lights SELV	84
Lights outside 2	LED lights SELV	49
Lights outside 3	LED lights SELV	78
Lights inside 1	LED lights	141
Lights inside 2	LED lights	67
Lights inside 3	LED lights	60
Bathroom	Sockets + LED lights SELV	545
Hob	Hob	3700
Oven	Oven	3700
Washing machine	Washing machine	2200
Dish washer	Dish washer	2200
Heat Pump	Stiebel Eltron heat pump	2000
Motor north	Single phase motors	8*400
Motor south	Single phase motors	6*400
Kitchen	4 sockets	400
Living room	8 sockets	250
Sleeping room	4 sockets	250
Outdoor sockets	4 sockets	500
Core module	2 sockets	500
GND	Grounding bar	0
Solaredge SE2200	PV plant	-1840
Sunways AT 3000	PV plant	-2875
DC-Charger	PV plant	-230

SECURITY DEVICES AND CONTROL SYSTEMS

Controlling system interaction

Smart meters for loads and grid feed-in will provide system information beside the inverters communication output and the battery communication. Everything comes together in the central controlling unit. The PV-Narrative Chapter and the Controlling System Chapter describe such system in more detail.

Security devices

To provide security for our resident's life the shutoff time for AC-circuits has to be below 0.2 s for DC-circuits and below 0.4 s for 230 V. DC-systems in our building with a voltage above 400 V (PV-circuits) have to provide shutoff times from maximum 0.1 s. DC-circuits with a voltage 230 V-400 V have to provide shutoff times below 0.2 s. These limits are provided by the use of the ABB RCBOs.

Main circuit breaker

The main circuit breaker connecting the inner housing grid from the external grid will have a RCD Type S of medium sensitivity (300 mA) and a breaking capacity of 6 kA. The rated current will be 63 A to provide 15 kW power with the 230 V one phase system. We will install a SPD type 2 under the main RCD to prevent surges in the electrical system.

Protection against overload

The MCB part of the RCBO devices has got a protection against overload (Figure 92).

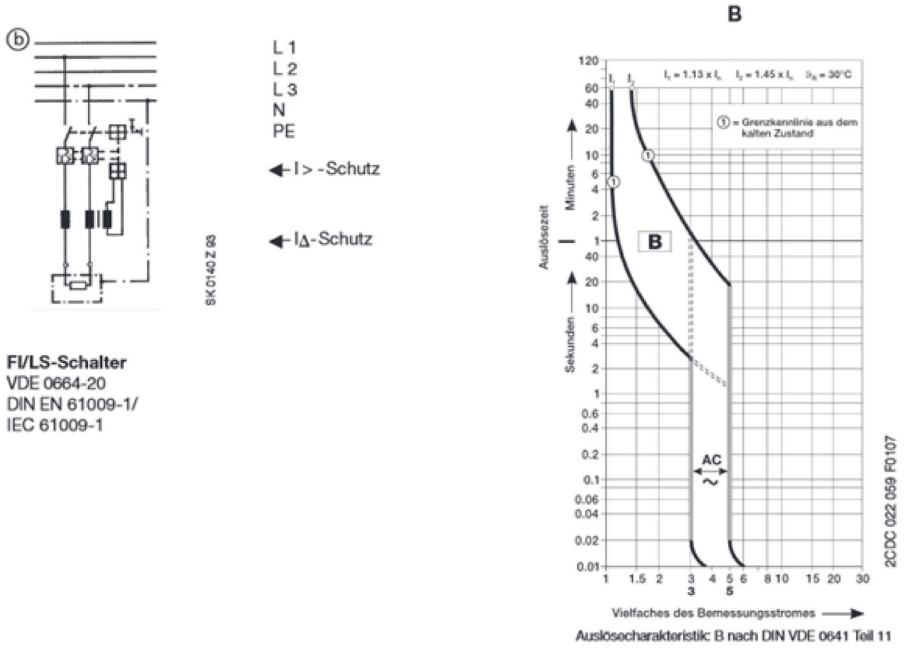


Figure 92: **Overloadprotection of the MCB devices integrated in the RCBOs**

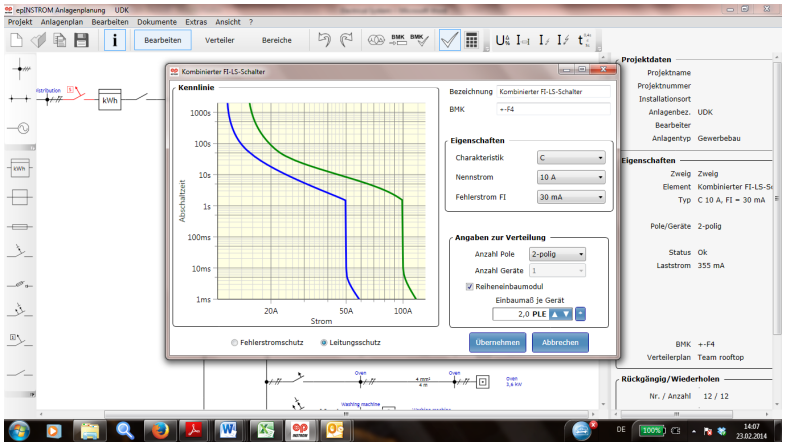
We propose to use the ABB DS951A RCBOs or an equivalent device with the same properties.

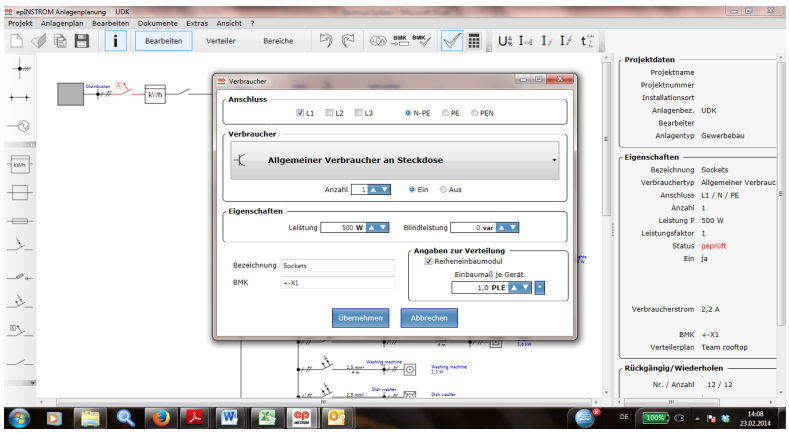
Property	ABB DS951A	Reference to rules
Number of poles	2	-
Rated current [A]	6|10|16|40	-
Type	A	Electric checklist p. 3
Sensitivity person protection [mA]	30	Electric checklist p. 3
Sensitivity fire protection [mA]	300	-

Residual Current Devices — Protection against direct contact

The electrical system of our house is according to DIN VDE 0100-410. Every circuit is going to be secured by an RCBO, an innovative combination of the classical RCD and MCB devices. The overload protection is thermal; the open circuit protection is electromagnetic in those devices. These guarantee us a maximum security with a low effort in installation and optimal spatial use. For the rating of these devices epINSTROM is a helpful tool. We manually input our data to calculate and simulate our electrical distribution system.

Calculating and choosing fuses and other protection devices is very easy in the epINSTROM software. After connecting branches defining circuits there is a wide range of consumers to choose. (See below) For this consumers you are able to choose a specific protection device (in our cases RCBOs) and to check the rating for compatibility with the system. There is a choice for single phase systems.





Calculating the fuses in epiSTROM

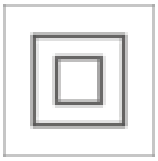
Beside the RCBs, there is another strategy to reduce the risk to health due to electric systems. The safest way is to prevent any direct contact with conductive or current-carrying parts. For this reason, our sockets will have children protection devices and we will choose the electric appliances respecting the best insulation class.

Every device has at least insulation class I and above. Electrical appliances and devices with insulation class I will be connected to the PE and the protective conductor. If we cannot avoid properties with IP I (As the Li-Ion batteries) we will store them in an appropriate envelop like a housing made of non-conductive plexiglass.

Electrical devices with insulation class II are double protected against indirect contact, hence there is no opportunity to contact parts under voltage.

Electrical devices with insulation class III are not allowed to be connected to the protection conductor. Class III devices work with protection transformers or run with safety extra-low voltage (SELV). Our lighting system in the bathroom will be working with SELV to grant maximum security for the residents.





Protection against indirect contact

We are going to ground every metal mass in the building to the general grounding-connection. Heating, plumping, water distribution pipes will be grounded, too. The earthing pins in the sockets are connected to the main earthing terminal to provide maximum protection, if class I insulated devices will be used.

See here the SELV-installations in the bathroom using a transformer for 100% separation between 230 V AC and 12 V DC.

More details see Section 12.2.4

EXTERIOR ELECTRICAL EQUIPMENT

We use special UV-resistant cables to guarantee a long-life installation without a risk for short circuits due to corroding isolation material. We cannot guarantee that our sockets installed at the terraces especially for the water pumps are at a water free surrounding, so we will use IP 65 sockets. The electrical distribution is thus safe from dust and dirt and against a direct water jet. The LED strips provide class IP 65 as well, so that there is no harm due to electric shocks. The transformers for the electric distribution of the lights on the façade will be mounted inside the building, so that they are not in any wet surrounding.

Fire fighter Protection and emergency shut down

A controllable contactor will be installed between external grid and battery inverter. In case of emergency shutoff the PV-Inverters stop feeding energy in the housing grid, because of their anti-islanding function. AC circles in the house are now without voltage. The very short DC-cables from the roof inlet to the inverters need no extra shutoff devices. Detailed wiring and device list will be handed in the upcoming deliverables.

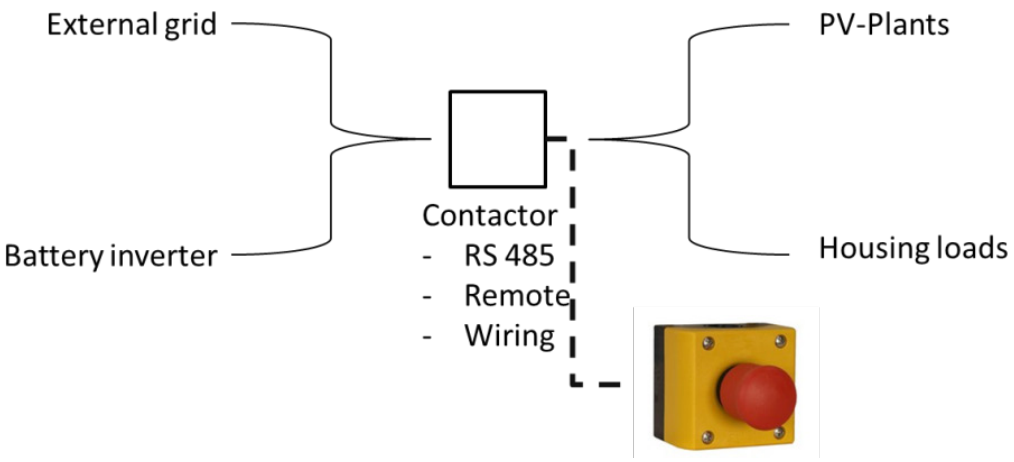


Figure 93: **An emergency switch seperates energy producing devices from grid and shutsdown the whole system.**

Provision of ground

Our grounding system is construed for the French TT grid and a single phase installation. All sockets and electrical consumers are installed with L1, N and PE-conductors. The earth line provided from the SDE-officials is connected to the central grounding bar in the core module's electric installation and provides the possibility for grounding for each of our technical devices by grounding brackets. Each grounding cable is going to be a green-yellow market halogen free cable.

Grounding for water distribution systems

Every water carrying system which is out of metal in kitchen and in the bathroom has to be grounded. Water pipes, for both fresh and grey water, sinks and the shower tray will be connected with a 6 mm² grounding cable directly to the grounding bar in the core module to reduce the risk of electric shock due to indirect contact or isolation failure.

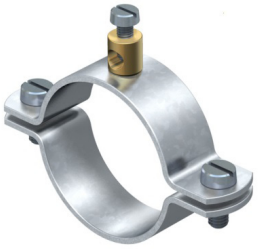


Figure 94: **Connection to ground for pipes**

One possibility of providing PE for pipes and heating installations is the use of this grounding clamps Typ 925 from OBO-Bettermann.

Maintenance and Repair

In order to provide an appropriate maintenance, the electric system has to be checked in regular periods by authorized and competent persons. There will be a catalogue of a detailed step-by-step introduction with measurement requirements and needed tools.

General steps to follow

Testing all the cables, fuses and devices for visible failures

Testing the PV-inputs for voltage and current

Checking communication lines for functionality

Connectors, clamps etc. have to be tight and fixed

Check the general monitoring values for irregularities

See the manufacturer's data sheets for further information

Values we need to provide a working and safe system

Resistance of the grounding system should be as less as possible but in any case below <2Ω;

Voltage and current of the PV generators have to be in the calculated ranges.

5.3.5 PHOTOVOLTAIC SYSTEM DESIGN

The Photovoltaic System of the house is designed to ensure that maximum solar energy is harnessed and caters for a large proportion of the house's energy consumption. The following sections describe the final PV System design for our house. For our innovative concept to share excess energy with the host unit see chapter 5.1.3 Individual or collective housing building project.

Figure 95 below illustrates a layout of PV modules on the house.

The northern and southern façades are mobile and follow the sun path. The fuctioning of these façades is described in Section In addition to shading, the southern façade has PV modules that generate electricity for the house. Modules will be mounted on the northern façade but only used after the competition. Each of the façade elements is able to move independently from each other.

Our PV plants are integrated within the architectonic concept of the whole building. They are not loose add-ons to the building, rather melting with the buildings optic. We believe that this aspect is immanent to raise the acceptance for the residents in the city to these form of energy production. In this synergy of engineering and architecture we knowingly adopt variations of common PV building standards for open space or classical plants.



Figure 95: **View oin the photovoltaic systems of the Team Rooftop Building**

PV SYSTEM: FAÇADE INTEGRATED AND ROOF MOUNTED SOLAR PANELS

Façade Integrated PV Design

The southern façade has 8 façade elements and each element will be mounted with 2 Solibro CIGS SL2 120 modules. This configuration still gives us a total energy output of 4.920 kWp and therefore it was decided to use 120W.

Solar Edge power optimizers with MPPT function will be used to achieve maximum power output and monitoring of the performance of each of the façade elements. These will be mounted behind the modules on each façade element. Figure 97 illustrates the layout of the modules on the Southern façade.

The power optimizers have a maximum power output of 400 W. Thus, with the new modules it is only possible to use 2 modules per façade. In total there will be 16 modules on the southern façade, delivering a maximum power output of 1920 W.

The data specifications for the power optimizers calls for a minimum of 8 and a maximum of 25 power optimizers within a string. This specification is still met with the new design. Furthermore, having two modules on each façade minimises the wiring and allows for each façade to move independently from each other. This was a restriction in the design proposed in Deliverable 3.

In the final design, the southern façade elements are connected in series to form 8 module pairs connected by a 6 mm² power line.

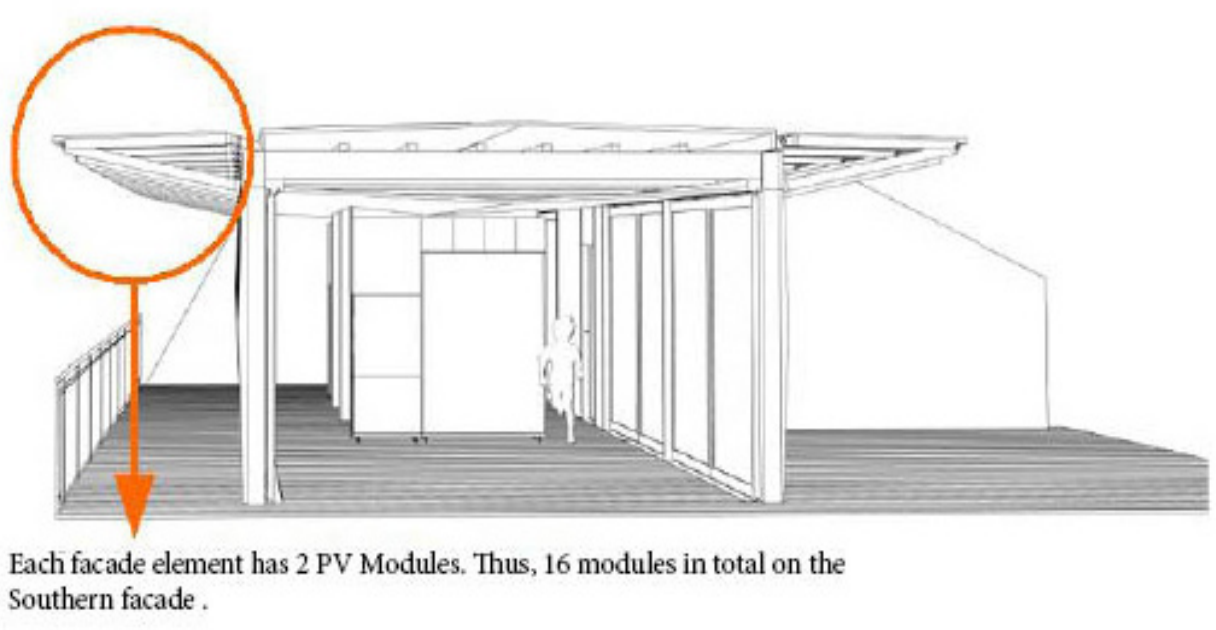


Figure 97: **Details of the PV-modules on the façade**

Power Optimizers and Inverter Configuration

The output from the power optimizers is connected to a surge protection device in the PV stringbox. This device is manufactured for our needs by the company HIS solar technologies. From the string box the cables career along to the SolarEdge Inverter in the core module.

Please see the project drawing PV-012 : General photovoltaic system for the detailed layout of the southern façade design.

The string box is mounted short before the roof provides surge protection type 2, ensuring that if there is a power spike, the inverter is protected.

The Solar Edge inverter converts DC current to the alternating current necessary for household appliances and for selling it to the grid. This type of inverter will be used as it is compatible with the Solar Edge power optimizers. The communication between the power optimizers and the inverter happens via powerline.

The power optimizers monitor each group of modules and communicate performance data to the inverter to provide a detailed overview of the behaviour of the modules, power analysis and reports of possible system failures. The MPPT function of the power optimizers allows for the independent movement of each façade. The power optimizers ensure that one string's maximum power is fed into the inverter. Thus, power optimizers are crucial for the optimal functioning of the façade design.

Overtime negative charge builds up on the TCO layer, causing damage to the PV module. The Solar Edge inverter is not able to prevent the negative charge. To overcome this inconvenient, a SMA PV Box is connected across the inverter. The SMA PV Box neutralizes the negative charge built up during the night, when no power is being generated in the solar panels. A functional grounding is not allowed due to the transformerless inverter.

The energy production of the façade will be monitored by a central web server, providing information to the home monitoring system.

Roof Mounted PV Design

The Solibro SL2 120W modules will be mounted in groups of 5 x 5 only. This is conforming to the restriction on the power of the battery bank inverter to be no more than 5000 VA, as explained in the Battery Management chapter. Modules will also be mounted but not connected on the northern side of the roof and they will not be used for the competition. Solibro, the manufacturer of the modules, guarantees that this causes no harm to the modules. They are able to withstand up to 1 month under direct sun without wiring.

The power generated from the 5 × 5 groups of modules will be fed in the AC housing Bus. See for more information the project drawings: especially PV-001 for inverter configuration and PV-013 for the string layout.

The modules within each of the 5 groups will be connected in series to form a string each. The modules are connected in series within each string to provide the maximum voltage to the Sunway Inverter.

On the roof, most of the shading occurs from the east and west direction. Thus, it was decided to group 5 modules as shown in Figure 99. In this layout, the shading will be significant only on the first and last string. If the modules in each group are connected in a row, then two strings on both the east and west side will suffer from shading.

The roof mounted PV panels are fixed on a substructure by the manufacturer k2-systems. The substrcture

will consist of two rails per row of modules, co–planar to the roof.

Figure 98 provides a top view of the Rooftop PV modules. The Rooftop PV plants do not need a functional grounding or a SMA PV-offset box as the façade string. The sunway inverter provides a negative potential-free operation of the strings due to its internal topography. This means that the TCO layer is not in danger of erosion. Solibro, our modules manufacturer, gave green light for using these inverters for their modules without a functional grounding.

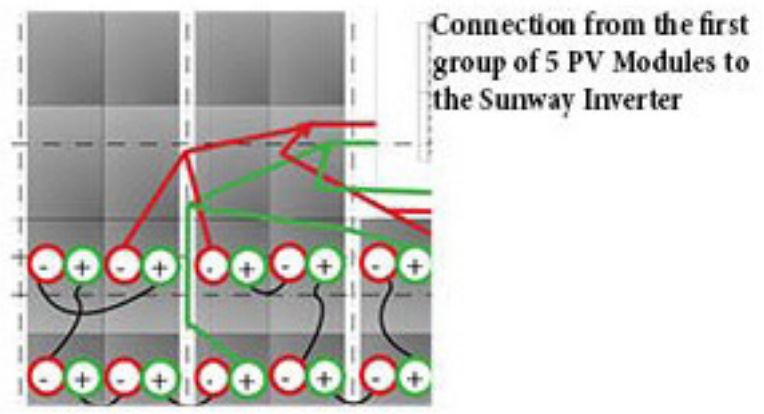


Figure 98: **details of the string connection on a part of the Rooftop PV-plant**



On the Southern Side of the rooftop there are 25PV Modules groups of 5. After the competition, 14 additional PV Modules will be installed on the Northern Side. The total modules on the roof will be 39.

Figure 99: **Modules will be installed on the roof of the building**

Inverter Configuration

In the final design, it was decided to leave out the power optimizers for the modules on the roof.

Please see the project drawing PV-001 : General Photovoltaic System for the detailed layout of the Rooftop design.

Similar to the set up for the façade integrated modules, the output from the Rooftop modules are fed into a string-Box with SPD device that connects the total output to a Sunway inverter. The Sunway Inverter prevents negative potential building on the TCO layer of the modules and thus a SMA PV Box or functional grounding is not required.

Please see project diagram PV- 012 : Rooftop plan for the wiring layout of the roof top and project diagram PV-011: Rooftop plan for the wiring layout on the façade.

PV SYSTEM DESIGN COMPONENT SPECIFICATIONS

The final PV Design consists of six strings: five strings for the PV modules on the roof and one string for the PV Modules on the southern façade.

Table 22 describes the characteristics of the string for the Rooftop modules. As it is the same design, the characteristics of each of the 5 Rooftop strings are the same.

Table 23 describes the characteristics of the string for the façade modules.

System		
Location:	Paris	
Climate Data Record:	Paris/Le Bourget Air (1961-1990)	
Number of modules/Pos	25/41	
String of 5 modules each		
PV Output:	3000	Wp
Gross/Active PV Surface Area:	23.5	m²
PV Array Irradiation:	26907	kWh/a
Energy Produced by PV Array (AC):	2908	kWh/a
System Efficiency:	12.82	%
Performance Ratio:	82.9	%
Inverter Efficiency (Max):	95.5	%
CO_2 Emissions Avoided:	2733	kg/a

Table 22: **Table: Rooftop Modules String Performance data**

System		
Location	Paris	
Climate data record	Paris/Le Bourget Air (1961-1990)	
Number of modules/Pos	16/16	
PV output	1920	Wp
Gross/active PV surface area	15.2	m²
PV Array Irradiation	171719	kWh/a
Energy produced by PV array (AC)	1910	kWh
System efficiency	12.43	%
Performance ratio	86	%
Inverter efficiency	97.6	%
CO_2 emissions avoided	1795	kg/a

Table 23: **Façade Modules String Performance data**

PV Panels

In the initial designs of the PV systems, it was planned to use manufactured monocrystalline PV modules on the southern façade. However, due to the wind load, weight and costs we decided to use the Solibro thin film modules with standard dimensions. Furthermore, thin film modules have a higher temperature resistance and are also less impacted through shading and diffuse light conditions if compared to monocrystalline modules.

Each Solibro SL2 120 thin film module has a bypass diode connected across its junction box to provide an alternative path for current flow in the case of shading. Thus, when shading occurs, the bypass diode prevents the degradation of performance and also protects the module from damage due to hot spots.

Table 24 outlines the characteristics of the Solibro 120 SL2 PV modules.

PV Module Name	Solibro SL 2	
Gross length	1190	mm
Gross width	789.5	mm
Height	7.3	mm
Weight	16.5	kg
Photovoltaic cell technology	Thin-Film | CIGS	
Cell dimensions	0.94	m²
Power P_MPP	120	Wp
Power tolerance †	+ 5 / - 0	Wp
Power tolerance ††	+/- 5	%
Wp/m2		Wp/m²
Module efficiency	12.8	%
Maximum power voltage†	76.9	V
Maximum power current†	1.56	A
Open circuit voltage††	97.6	V
Short circuit current†††	1.69	A
Maximum system voltage	1000 (IEC) / 600 (UL 1703)	V_DC
Temperature coefficient ofthe open-circuit voltage	- 0.29 ± 0,04	% / K
Temperature coefficient of the short-circuit current	+0,00 ± 0,04	% / K
Temperature coefficient of power at MPP	-0.38 ± 0,04	%/°C
Cable type	Solar Cable 2,5	mm²
Connectors	MC4	

Table 24: **Solibro CIGS SL2 115 Data Sheet**

† Measured under Standard Test Conditions (STC) of 1000 W/m2 irradiance, AM 1.5 G spectrum, 25°C cell temperature

† † Values of current, voltage and power +/- 10%

Inverter and Power Optimizer

In the plan presented in the Deliverable 3, all 50 PV modules were connected in one string, in groups of 4 and one group of 2, with a Solar Edge power optimizer for each. Only one Solar Edge inverter was needed. The power optimizers and inverter were from the same manufacturer and the configuration could be used to monitor the performance of all the modules.

However, to minimize the risk of damage caused by the negative charge build up on the TCO layer of the Solibro modules, it was decided to separate the strings. According to the manufacturer of the modules, Solibro, the Sunway inverter is certified to provide the best protection for the Solibro modules. As the modules on the Rooftop do not require power optimizers, they could be connected directly to a Sunway inverter. The absence of power optimizers also reduces the balance of system costs of the PV design. The drawback of this design is that it is not possible to monitor the performance of individual strings on the roof.

In contrast, the motion of the façade elements mandates power optimizers for each element. Thus, a Solar Edge Inverter is used for the southern façade albeit with a smaller maximum power input of 2.2 kWh. In Deliverable 3, the design had a larger inverter with maximum power input of 5 kWh to cater for the 50 PV modules.

The reasons for choosing the Solar Edge inverters for the southern façade string are the following:

- maximum power generation from each of the PV façades
- isolation of one façade from the others. Shading of one façade does not affect the others. The façades can operate in any orientation without affecting the others
- each power optimizer has its own MPP tracker
- the power optimizers are connected to the inverter with a communication system that allows a detailed surveillance of each modules performance
- modular design, easy to install
- power optimizers can be used instead of a standard junction box or simply connected to one
- a problem with one power optimizer does not affect the power generation of the other modules.



Figure 100: **Solar Edge Power Optimizer**

The following table lists the data specifications of the Solar Edge Power optimizer illustrated above.

Technical Specifications	OP400-EV
Input data (DC)	
Rated input DC power (STC with up to 5% power tolerance of the module)	400 W
MPP operating range	15 V – 125 V
Absolut maximum input voltage (V_oc)	125 V
Maximum continuous input current (I_sc)	7 A_dc
Maximum efficiency	99.5
Weighted efficiency	98.8
Overvoltage category	II
Output Data (DC)	
Maximum output current	15 A_dc
Operating output voltage	5 – 60 V_dc
Safety output voltage per power optimizer	1 V_dc

Installation Specification	
Maximum allowed system voltage	1000 V_dc
Dimensions (L × W × H)	210 mm × 143 mm × 45 mm
Weight	450 gr
Input connector	MC4/Tyco/H+S/Amphenol
Output wire type	6 mm²; MC4
Output wire length	1.6 m
Operating temperature range	- 40 °C to + 65 °C
Protection rating	IP 65 / NEM A4
Relative humidity	0 – 100 %
Minimum string length (Power Optimizers)	16
Maximum string length (Power Optimizers)	50
Maximum power per string	11250 W
Parallel strings of different length or orientation	Yes

Table 25: **Table: Solar Edge Power Optimizer Data Sheet**



Figure 101: **Solar Edge Inverter SE2200**

The following table lists the data specifications of the Solar Edge Inverter SE2200 illustrated above.

Technical Specifications	SE2200
Input Data (DC)	
Recommended maximal DC power (STC)	2400 W
Transformerless, ungrounded	Yes
Maximum input voltage	500 V_dc
Nominal DC input voltage	350 V_dc
Maximum input current	8.5 A_dc
Reverse polarity protection	Yes
Ground – fault isolation detection	600 KOhm sensitivity
Maximum inverter efficiency	97.6 %
European weighted efficiency	97.6 %
Nighttime power consumption	< 2.5 W
Output data (AC)	
Rated AC power Output	2200 VA
Maximum AC power output	2200 VA
AC output voltage (nominal)	220/230 V_ac
AC output voltage range	184 to 264.5 V_ac
AC frequenzy (nominal)	50 / 60 ± 5 HZ
Maximum continuous output current	12 A
Residual current detector/ residual current step detector	300 / 30 mA
Utility monitoring, islanding protection, configurable power factor, country configurable thresholds	Yes
Standard compliance	
Safety	IEC 62103 (EN50178), IEC-62109
Grid connection standards	VDE 0126-1-1,VDE-AR-N-4105, AS-4777, RD-1663, DK 5940
Emmisions	IEC61000-6-2, IEC61000-6-3, IEC61000-3-11, IEC61000-3-12, FCC part15 class B
RoHS	Yes
Installation specification	
AC output	Cable Gland – diameter 9-16 mm
DC input	2 MC4 pairs
Dimension (H × W × D)	540 mm × 315 mm × 191 mm
Weight	21.7 kg
Operating temperature range	-20 °C to +50 °C

Cooling	Natural Convection
Noise	< 50 dBA
Protection rating	IP65 – Outdoor and Indoor
Bracket mounted (bracket provided)	
Additional features	
Supported communication interfaces	RS485, RS232, Ethernet, Zigbee (optional)

Table 26: **Table: Solar Edge Inverter SE 2200**

Lightning and Protection

Lightning protection for the Rooftop House is essential to prevent harm to the inhabitants and the house infrastructure, especially due to the house positioning.

German law requires Surge Protection D Type 1 for buildings at an altitude of more than 23 m above ground. The competition rules require SPD Type 2 protection. Thus, we will install SPD Type 2 protection for the competition and SPD Type 1 when the house will be reconfigured in Germany. It is intended to use SPD-string-boxes from Hensel with the required protection class.

According to German standards (VDE V 0675-39-12, DIN EN 62305), lightning protection needs to be done by a registered expert in the field. Once the house will be back to Berlin, a lightning installation specialist will be consulted to design the lighting system of the house. This additional lightning system beside the existing SPD protection is only used for the application in Berlin. For the competition the SPD Type 2 are sufficient.

Surge Protection

Surge protectors are devices that are installed in the combiner box of the system. In the house, they are provided by a string box located on the roof, before the entry into the main house. These devices protect the circuit against surges and spikes in electricity.

In addition, SPDs will be used under the main RCD Type S in the housing energy line.

Another way to protect against surge-related problems is to reduce the number of loops in the electrical circuit. This will be noted when laying down the wiring. Please see project drawings PV-011 and PV-012 for the string diagrams. The DC cables go directly to the house inlet.

Earthing

Earthing of the system protects the inhabitants from potentially fatal shocks due to short-circuits. Please see project drawing PV-031: Grounding system for a schematic of the grounding system for the PV system and the Section 5.3.4 and 12.2.4.

In the new design, the Sunway Inverter provides protection against the build of up negative change whilst the SMA box or the Solar Edge Inverter eliminates the negative charge build on the façade modules. In this way, there is no further need for functional grounding.

The rails of the PV substructure will also be earthed to ensure that there is no voltage on the metal structure if there is poor cable isolation.

As regulated, all inverters will be grounded to the earth.

The earth conductor needs to be connected in the shortest way to the earth electrode. No loops are permissible; they should be laid straight and vertical.

Fire protection

The following steps will be taken to protect the building from fire:

- We will not install DC-cabling and inverter at stairs and escape routes.
- We will mount inverter and all electrical connections on a ground and surroundings which is not inflammable.
- We will use suitably insulated wires.
- Our selected power optimizers have an integrated open circuit protector. They automatically decrease the voltage on a harmless value of 1 V DC
- DC-wiring connecting the inverters with the PV panels in the interior will be duct through fire protective cable channels with E30I90 certificate.
- An emergency stop button will be installed in the floor to shut down the PV-inverters and the studer in case of fire and emergency.

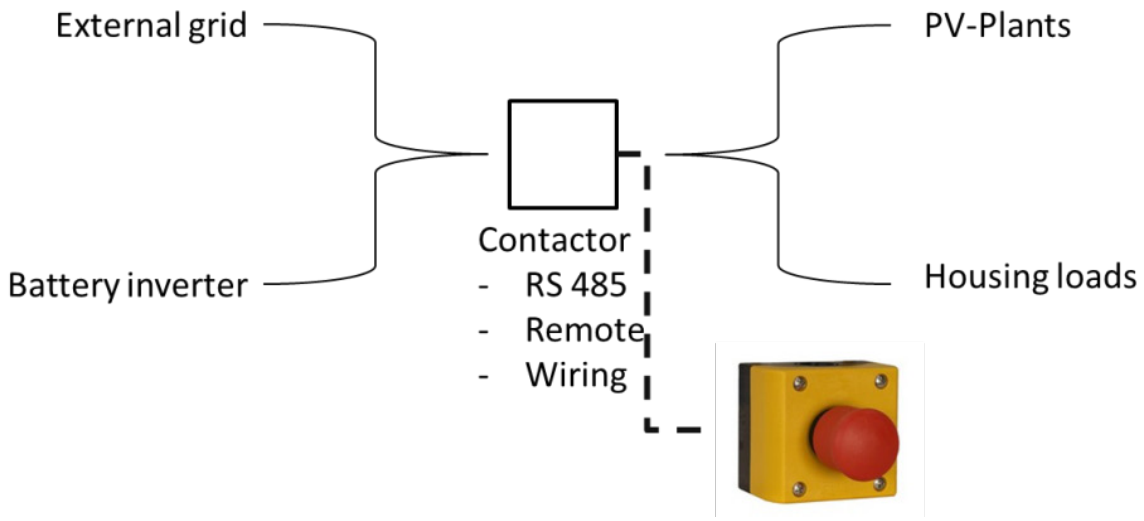


Figure 102: **Firefighter protection and emergency switch**

MAINTENANCE PLAN

This section explains the maintenance procedures that are important to ensure longevity of the Rooftop system.

Photovoltaic modules:

- The PV modules should be cleaned frequently to avoid power loss due to a layer of dust on the surface of the panels.
- Connectors and wires should be checked to see if they have been chewed away by animals or are corroding.
- The façade systems mechanical parts would have to be serviced every 2-3 years just to check their structural and electrical integrity.
- The gears and mechanisms need to be oiled and checked.

Supporting Structure:

- The supporting structure for the PV modules is the façade frame which supports a dual axis motion of the panels. Hence, to ensure its integrity we need to ensure that no more than the designed load is resting on the frames. These frames are built for a good amount of snow loads, but the home owner should remember to close the façade in case of heavy snow accumulation.

Cable and wiring

- Cabling and wiring should only be touched by an electrician.
- Checks should be done periodically for short circuits and current leakages.

MOUNTING SYSTEM

The Rooftop and façade modules will be mounted on horizontal mounting rails. The system that will be used is the K2 SpeedRail system. The speed rail system is certified for the SL2 Modules. This is the most suitable solution for both the grooved structure of the roof and the flat surface of the façade.

The rails will be mounted using speed clips that are easily fastened. The layout of the rails on the roof will resemble Figure 103 (Source : K2 Systems SpeedRail Data Sheet).

Once the rails are locked in, the PV modules will be clamped into the structure with the K2-Clamps. The big advantage is the fast mounting technology of the speed rail system. In our previous experiences with PV plants, the installation of the substructure takes about half of the total PV installation time. Thus, with a user-friendly and easily mountable structure, we can significantly reduce the PV installation time for the house.

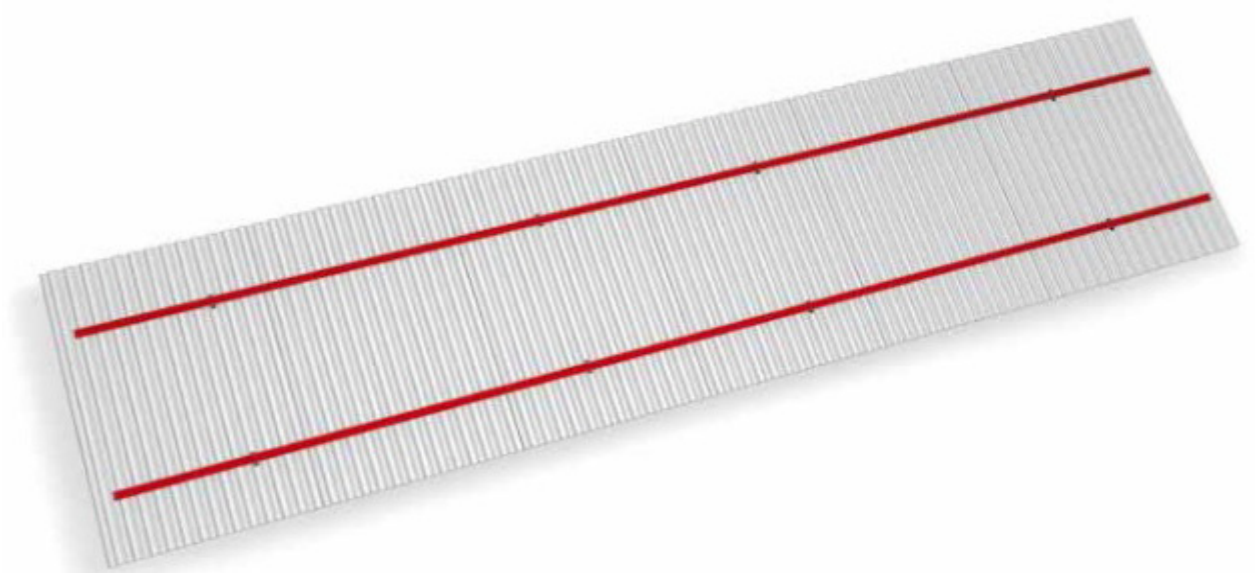


Figure 103: **We need two rails of K2 speed rails for aonerow of modules**

Each module will be fixed with 4 clamps, as this is the requirement for frameless glass-glass PV modules. As recommended by Solibro and visible in **Figure 104**, a minimal gap of 15 mm between the back of module and the rail is foreseen under a load of 2400 Pa.

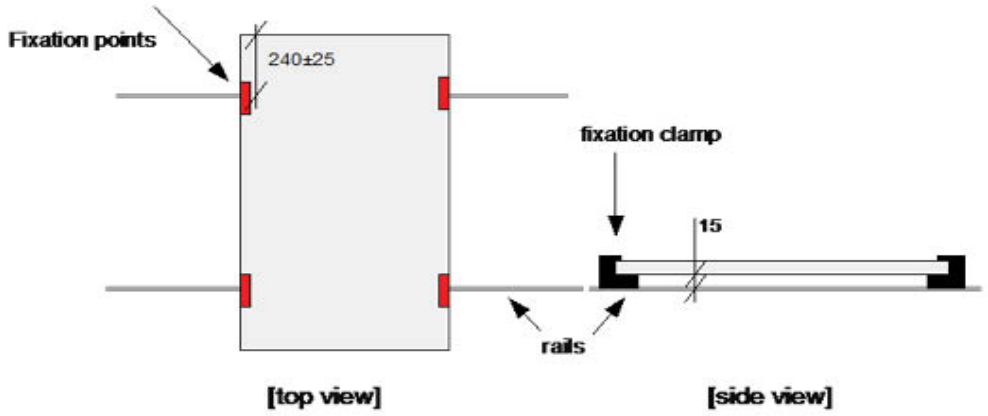


Figure 104: **Mounting Requirement for SL2 115 PV Modules.jpg**

The ending clamps and the centre clamps needed for the Rooftop modules and the southern façade are as shown below. Figure 105 illustrates the clamping for a section for the façade and the roof:

Number of ending clamps

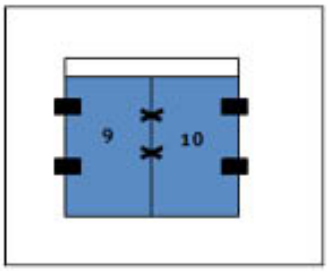
Southern roof side: 8 × 5 + 4 × 1 = 44

Southern façade: 4 × 8 = 32

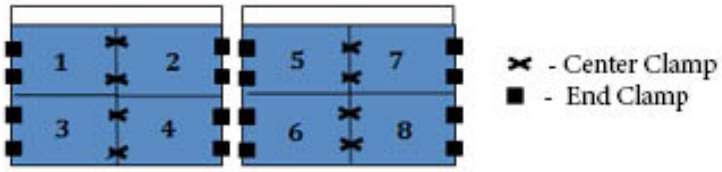
Number of centre clamps

Southern roof side: 4 × 5 + 1 × 2 = 22

Southern façade: 8 × 2 = 16



a) Layout of End and Center Clamps on Facade Module



b) Layout of End and Center Clamps on Rooftop Group of 5 Modules. Modules 1,2,3, 4 and 5 make one group.

Figure 105: **Layout of the K2 clamps certified for Solibro SL2 moduls**

BATTERY AND ENERGY MANAGEMENT

In times of the energy transition, for instance in Germany, it is important to create efficient storage options for renewable generated electricity. The growing use of renewable energies lead to more energy fluctuations due to variations in production and consumption within the grid.

The time and amount of electricity that will be produced is dependent on renewable resources like the radiation from the sun, the ocean (tidal power plant) and wind. A system of decentralised storage units in private use across the country and a smart grid will help address the energy storage issue. For our Rooftop House we considered different possibilities of energy storage to store additional energy produced and use when there consumption is maximum.

The energy storage option chosen for the house was the Lithium-Ion battery. The intention was to use as much of the PV generated energy as possible. The battery allows to store excess PV generated energy and to make it available during times of high energy consumption. By using an intelligent energy management system, we can eliminate or at least reduce the peak energy demands on the grid.

The AC current from the Sunway and Solar Edge Inverters can be fed to the Studer Xtender, to the house's grid or to the individual components. In addition, excess PV generated energy can also be fed to the main grid. Based on the different options described above, the energy management system controls the flow of energy.

It is accepted that energy losses are encountered during the conversion from AC to DC at the Studer inverter for storage into the battery.

The Studer Innotec inverter charger does not have anti-islanding capability compliant with DIN-VDE-126-1-1. This fact was confirmed by the manufacturer. However, this is currently the only inverter charger type in the market which is able to deal with the given parameters. Other inverter chargers offering anti-islanding capability and compatible to our parameters are no longer on the market. Thus, it was decided to use the Studer Innotect inverter charger.

For anti-islanding functionality, we decided to use the UfE ENS26NA network and system protection unit that is compliant with standard DIN-VDE-126-1-1.

The battery management system is a labour intensive task because it requires expertise in the areas of electrical engineering, controlling and programming. In order to design and implement the battery management system, we work closely with the manufacturer of the battery inverter and the retailer of the super B Li-ion batteries. The main work will be done by the Xtender's communication and regulation tools xcom232i and RCC-01. By means of this combined package, we are able to program the battery's and inverter's parameters using the Ethernet connection of the xcom232i device. Furthermore, we are able to define loading times, loading modes and battery management strategies. A smart management system using the housing load data, expected PV production and so on will be a central part of the controlling and regulation part.

In a standard configuration, the grid output is given priority over the inverter output. However, in this project, the aim is to keep the grid energy consumption to a minimum and use the PV generated energy as much as possible. In accordance with Studer, it was decided to use an external automatic bypass circuit to ensure that the inverter output is given priority and fallback to grid occurs when strictly necessary. Figure 106 gives

a detailed representation of the layout of the mechanism.

The delay switching system ensures that the inverter output is given priority. Thus, as long as the energy stored within the battery is enough to meet the requirements, grid energy is not used. Furthermore, the switching system ensures that the house load sees a constant power curve when changing energy source from grid to battery.

Switched power	max 5750 W
Own consumption	1.5 W
Housing	Plastic, suitable for housing on the top hat rail
Overall dimensions (W x H x D)	146 mm x 99 mm x 125.4 mm
Cut-out dimensions (W x H)	146 mm x 73 mm
Ambient conditions	-20⁰ C to + 40⁰C, 10 to 90% relative humidity,non condensating
Nominal current of power feeder	25 A
The unit disconnects the mainds under the following define conditions (comply-ing with regulation VDE-AR-N-4105 and standard DIN V VDE V 0126-1-1/A1):	
Overvoltage (fast shutdown)	> 300 V (response time 20 ms)
Overvoltage	> 264 V (response time < 200 ms)
Overvoltage	230 V + 10% over 10 minutes
Undervoltage	<184 V (response time < 200 ms)
Frequency Division	-2.5 Hz / + 1.5 Hz (response time < 200 ms) optional: + 0.3 Hz to + 1.5 Hz statistically distributed (response time < 200 ms)
Impedance jump detection	> 0.5 Ohm (response time 500 ms)

The energy management system has four different modes :

Mode 1 :

In this mode the house's power requirements are provided by the PV panels. The energy management system secures the requirements of the building's consumers and charges the battery with excess energy. Any excess energy after the battery is charged is fed to the grid.

Mode 2 :

In this mode the required power is provided by both PV panels and the battery. This is the maximum power consumption mode and also the evening mode. If the battery is full and the PV system cannot guarantee the energy demand, the battery starts its back-up function.

Mode 3 :

This mode is the stand-by mode when energy consumption is low. This is most likely to occur during the night. In this mode, when there is no PV energy production, the battery supplies the building's energy consumption. This is mainly the energy demand of devices in stand-by mode and the buildings other technical functions.

Mode 4 :

When the battery is low and there is insufficient energy production by the PV panels, grid fallback starts. As the battery is not to be charged with expensive grid energy, the energy management system disconnects the battery.

The inverter charger Xtender can handle a constant power of 5000 VA for a period of 30 minutes, or a constant power of 4500 W. This amount meets the requirements, where the nominal power of the battery bank inverter is limited to 5000 VA.

In Deliverable 4, it was proposed to use a smaller charger powered by two PV modules on the roof as a precaution to ensure the battery does not drop to undervoltage. However, it was found that the charger with MPPT functionality required for the Lithium Ion Battery has a nominal power of 2000 W. In combination with the Studer Inverter, this extra precaution would increase the battery bank inverter capacity to over 5000 VA.

Thus, it was decided to leave out the battery charger, further simplifying the design.

Figure 106 explains the process of switching between different energy sources.

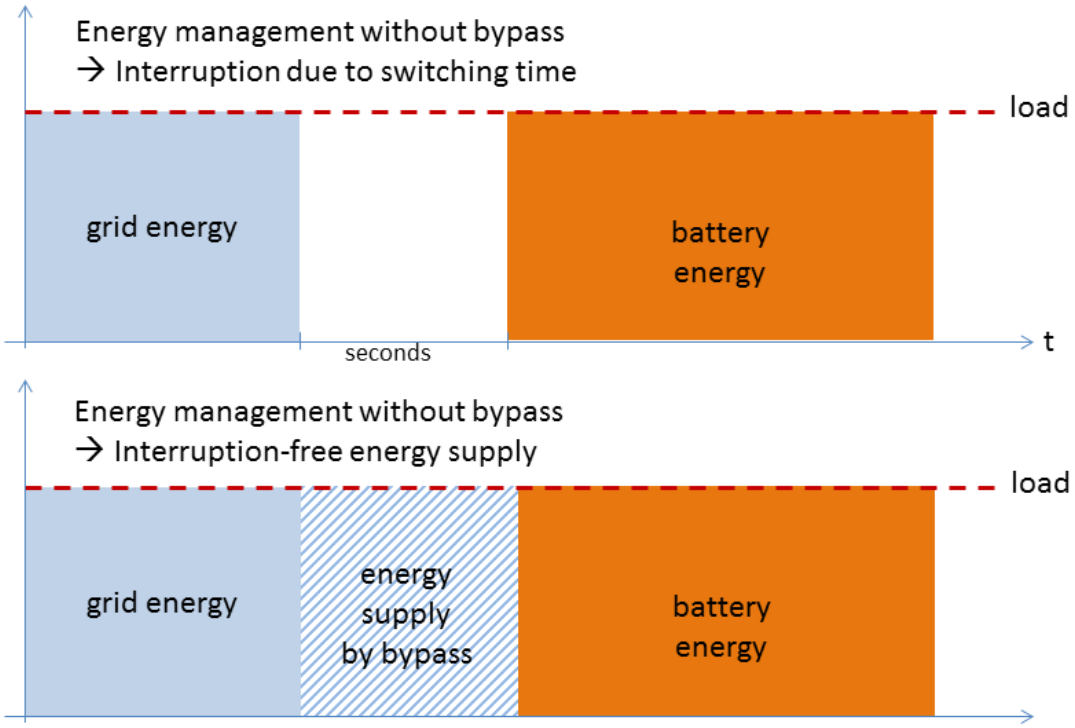


Figure 106: **Bypassing the battery inverter.**

The current design does not ensure an interruption-free switch from the inverter output to the grid output. This aspect will have to be finalised in the coming weeks. With the use of the bypass system and the programming of the Inverter, it will be possible to control the flow of energy within our system.

As far as it concerns the storage, we selected the super B Li Ion battery as it offers the best capacity possible. The SuperB-12V160E is a 12 V battery. We are going to install them in series to increase the system voltage up to 24 V as required from the Xtender. The batteries have a rated capacity of 2112 Wh each. Thus, the total capacity of the battery bank is under 6 kWh. See the data sheet and the material safety datasheet of the battery in the Section 12.2.4.

Figure 107 illustrates the wiring of the battery bank.

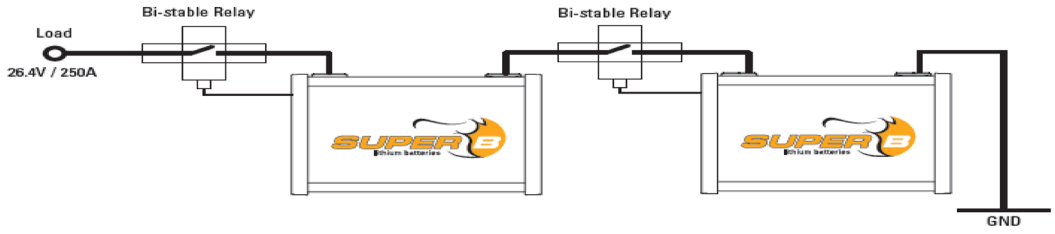


Figure 107: **Wiring of the hard wired battery bank**

Nominal voltage	13.2 V DC
Charge method	CCCV
End of charge voltage	15 V DC
End of charge voltage for endurance (cycle life)	14.6 V DC
Charge current	160 A (1C)
Charge current for endurance (cycle life)	52.8 A (C/3)
End-of-discharge voltage 8V DC	
End-of-discharge voltage for endurance (cycle life)	10V DC
Maximum serial string connection voltage	1150 V DC
Discharge current	480 A (3C)
Discharge current for endurance (cycle life)	52.8 A (C/3)
Discharge pulse current (10 seconds) (external fuse)	1280 A (8C)
Discharge pulse current (60 second) (external fuse)	800 A (5C)
Discharge performance at 20 °C (rated capacity)	160 Ah / 2112 Wh
Discharge performance at –20 °C (capacity)	104Ah / 1372.8 Wh
High rate discharge performance at 20 °C (capacity)	144 Ah / 1841.4 Wh
Short-circuit protection (fuse):	500 A
Self discharge:	± 10 % per year

Table 27: **SuperB 160E12V**

Inspection

1. Inspect for loose and/or damaged wiring and contacts, cracks, deformations, leakage or damage of any other kind. If a damage at the battery is found, it must be replaced. Do not attempt to charge or use a damaged battery. Do not touch the liquid from a ruptured battery.

2. Observe and note the run time that a new, fully-charged battery provides for powering your product. Use this new battery run time as a basis to compare run times for older batteries.

The run time of the Li-Ion battery will vary depending on the product's configuration and the application it is used for.

3. Routinely check the battery's charge status. Lithium Iron Phosphate batteries continue to slowly self-discharge (10% per year) when not in use or while in storage.

4. Carefully monitor batteries that are approaching the end of their estimated life.

5. Consider replacing the battery with a new one if you note either of the following conditions:

The battery run time drops below about 80% of the original run time.

The battery charge time increases significantly.

Cleaning

If necessary, clean the Li-Ion battery with a soft, dry cloth. Never use liquids, solvents, or abrasives to clean the Li-Ion battery.

Maintenance

The Li-Ion battery is maintenance free. Charge the battery to approximately 50% of its capacity at least once every 2 years to preserve the battery’s capacity.

MONITORING EVALUATION OF PROTOTYPE IN VERSAILLES

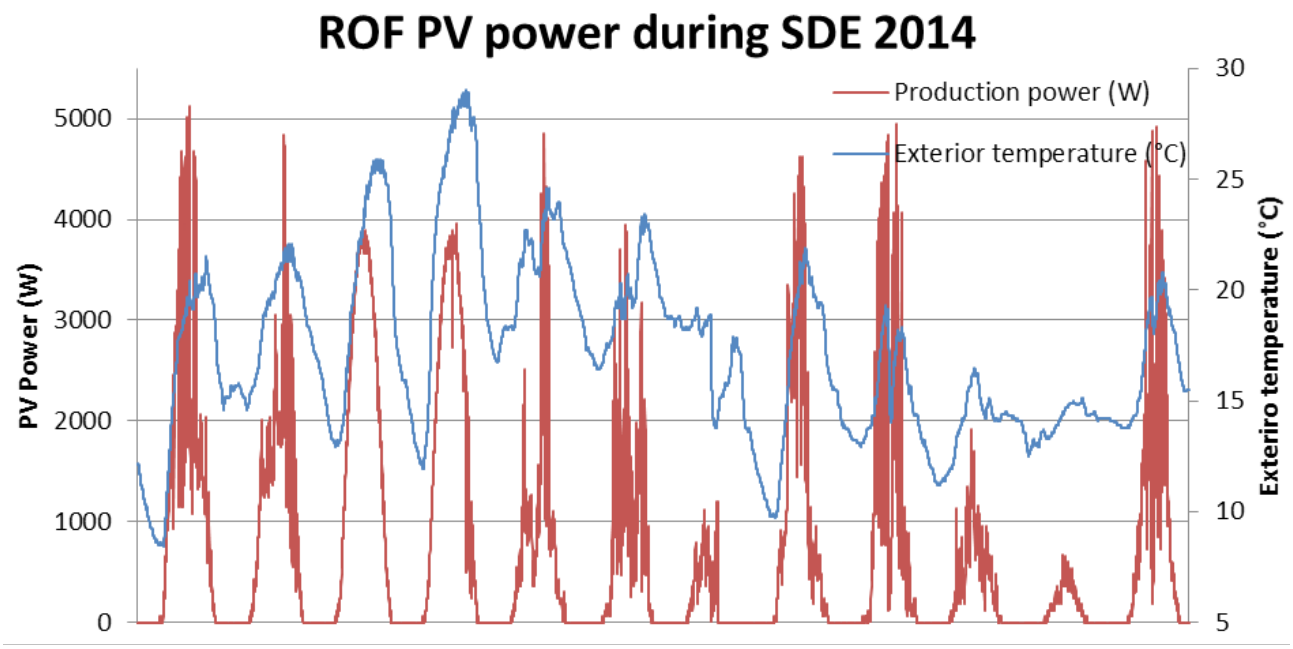


Figure 108: **PV power production and exterior temperature during the competition phase**

The maximum performance of 5 kW was achieved several times (see Figure 108). Furthermore, it's interesting to see the influence of the exterior temperature on the performance. On the hot and cloudless days 3 and 4, the highest performance is 1 kW lower than on the more cloudy days (for example day 1) that only permitted few sun breaks: those conditions are optimal. During the whole competition phase, an overall efficiency of 11.8% was achieved.

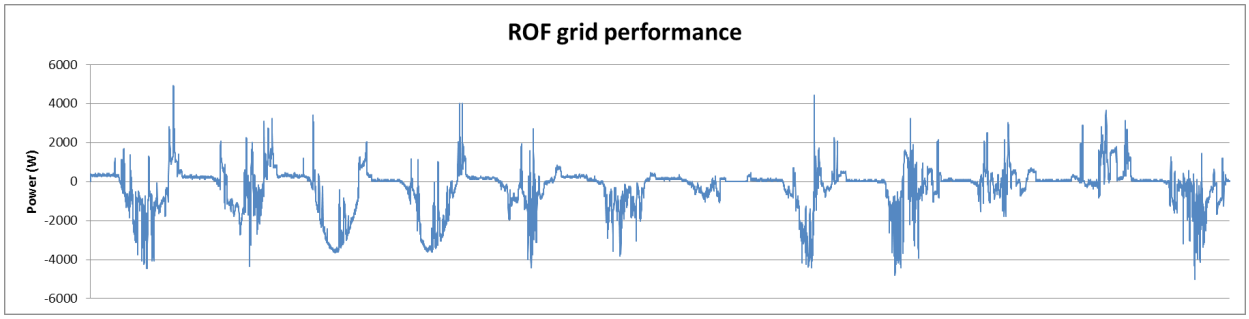


Figure 109: Grid performance of the prototype during the competition

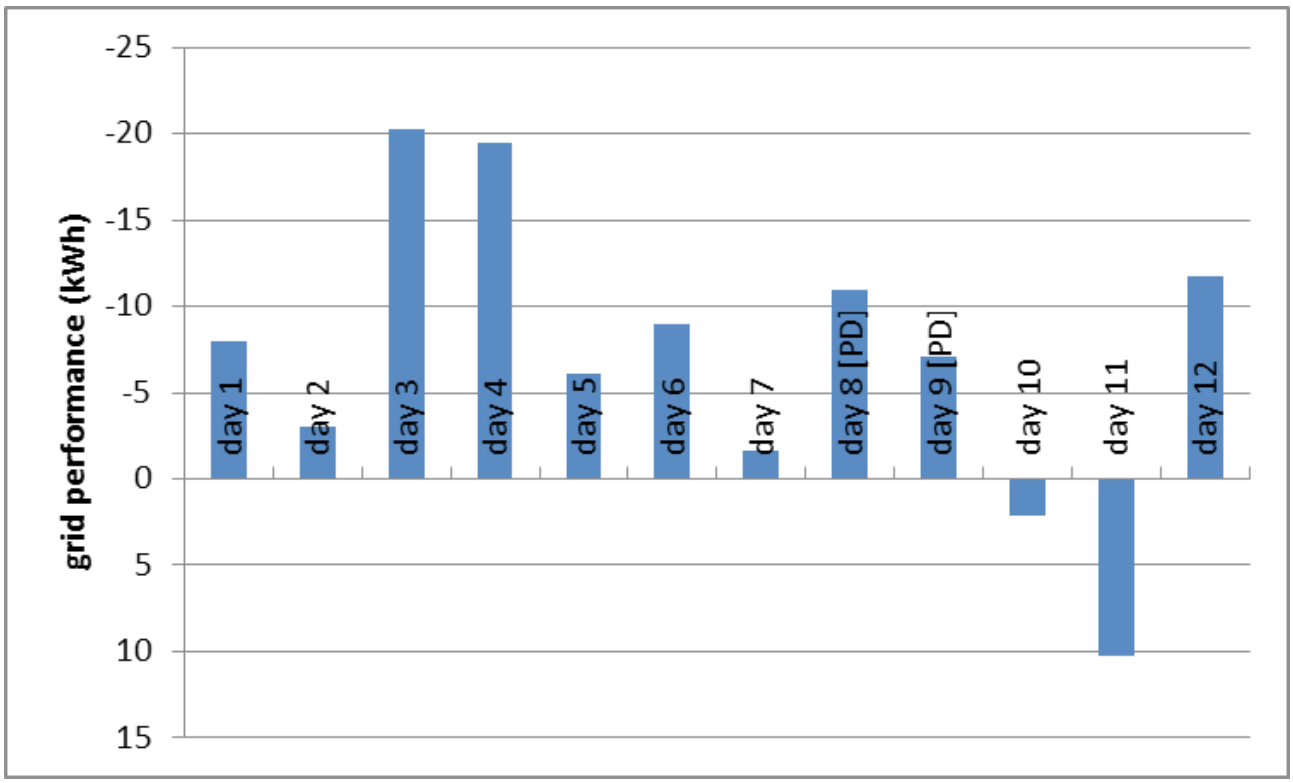


Figure 110: **Day specific grip performance of the prototype during the competition phase**

On almost every day, an excess of electricity could be measured (see Figure 109). The days 3 and 4 were especially fruitful with an excess of around 20 kWh. However, on day 11, which was very cloudy, we had to take around 10 kWh from the net (see Figure 110). With the installed 5KWp solar system, a solar coverage of 174% is the result of the 12 day time phrame.

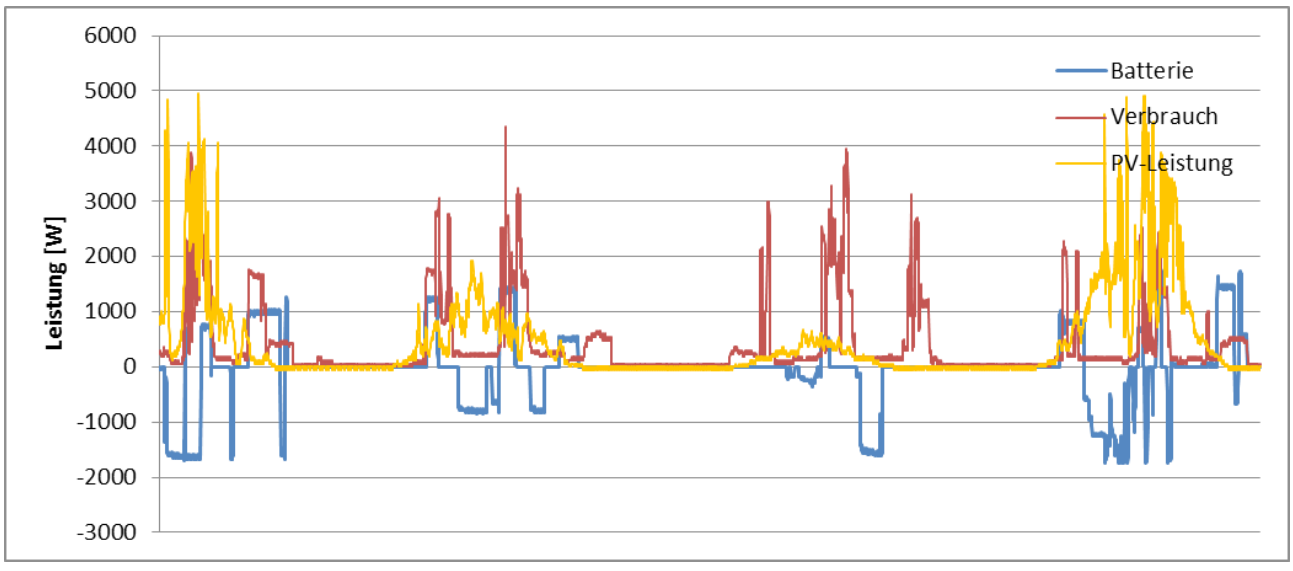


Figure 111: **Battery performance, photovoltaic production and consumption during the last four days of the competition**

The battery has only been used manually at the end of the competition phase. The manual usage of the battery could not be perfectly synchronised with the peak times of the photovoltaic production and energy consumption. We could have achieved better results with an automatic controlling system (see Figure 111).

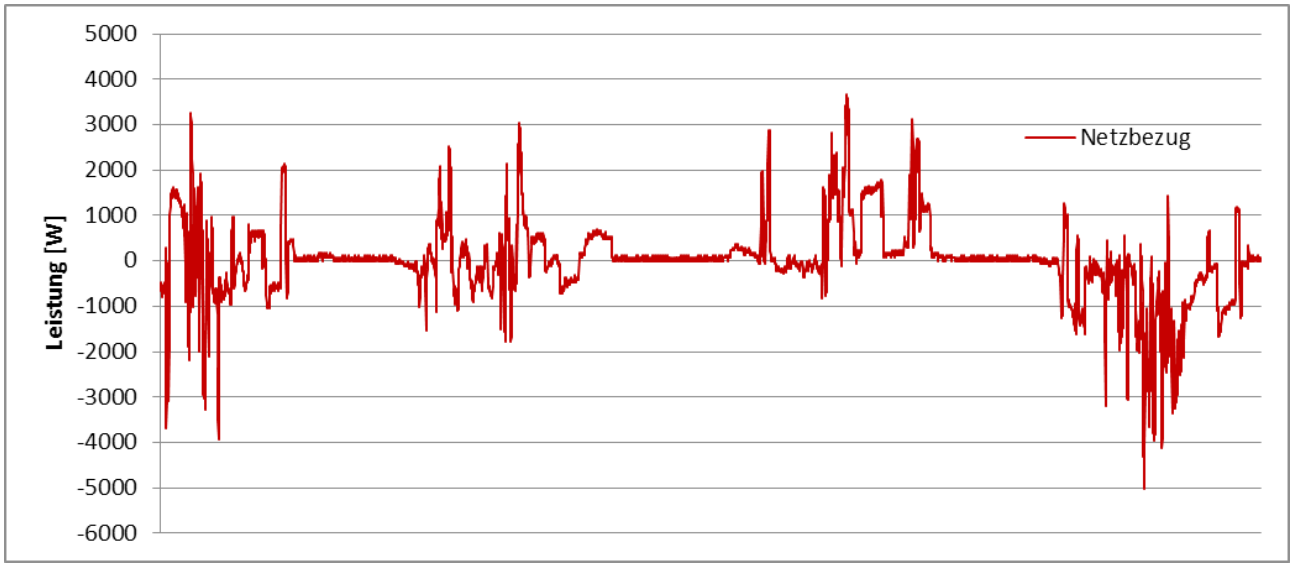


Figure 112: **Net draws as a result of consumption and battery performance during the last four days of the competition**

Figure 112 reflects the results of Figure 111. If you compare the days 1 and 4, you can see that even with manual usage of the battery, the consumption peaks were reduced and the net draws minimised

5.3.6 ELECTRICAL ENERGY BALANCE SIMULATION

To simulate the energy balance of the house, it was necessary to take all the electronic devices (e.g. pumps, ventilators, lights, appliances) which are running in the house, assume the user behaviour and oppose this to the energy production of the PV modules. For the appliances we took very efficient, energy saving devices. Most of them have an energy rating class of A++. Here is a list of all the appliances we took and all the assumptions we had to make concerning the user behaviour expecting that the house owner has a good environmental awareness and is mindful of not wasting energy:

Appliances

Refrigerator + freezing combination:

Miele KFN 37452

Refrigerator size 196 l > 170 l (SDE rule)

Built in freezer size is 59 l > 57 l (SDE rule)

Takes about 228 kWh/a

220-240 V AC, 50 Hz

Connected load: 90 W

Washing machine + dryer combination:

Miele WT 2789I (A)

3,7 kWh per washing and drying program at 60°C

0,8 kWh per washing cycle

196 kWh/a for 53 standard washing cycles per year (one time in a week)

220-240 V AC, 50 Hz

Water-consumption: 69 l

Connected load: 2200 W

Dishwasher

Miele G 4860SCVi

Energy-consumption: 0,7 kWh

Water-consumption: 6,5 l

guessed energy-consumption per year 102 kWh/a aby running it 122 times/year

220-240 V AC, 50 Hz

Connected load: 2200 W

Fuse Protection: 10 A

Oven

Miele H 6860 BP

0,89 kWh per standard meal

Takes 288 kWh/a if the oven runs every day

220-240 V AC, 50 Hz

Connected load: 3700 W

Hob

Miele CS 1222 I

0,79kWh per standard meal

Takes 288 kWh/a if you cook every day of the year

220-240 V AC, 50 Hz

Connected load: 3700 W

TV

LG 32LA6678

Takes 14,5kWh/a if it runs every second day 2 hours

220 - 240 V AC, 50/60 Hz

Connected load: 40 W (Standby 0,4 W)

Light

465 W (275 W interior lighting + 190 W exterior lighting)

MAIN ENERGY CONSUMERS

The first scheme shows the yearly energy consumption of each appliance. Devices with the biggest amount of energy are oven, hob, refrigerator, washing machine and the lighting.

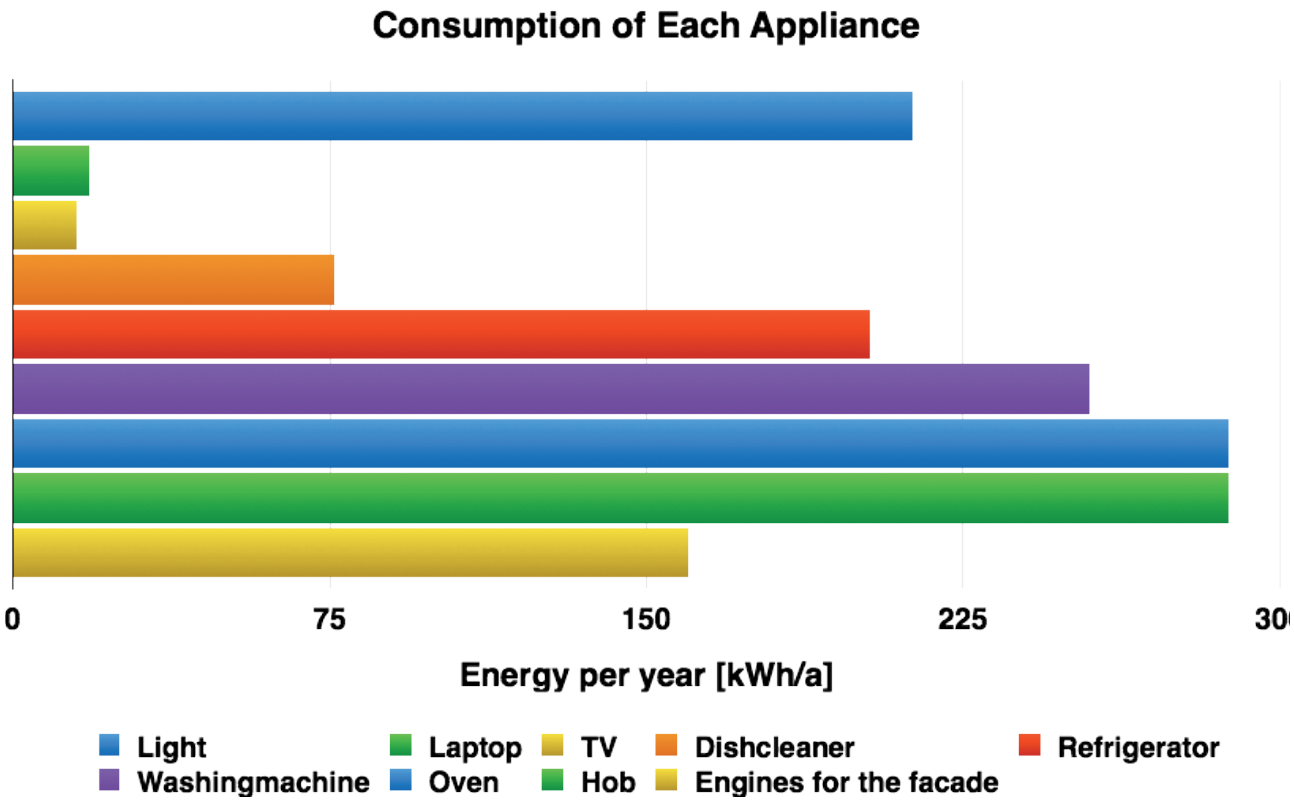


Figure 113: **Consumption of each appliance per year**

The Appliances listed above will take about 1460 kWh per year if we assume following usage behaviour. The house owner cooks every day of the year, the washing machine runs one time in a week, the dishwasher runs every third day and the television runs every second day for two hours.

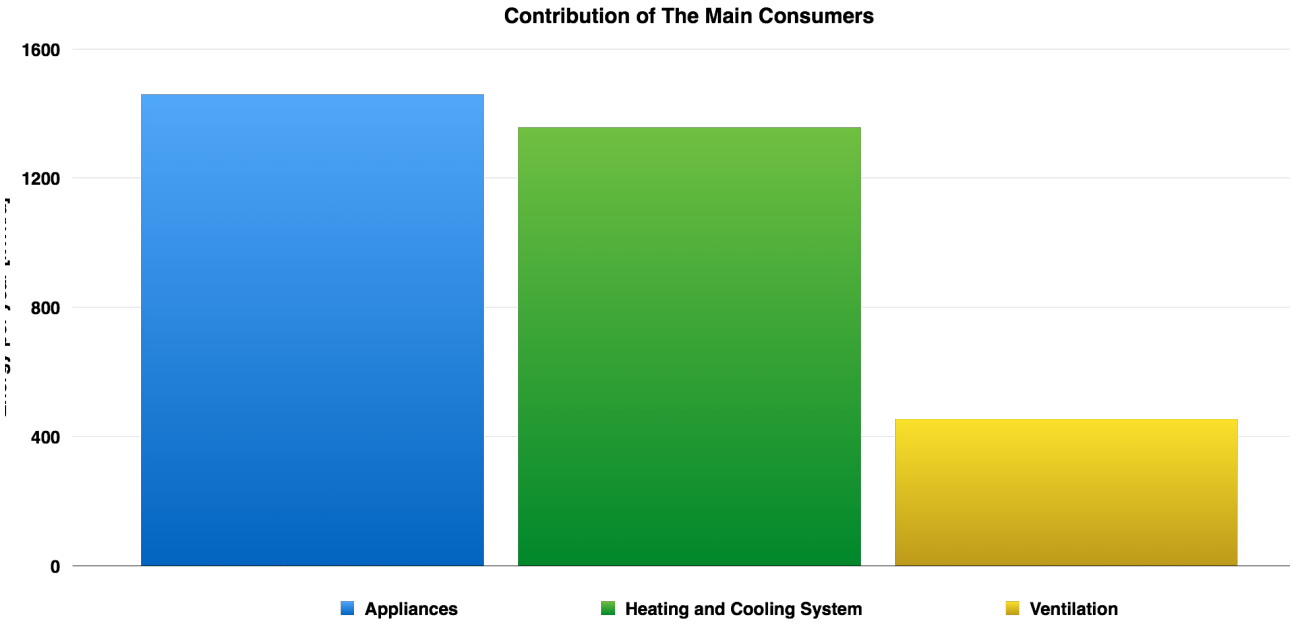


Figure 114: **Consumption of the main consumers per year**

A further huge part of the consumption is the heating, cooling and warm water provision with the heat pump as its biggest consumer which takes 1356 kWh/a. The 2 fans for the supply air and used air are running with each 24 W in average assumed 24 hours on 7 days in a week what results in a yearly energy need of 453 kWh/a. There will also be a backup induction heater with a predicted consumption of 6 kWh/a. The sanitary system uses 3 pumps with a power of 16,8 W running 19,3 minutes per day and one pump with a maximum power of 300 W running 15 minutes a day. This results in a yearly maximum energy-consumption of 29,4 kWh/a for the sanitary system.

The engines for the folding façade will take about 160kWh in one year if we assume that the whole façade goes one time up and one time down on every single day of the year. Calculations revealed that the electric plus energy we can gain due to the façade which enables the tracking of the sun amounts approximately 400 kWh/a. In addition the insulating virtue of the closed façade saves about 200 kWh/a, we would use for heating.

Energy Plus House

If we sum up every consumption of one year and do the same with the energy production, we can see that we have an energy production of 130% of the consumption (1,3 times bigger), what makes our house to an energy plus house (Figure 115).

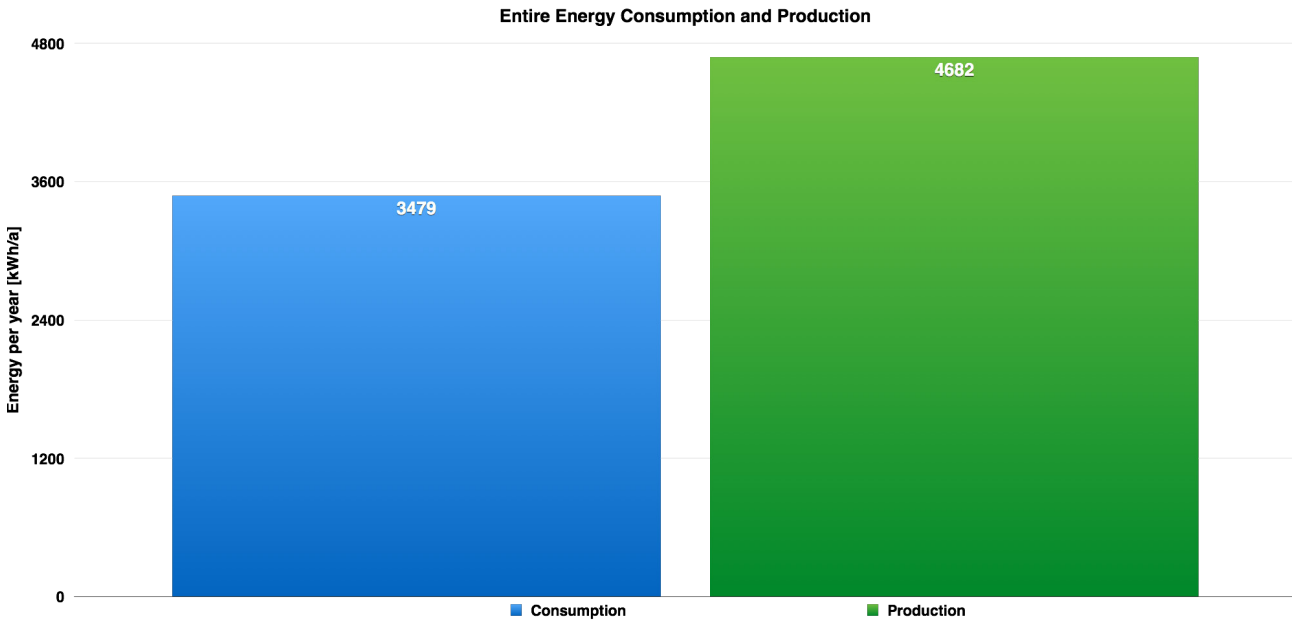


Figure 115: **Entire energy consumption and production.**

Obviously due to the fact that we have in Germany a very pronounced winter and summer, this factor of 1,3 can't be hold up as a constant value through the whole year. In summer we have way more energy production than energy consumption and in winter time it's the opposite as the next graph (see Figure 115) shows. The course of the curves was generated by PVSol (consumption) and SolarEdge (production) with the weather data of Paris. Of course it is not ecological and economical to store the plus energy from summer until summer if it is even possible. But we store the daylight plus energy during summer for the night hours. Results of latest examinations (ELIAP) from IdE Institut dezentrale Energietechnologien prove that PV-battery-systems are already profitable. The self consumption can be improved by 62%. The results also show that the system stores in two up to three years the same amount of energy, it needed for its production. During the whole time of usage it stores even ten times of this energy. So due to rising energy prices, it gets more and more profitable to install a house battery.

It was also necessary to take a look at the load course of one day. What sticks out in the next diagram (Figure 116) is the moving of the façade in the morning and in the evening. The engines are regulated to move very slowly one after another so that the inside of the house lights up slowly. It will look like a wave and the house owner will awake very smoothly. That's also better due to noise generation because the engines wouldn't run under full load what would be very loud and we wouldn't have a huge peak of 300 W per engine (14 engines=4,2kW). Hence all the engines will run for an entire time of 15 minutes for each upward or downward movement with an average load of 1,77kW.

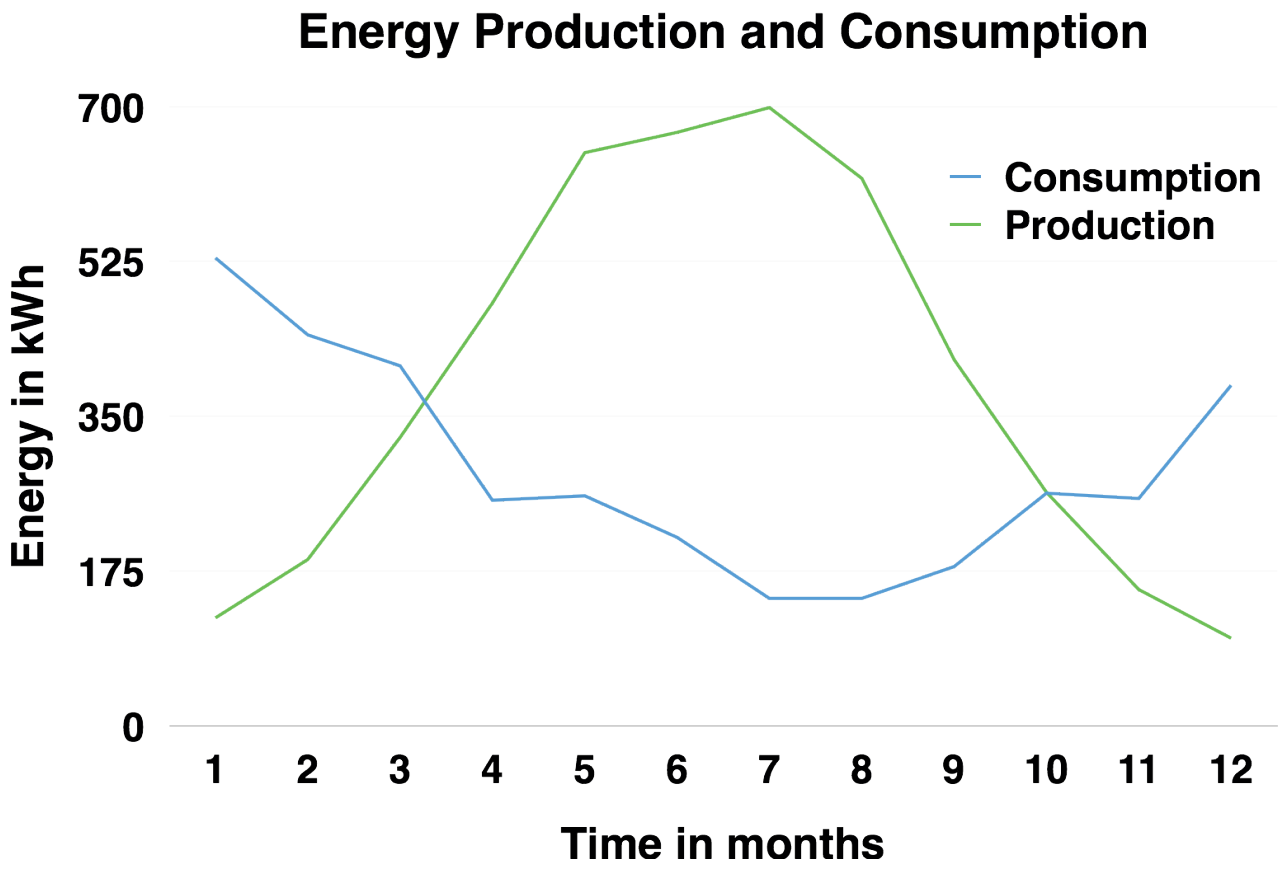


Figure 116: **Energy consumption and production during one year for each month**

Further big consumers which shine out in the chart are the washing machine and dishwasher. Inbuilt timers allow that both the washing machine and the dishwasher just run at midday, when we have the biggest electricity production. At 4:00 pm we can see that the owner begins to cook.

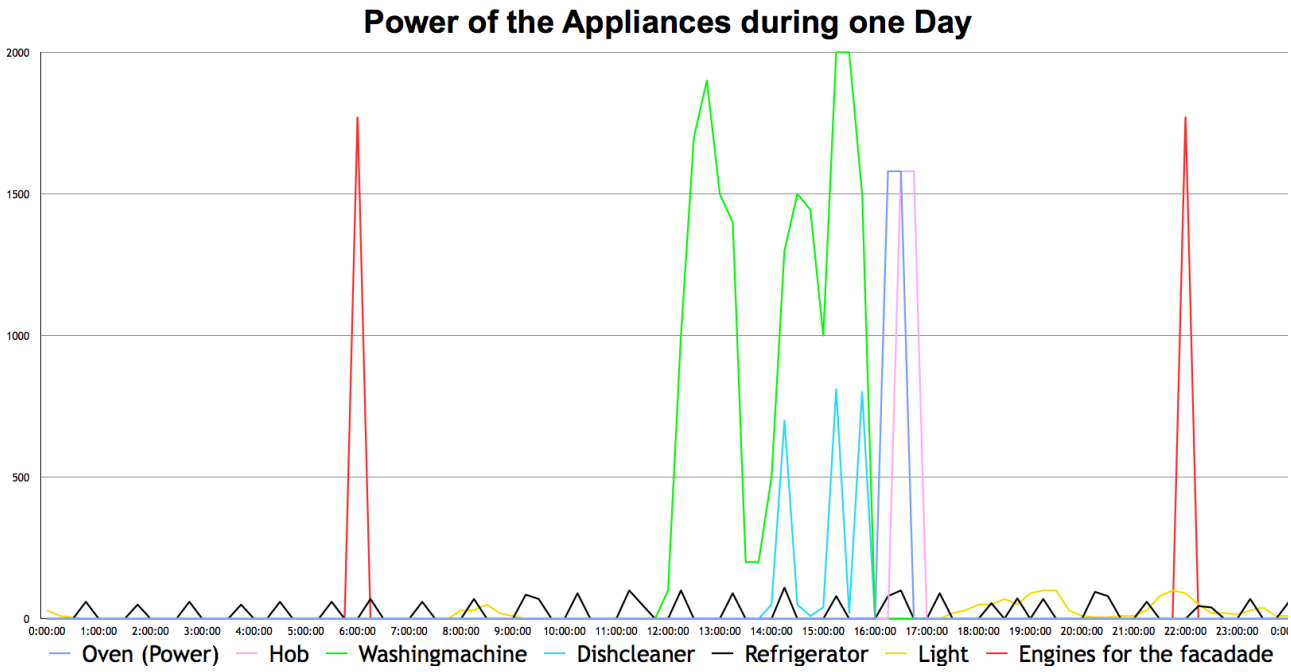


Figure 117: **Power of the appliances during one day**

In the next scheme you can see the cumulated Power and Energy Consumption of all the electric devices. For that summer day the owner used about 15,3k kWh of electricity.

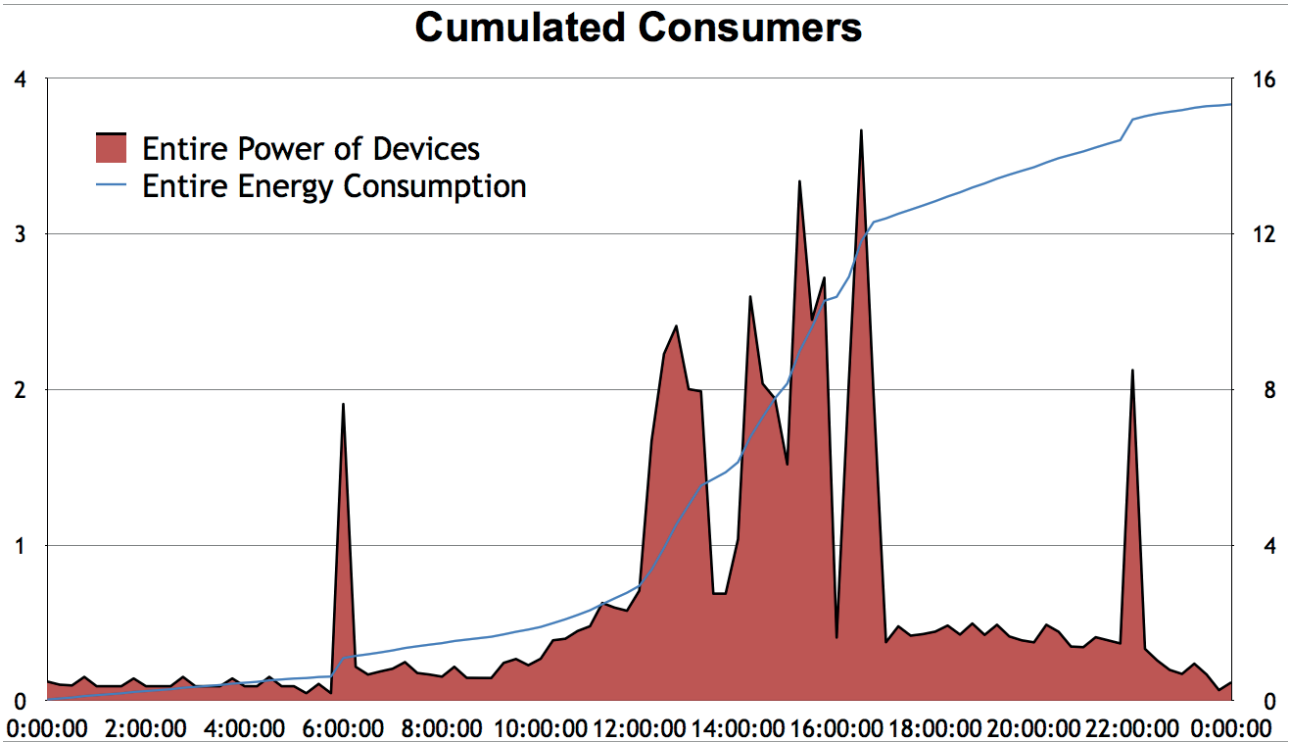


Figure 118: **Cumulated power of the consumers and the consumed energy in one day**

In midsummer on a very sunny day, how the next diagram (Figure 119) shows, we can live completely electric autarchic. Our battery with a capacity of 4,2 kWh wouldn't be empty for a minute and we wouldn't be forced to draw energy from the grid. On the contrary we will be able to feed a lot of the produced energy into the village's grid. Due to that the CO2-emission will be reduced. During the time where we have no PV-production, we need about 3,6 kWh. Referring to the "Umweltbundesamt" (german federal environmental agency) the specific CO2-emission factor is 546g/kWh. So we will reduce CO2-emission by about 1960 g per sunny summer day. If there is a less sunny day, the battery isn't fully loaded and we take more electricity from the grid.

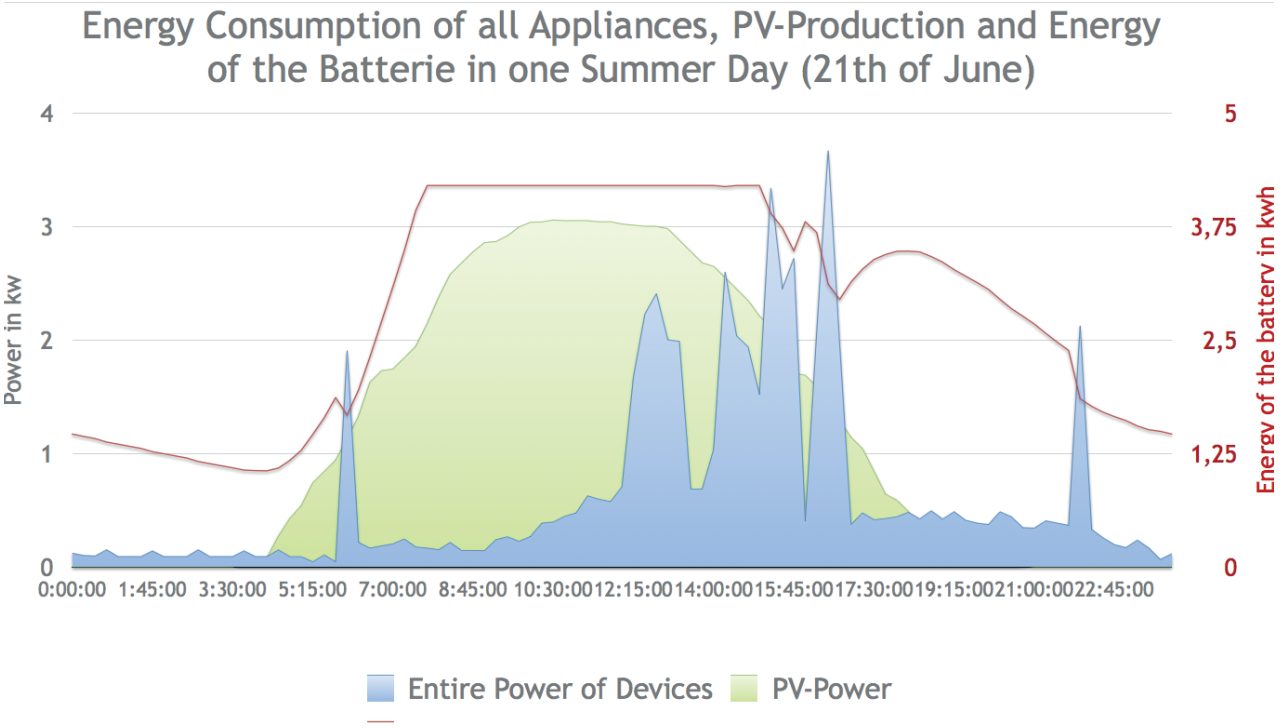


Figure 119: **Power of all consumers, PV-Production and energy of the battery in one summer day (21th of June)**

It looks crucially worse if we take a look at the similar diagram just on a winter day (Figure 120). The owner consumes 34 kWh. This huge amount is mainly caused by the heating energy. The PV energy production is very less never mind that we are far off bringing the battery in use. That is the destiny of all the PV modules installed far away from the equator. Due to very expensive and non-economical seasonal energy storages, it's nearly impossible to build a house in such a northern region which is completely autarchic throughout the whole year.

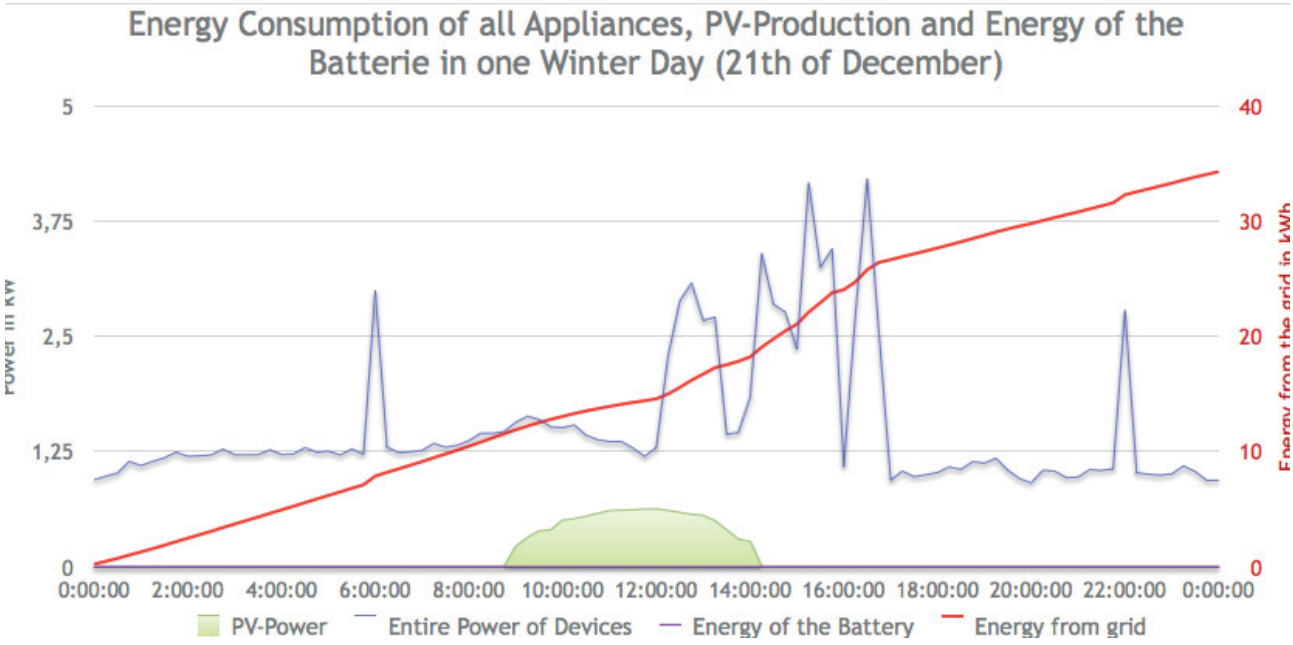


Figure 120: **Power of all consumers , PV-Production and energy of the battery in one winter day (21th of December)**

5.3.7 SOLAR THERMAL DESIGN[1]

Solar thermal systems employ solar power in the form of thermal energy, which is used for space heating and domestic hot water (DHW). For our house the most efficient option is to use the solar thermal system to provide domestic hot water only; this is because the solar thermal collectors are made useless in the winter as Berlin is characterized by extremely low temperatures with peaks up to -12 °C. The solar thermal system is optimized for an average summer day during which it could be able to provide for 100% of the house's heating requirement (in the summer season, in absence of space heating, this equals to the domestic hot water requirement). When higher solar fractions are present, a domestic hot water storage tank and a buffer tank are used to store the solar heat gained during the day and to make it available into the night. The domestic hot water is stored at a temperature of 45 °C in winter to operate the heat pump at its highest efficiency. In the summer the domestic hot water temperature raises to 70°C so that more energy can be stored at higher temperatures. A scalding protection prevents hot water to flow into the sanitary piping. The buffer tank for the heating system is maintained at 35 °C and it is supported in the transition times from the solar thermal system.

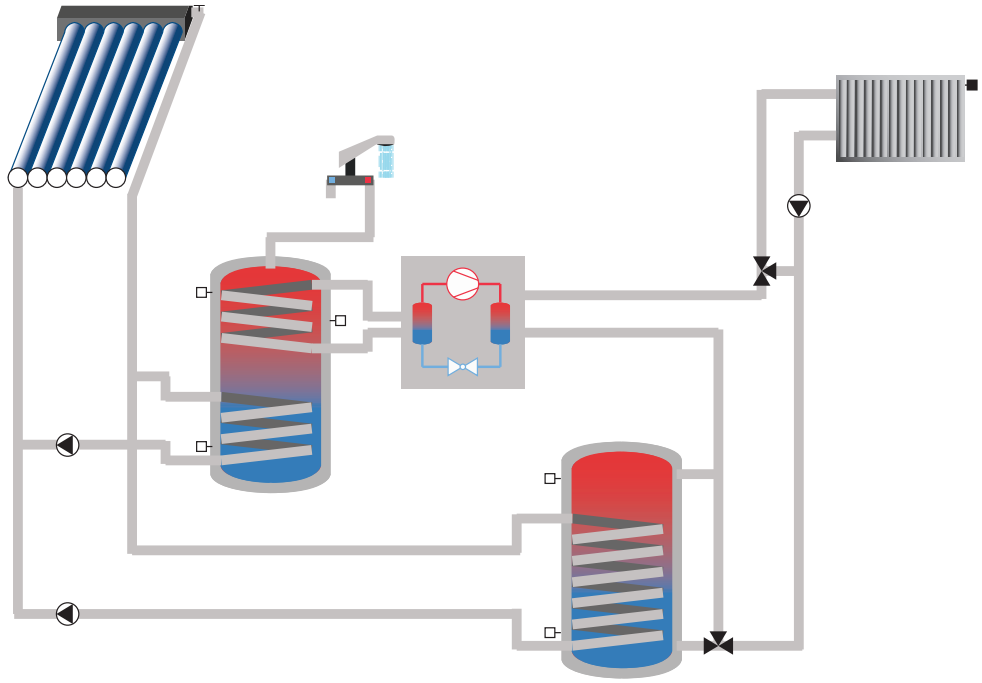


Figure 121: **Solar thermal installation: solar collectors, internal DHW cylinder 235 l and extra buffer tank 200 l**

The system consists of 2 vacuum tube collectors (DF6) from the manufacturer augusta-solar. These collectors were chosen because they can be aligned on a flat horizontal roof like the one of Team Rooftop. The vacuum tubes are aligned so that the collectors face south and individual tubes are rotated by 30° to face the sun by

1 M. Tsavolakis, Simulationsgestütztes Energiekonzept für ein kleines Plusenergie Wohngebäude, Master Thesis, University of Applied Sciences Berlin, 2013, p. 14 – 44.

means of a special plug-in system. This possibility offers an efficiency advantage over other collectors, and thus optimizes the use of solar thermal energy in a limited space of only 1.6 m² per collector. Hence, with a total area of 3.2 m², around 70% of the domestic hot water demand is covered.

The demand estimate of domestic hot water (DHW) for two persons is 64 l/day, or 32 l/person/day. This value is considered realistic as it represents an intermediate value of the average range of hot water consumption in Germany, which is between 20 and 60 l/person/day.[2] As mentioned above, the DHW will be stored in a 235 l DHW-tank which is integrated in the compact heat pump. The heat pump will have an electrical backup heater if the heating capacity of the heat pump and solar thermal collectors alone prove not to be sufficient. The accessibility of the installation for maintenance tasks is over the old existed staircase construction.

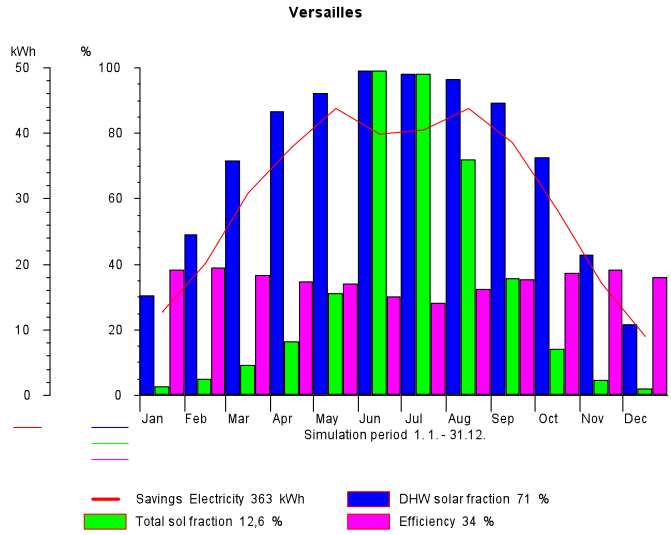


Figure 122: **Yearly simulation in Versailles and results summary**

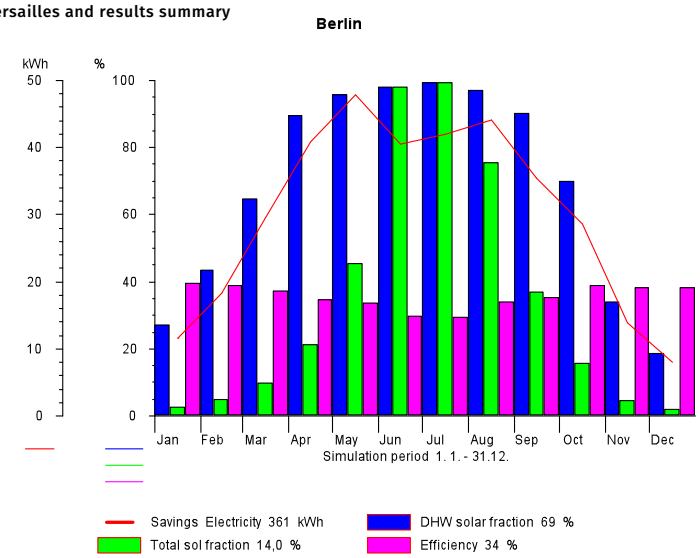


Figure 123: **Monthly simulation in Berlin and results summary**

2 de.wikipedia.org/wiki/Verbrauch; other sources include www.energie-lexikon.info/warmwasser.html and www.esv.or.at/bauen-wohnen/warmwasser-heizen/warmwasserbereitung/

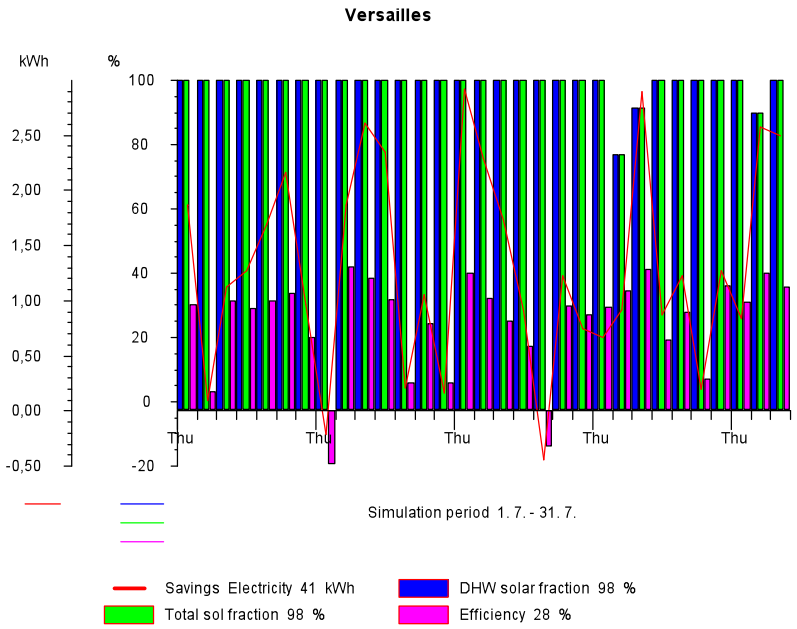


Figure 124: **Monthly simulation in Versailles and results summary**

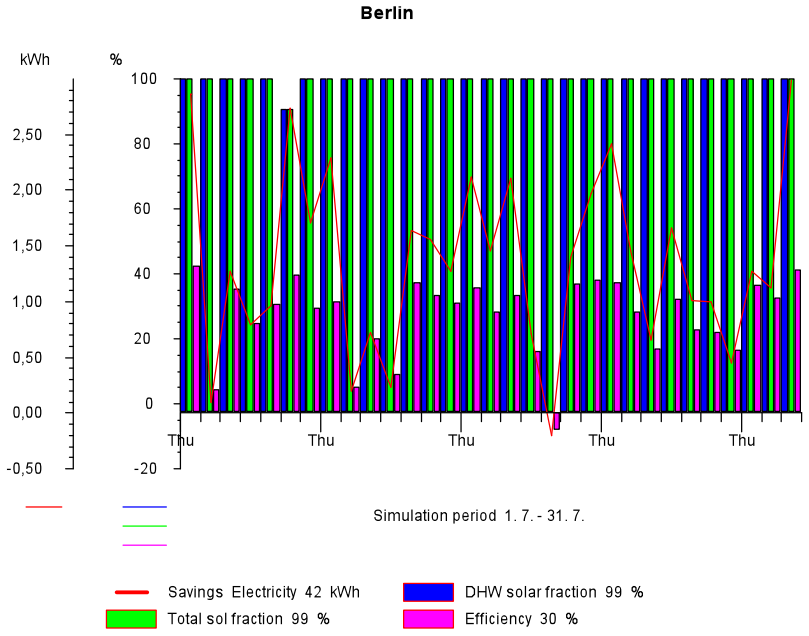


Figure 125: **Monthly simulation in Berlin and results summary**

HEATING CONCEPT[3]

The heating concept is based on the employment of the thermal energy present in ambient fresh air and of the residual heat from the exhaust air leaving the indoor environment. Thus, it is possible to implement the concept of a central heating system in our core module, which enables an easier transportation of all the house's technical systems and a simpler maintenance.

Being the Rooftop located on a roof of an old building, fresh and exhaust air are among the most important heat sources. The use of fresh air and exhaust air as heat sources and for ventilation is realized with short ducts from the heat pump to the roof; all ducts come from the technical room, ensuring that the length of these ducts would not be more than a few meters.

This minimizes the loss of pressure within the system. One part of the heat from the exhaust air is used for heat recovery to warm up the fresh air. Further in the circuit, at the evaporator, the fresh air is mixed with the residual heat from the exhaust air. The central air gate enables the use of thermal discharge from the living room, bedroom, bathroom and the electrical waste heat from the batteries. Therefore, it serves a dual purpose of both cooling of the electrical devices and heating of the indoor space and domestic hot water.

In order to exploit the full potential of the heat pump, an internal separation system makes sure that the temperature levels of the heating system are maintained as low as possible. This aspect is very important because only with a low difference between the temperature levels the heat pump is able to work in an efficient zone with good coefficient of performance (COP) and a low need of electricity.

The system of separation comprehends two tanks: one for domestic hot water with a volume of 235 liters and a temperature level of 45 °C and the other one for the heating system with a volume of 200 liters and a temperature level of 35 °C.

Thanks to the large surface of the floor, the heat can be effectively transferred with a relatively low temperature level of 35 °C. This system of heat transfer not only increases the efficiency of the heat pump, but also offers better comfort without spatial losses of area that would occur using radiators. Moreover, better hygiene conditions are achieved as the strong convection thermal exchange and the consequent dust generation/movement typical of radiators are prevented.

Two solar thermal vacuum collectors support the heating of domestic hot water, which covers around 60% of the house's demand. In summer time the heating of domestic hot water is completely covered by solar thermal energy. The pump for the collectors can be operated up to a temperature level of 70 °C, thus the energy of the sun is optimized for the heating of the domestic hot water. The domestic hot water production with the heat pump works on a temperature level of 45 °C. This choice results in an efficient working mode of the heat pump and reduces the need of electrical power. A temperature level of 45 °C is absolutely adequate to meet the requirements of the bathroom and kitchen of a single-family-house. The washing machine and the dish washer are connected with the hot water network within the storage tank, thus the water does not have to get warmed by means of an electrical heater.

3 M. Tsavolakis, Simulationsgestütztes Energiekonzept für ein kleines Plusenergie Wohngebäude, Master Thesis, University of Applied Sciences Berlin, 2013, p. 14 – 44.

Dimensioning of the heating system

As far as it concerns the dimensioning of the heating system, care must be taken as to what the calculation of the heating load includes, for example ventilation and different night regulation. Furthermore, in a low energy home it is essential not to overheat the domestic hot water because of the high amount of energy needed. At the dimensioning of the heating load of the heat pump the heating of domestic hot water is considered as a surcharge.

Heating load in accordance with DIN EN 12831 (simplified proceed):

Heating load: exterior					
Component	Surface [m²]	U-value [W/m²K]	dT Berlin [K]	fk	Qt [W]
Roof	62,46	0,109	34	1	231,48
Floor	62,46	0,134	5	0,5	20,92
Exterior w	53,7	0,125	34	1	228,23
Window 1	75,9	0,7	34	1	1807,04
Interior w	189,215	0,23	5	0,8	1,740,778
Interior w	167,895	0,23	-4	0,42	-648,746
					2298,58

Heating load: Bathroom					
Component	Surface [m²]	U-value [W/m²K]	dT Berlin [K]	fk	Qt [W]
Roof	4,46	0,109	38	1	18,47
Floor	4,46	0,134	9	0,5	2,69
Interior wall installation room	18,655	0,23	9	0,8	3,089,268
Interior wall exterior	93,275	0,23	4	0,42	3,604,146
Door to exterior	10,66	0,2	4	0,42	358,176
					31,44

	Volume flow [m³/h]	roh [kg/m³]	cp [kJ/kg K]	dT Berlin [K]	Ql [W]
Exhaust air bathroom	45	1,2	1	4	60
					91,44

Mechanical ventilation:						
Component	Volume fl	roh [kg/m	cp [kJ/kg K	dT Berlin [	Heat recov	Ql [W]
Central ventilator 1	120	1,2	1	34	0,8	272

$$Q_{HL} = Q_T + Q_L = 2662W$$

Need of thermal heat:

The heat quantity is strongly related to the thermal shell of the house, which determines the required heat supply to meet the comfort requirements of the indoor spaces. It is independent of the heating system.

IDA ICE- Thermal heat requirement simulation in a whole year (without shadowing):

Used energy for heating and heating up domestic hot water, optimized scheduling

Heating: 3000 kWh

Domestic hot water: 601 kWh

3600 kWh / 54.6 m² = 66 kWh / m² (low-energy-house)

New construction accordance with EnEV	40 - 100 kWh/m²
Low-energy-house	35 - 75 kWh/m²
Passive house	10 - 15 kWh/m²

Heating up of domestic hot water:

Guidelines DIN 4708

Bedarfskennzahl N (Normalaustattung):

$$N = \frac{\sum(n * p * v * w_v)}{p_E * w_{vE}}$$

$$= \frac{1 * 2 * 1 * 5820\ Wh}{3{,}5 * 5820\ Wh} = 0{,}57$$

where

n	-	Number of flats
p	-	Occupancy
v	-	Number of taps
w_v	-	Energy per standard flat
p_E	-	Number of persons in one flat (3,5)
w_{vE}	-	Energy requirement for tub in one flat (5820 Wh)

IDA ICE Need of energy for heating up domestic hot water:

11 kWh / m² = 601 kWh / year

Additional power for base heating:

With a tank for domestic hot water of about 150 liters the surcharge for bowl amounts to a maximum of 2 kW with a demand index of N = 1 (4 persons).

According to the manufacturer the surcharge amounts to 0.25 kW per person.

Conclusion: The power for a storage tank for domestic hot water up to 1 kW is enough for two persons.

Heat Pump

The heat supply of the house is provided by an underfloor heater. The great advantage of an underfloor heater over heat transfer by radiators is given by the big heating surface, which provides the same heat flow at much lower flow temperatures. The flow temperature by radiators is normally about 70 °C, whereas the underfloor heater works at temperatures of about 35 °C and it grants the same heat flow. This enables an efficient use of heat pumps. The functioning principle of heat pumps is the increase of the temperature level of a fluid from a low level to a higher one by using another energy source, for example electricity.

One important parameter is the coefficient of performance (COP), which is the ratio of heating or cooling provided to electrical energy consumed. The COP is highly dependent on the working conditions, and in particular on the relative temperature between sink and system: the smaller the difference between the two temperatures, the higher the performance. Thus, the goal is to obtain a low temperature of the heating fluid and a high temperature level of the input fluid. The use of underfloor heating allows a relatively lower temperature level of the heating fluid. In order to raise the temperature of the input fluid, keeping in mind energy efficiency, no other energy source will be used apart from the recovery heat from exhaust air.

To ensure the supply of domestic hot water it is advantageous to hold the temperature of stored water on a constant level. Thus it is not necessary to heat up cold water with a temperature level of 10 °C instantaneously up to 45 °C.

The system LWZ 304 by Stiebel Eltron (picture below) includes the following functions: ventilation, heating, cooling and supply of domestic hot water. The main component is an air/water heat pump which raises the temperature of the fluid up to the desired level.

The heat pump (COP: 3.3 (A2/W35); 2.7 (A-7/W35)) uses the temperature level of the outdoor air and it transfers its heat to the working fluid in a heat exchanger (see stream one in Fig. 1). Additionally, part of the fresh outdoor air is warmed up in a cross-counterflow heat exchanger using the exhaust air from the indoor (see stream 2 in Fig. 1). These streams flow into the heat exchanger and transfer part of their heat to the working fluid. This heat recovery increases the efficiency of the heat pump because of the higher temperature level of the flow temperature.

After the heat pump, the heated fluid streams into a heat exchanger placed in the storage tank of the domestic hot water to regulate its temperature or it streams directly into the heat system consisting of the floor heater.

When the difference between the temperature levels within the heat pump becomes too large, an electrical booster heater will engage to provide the extra needed heat. The heat pump needs the backup heat only for outdoor air temperatures below -14 °C.

The storage tank for domestic hot water collects a volume of 235 liters with a temperature level of 45 °C (winter season). A second storage tank for the heating system collects 200 liters with a temperature level of 35 °C.

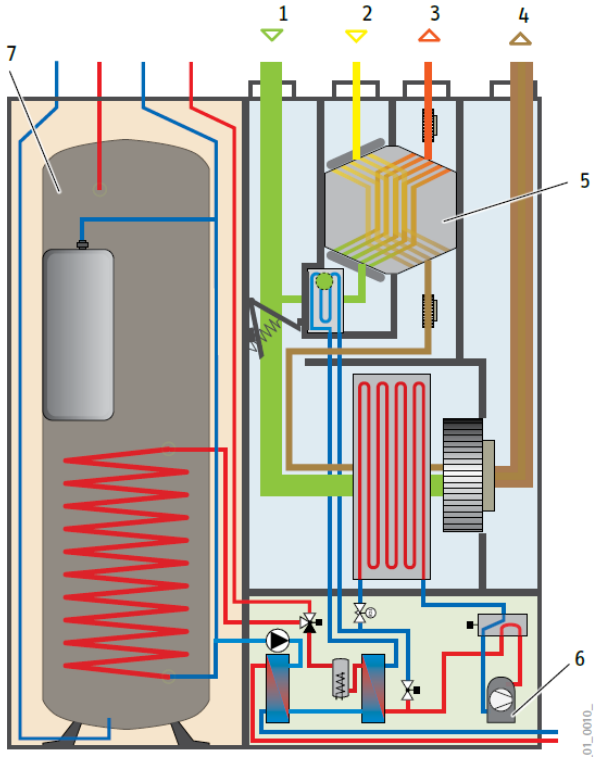


Figure 126: **scheme LWZ 304**[4]

LWZ 304 includes a preinstalled regulation which can be adapted to individual needs. The regulation is based on the data of a sensor for the outdoor temperature, which has to be placed away from direct solar radiation and induced sources of heat.

In the summertime the heating function is not used for most part of the time. To ensure a comfortable indoor temperature it is necessary to reduce the temperature level. The great advantage of using a reversible heat pump system is that it is possible to use the same circuit – and the same working principle – also for cooling during the hot season.

Heat demand of the heat pump:

Norm heating load	2.7 kW
Heating up of domestic hot water	+1 kW
Power of heat pump:	3.7 kW

Air-water heat pump interior with use of exhaust air (compact with RLT plant)

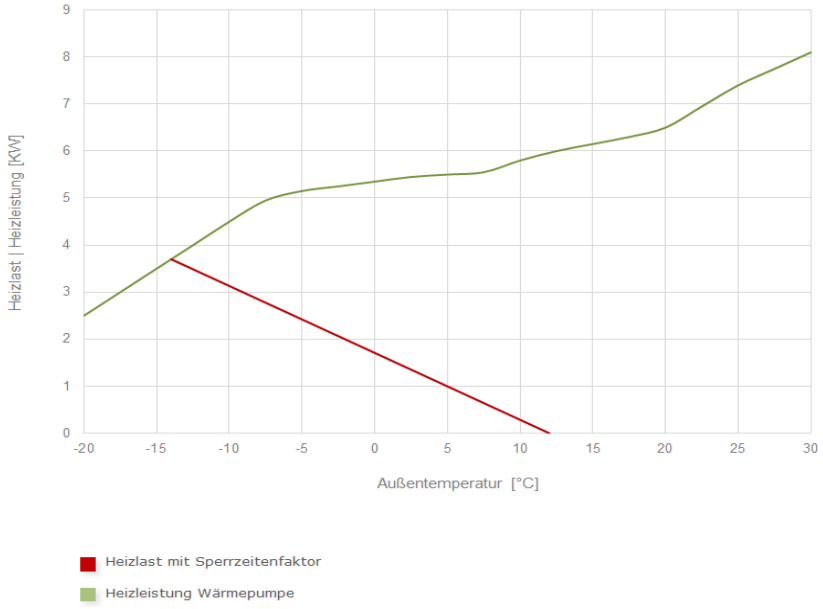
LWZ304

4 Stiebel Eltron: Planung und Installation, Lüftung; Erneuerbare Energien, März 2013 – S. 179

COP (A2 / W35) 3.3

COP (A-7 / W35) 2.7

JAZ 3.59 (manufacture's information)

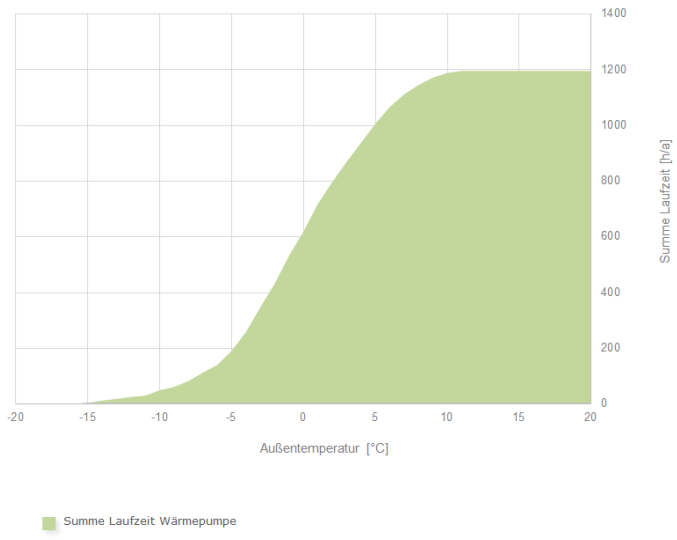


Supply water 35°C

Border of heating 12°C New construction ENEV 09

→monoenergetical

Runtime of the heat pump → 1196 h/a



Heat pump LWZ 304

The LWZ 304 is a reversible compact air-water heat pump which uses exhaust air as a heat sink. The manufacture's information presents the pump as that with the best COP over a whole year out of the competition.

Cooling

The reversible operational mode enables the cooling of the PCM ceiling with the same storage tank. An active cooling with the heat pump is used in association with the electrical power from the PV panels as the hot season, when most radiation is available, is also the time when cooling is necessary.

Ventilation

This heat pump includes a regulation for the humidity above the heat exchanger. This is important for ventilation because due to the high number of windows, the differences between the temperature levels indoor and outdoor can result in the formation of condensation. The ventilation system does not perform air conditioning, cooling or heating of the fresh air because it is more effective to cool or heat with the water circulation. The ventilation device conducts the supply of fresh air, heat recovery and dehumidification.

Dimensioning of floor and wall heater[5]

Theoretical calculation and calculation program

1. Choosing the system

a. Exterior flooring floorboards (14mm)) $R_{\lambda B} = 0{,}1 m^2 K/W$

(Exterior = sleeping room, living room, floor, kitchen and addition)

b. Bathroom flooring cork

Values for

Sharing a [cm]	10	15	20	25	30
$K_H\ [\frac{W}{m^2 K}]$	3,595	3,254	2,947	2,673	2,426

2. Need of heat power and –concentration

With a heating load caused by central RTL system about 2.6 kW

Allocation of floor and wall heating	footprint [m²]	Heating surface [m²]	Heating load [W]	Heat flux density [W/m²]
Sleeping room with floors	23,08	32,56	1200	36,86
Living room	25	34,48	1300	37,70
Bathroom	4,46	3,02	100	33,11
			2600	

3. Border area and auxiliary heating

5 In this Section, the possibility of an additional wall heating system is addressed. However not developed in the building for the competition, it is an additional option for locations with rigid climates such as Berlin.

The heat flux densities are all lower than the critical heat flux density by a value of about 100 W/m² which gain a maximal temperature level of the surface about 29 °C. Thus, no heating is needed in the border area nor an auxiliary one.

The spreading in the reference room is chosen at about a = 15 cm, which increases the comfort and minimizes the flow temperature.

4. Reference Room

The reference room has got the highest needed heat flux densities because of the exterior. The flow temperature of the building follows that one in the reference room.

5. Temporary spreading

σ = 5 K

6. Flow Temperature

a = 15 cm for the reference room.

$\dot{q} = K_H * (\Delta\vartheta_H)^n$ with n = 1

$$\Delta\vartheta_H = \dot{q}/K_H$$

$$\Delta\vartheta_H = \frac{38}{3{,}254} = 11{,}7\ K$$

That results in a flow temperature of

$$\vartheta_{VL} = \vartheta_i + \Delta\vartheta_H + \sigma/2$$

$$\vartheta_{VL} = 20 + 11{,}7 + 2{,}5 = 34{,}2\ °C$$

Therefore the flow temperature of 35 °C is chosen.

Finally spreading:

$$\delta = \frac{\Delta\vartheta_H}{\vartheta_{VL} - \vartheta_i} = \frac{\Delta\vartheta_H}{\Delta\vartheta_V} = \frac{14{,}2}{15} = 0{,}95$$

$$\sigma = f_s * (\vartheta_{VL} - \vartheta_i) = 0{,}098 * (35 - 20) = 1{,}47\ K$$

7. Control of the heat-fluid temperature

$$\Delta\vartheta_H = \frac{1{,}47}{\ln\left(\frac{15}{15 - 1{,}47}\right)} = 14{,}2\ K$$

Compliance.

8. Thermal resistance

Manufacture information about dry-screed:

$$s_u = 25mm\ mit\ \lambda_E = 0{,}28\ W/mK$$

Manufacture of isolation course PUR 52 for the ceilings against unheated rooms (+25mm socket plate =77mm)

$$d = 52mm\ mit\ R_{\lambda,Ins} = 2{,}702\frac{m^2K}{W}\ und\ U = 0{,}35\ W/m^2K$$

$$R_0 = \frac{1}{h_0} + R_{\lambda,B} + \frac{s_u}{\lambda_E} = 0{,}093\frac{m^2K}{W} + R_{\lambda,B} + \frac{s_u}{\lambda_E}$$

$$= 0{,}093 + 0{,}1 + \frac{0{,}025}{0{,}28} = \mathbf{0{,}28}\frac{\boldsymbol{m^2K}}{\boldsymbol{W}}$$

$$R_u = R_{\lambda,Ins} + \sum\left(R_{\lambda,De}\right) + \frac{1}{h_u} = R_{\lambda,Ins} + \sum\left(R_{\lambda,De}\right) + 0{,}17\frac{m^2K}{W}$$

$$= 2{,}702 + \sum\left(\frac{0{,}012}{0{,}13} + \left(0{,}1 * \left(\frac{0{,}24}{0{,}13}\right) + 0{,}9 * \left(\frac{0{,}24}{0{,}038}\right)\right) + \frac{0{,}04}{0{,}21} + \frac{0{,}012}{0{,}13}\right) + 0{,}17\frac{m^2K}{W}$$

$$= 2{,}702 + (0{,}09 + 5{,}87 + 0{,}19 + 0{,}09) + 0{,}17 = \mathbf{9{,}112}\frac{\boldsymbol{m^2K}}{\boldsymbol{W}}$$

$R_{\lambda,De}$:

Material	Thickness in mm	Thermal Conductivity λ in $W/(mK)$	Heat Capacity c_p in $J/(kgK)$	Density ρ in kg/m^3
OSB Board	12	0,13	2100	620
Wood Fiber Insulation	240	0,038	2100	50
Construction Wood: Larch	240	0,13	1600	460
Plasterboard Panel	40	0,21	1000	790
Wooden Substructure: Pine	12	0,13	1600	460

$$\frac{R_0}{R_u} = \frac{0{,}28}{9{,}112} = 0{,}031$$

9. Amounted heat flux density down

$$f_u = 1 + \frac{R_0}{R_u} + \frac{(\vartheta_i - \vartheta_u)}{\dot{q} * R_u}$$

$$f_u = 1 + 0{,}031 = 1{,}031$$

$$f_u = 1 + 0{,}031 + \frac{(20-15)K}{37{,}7\frac{W}{m^2} * 9{,}112\frac{m^2K}{W}} = 1{,}046 \quad (4\,\%)$$

10. Need of heat-fluid mass flow

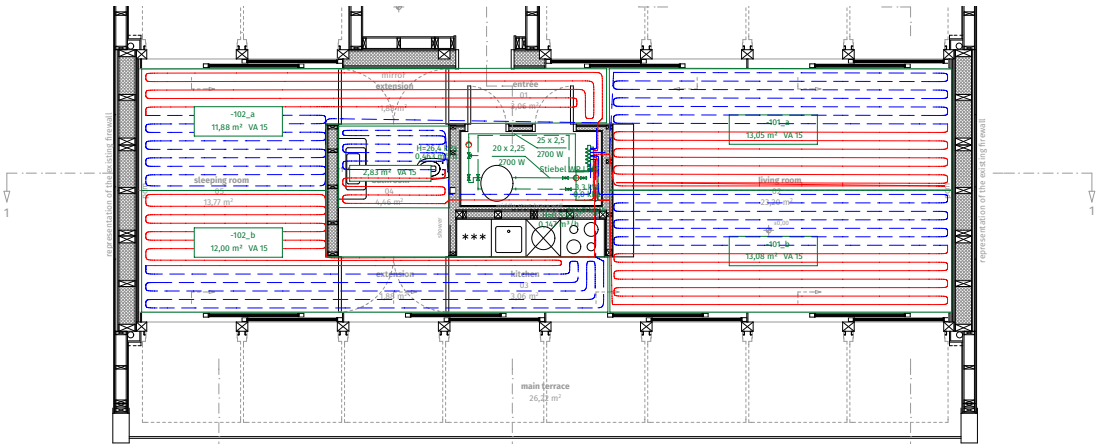
Dimensioning with the calculation program HSE:

Heating circuit	Label	Length of pipe	Surface	Installation gap	Mass flow
Sleeping room 1 GH	102_a	65,4	12,5	15	66,4
Sleeping room 2 GH	102_b	89,8	12,4	15	88,7
Sleeping room 3 WH	102	63,3	9,5	22,5	90,6
Living room 1 GH	101_a	70,4	11,6	15	70,7
Living room 2 GH	101_b	82,5	11,6	15	82,6
Living room 3 WH	101	58,3	9,5	22,5	88,4
Bathroom GH	103	26,9	3	15	15,6

GH - Ground heating

WH – Wall heating

Ground plan Floor heating and wall heating (flow temperature 35 °C):



Supporting structure details

The main purpose of a support system is to make sure that the collectors are in the correct orientation for maximum solar gains. This sentence poses a first challenge as the optimal inclination actually changes between summer and winter season due to the different sun trajectory.

The augusta solar DF 6 vacuum tube collectors were also chosen because of their wide range of installation possibilities. In fact, such collectors can be mounted both in flat and sloped roof and at any inclination angle between 0° and 90°.

When the roof is flat - as in the Rooftop project - it is possible to inclinate the vacuum tube collectors between 0° and 30°. In order to optimize the solar gains, as the theoretical summer mode best option is over 30°, an inclination of 30° was chosen.

Furthermore, the supporting structure also withstands the various structural and thermal loads and must resist the impact of environmental deterioration. The material chosen for the array structure must be able to cope with environmental degradation and oxidation. In particular, the chosen fastening elements of the supporting structure are made of aluminium; they cover a snow load of 0.75 kN/m² and a wind load of 0.50 kN/m² calculated according to DIN 1055 and DIN 18800.[6]

Aluminium is required for the array support structure because the oxide layer that forms on the surface when it is exposed to moisture protects it from further degradation. Often, aluminium is anodized to provide a controlled layer of oxidation. The effect of temperature change must also be taken into account for large structures, especially the difference in thermal expansion between the various types of metals used in solar systems.

List of maintenance tasks

One of the strengths of the Rooftop project is its core module, the heart of the technical systems and hence of the house. The technical room is easily accessible through two doors, which grant direct entry on both the LWZ 304 SOL SET heat pump and on the buffer tank. The internal plan layout of the core module has been studied in order to allow maximum movement and at the same time to be as compact as possible.

The main maintenance tasks are specified in a detailed way for each utility in the appropriate installation and operation manual.

As far as it concerns the integrated unit LWZ 304 SOL SET from Stiebel Eltron the following maintenance tasks have to be performed[7]:

- Cleaning of the air/air heat exchanger (at least once a year)
- Cleaning of the outside air filter behind the countercurrent flow heat exchanger
- Cleaning of the evaporator fins (from time to time make sure they are free from impurities)

6 See Installation Manual of the vacuum tube collector AS100DF6, download at: http://p17955.typo3server.info/uploads/media/Kollektor_as100df6_stand04_2012.pdf

7 An extensive list of cleaning and maintenance tasks can be found in the LWZ 304 SOL SET installation manual, download at XXXX

- Cleaning of the condensate drain (regularly, dirt or obstructions should be eliminated immediately)
- Cleaning of the filter ball valve
- Replacing the anode
- Checking the expansion vessel

For the extra buffer cylinder SBP E cool from Stiebel Eltron no special maintenance is required. A regular visual check and cleaning of the outer casing with a slightly damp cloth is in this case sufficient.

Also the high vacuum tube collectors DF 6 from augusta-solar are practically maintenance free. In fact, if a tube were to break or to lose its vacuum, one could simply replace the component. The system would still be functioning, though at a lower efficiency. On the other hand, if a flat plate collector is damaged, the whole plate must be replaced and the system shut down. Moreover, the vacuum prevents the delibitation of all internal components due to weathering and corrosion. In this sense, the choice of vacuum tube collectors represents an additional time and cost saving strategy.

Cost of the installation

The following Table provides the costs of each component of the solar heating installation and supporting structure. As expected, it can be noted that the integrated device with solar connection (Stiebel Eltron LWZ304), which includes heating, cooling, solar connection and ventilation, represents the most important source of expense (about 72% of the total installation cost). Another important item are the two vacuum solar collectors from the manufacturer augusta-solar, which alone account for about 9% of the total expense.

The total cost of the installation is 20998 € .

Description	Article Number	Quantity	Cost per unit [€]	Total Cost [€]
Integrated device with solar connection LWZ 304 SOL SET	Stiebel Eltron LWZ304	1	14752	14752
Buffer Tank SBP 200 E cool	Stiebel Eltron SBP 200 E cool	1	787	787
External wall carrying AWG 315	Stiebel Eltron AWG 315	1	383	383
Thermally insulated air hose DN 315,4 m	Stiebel Eltron DN 315	1	217	217
Remote control FES comfort	Stiebel Eltron FES Komfort	1	277	277
Heating compact installation WPKI 6	Stiebel Eltron WPKI 6	1	258	258

Description	Article Number	Quantity	Cost per unit [€]	Total Cost [€]
Heating compact installation WPKI-HKM E	Stiebel Eltron WPKI-HKM E	1	685	685
Activation LWZ 303/304/403/404 SOL	Stiebel Eltron LWZ 304	1	420	420
Activation cooling function heat pump	Stiebel Eltron	1	88	88
Activation solar heat pump function	Stiebel Eltron	1	114	114
Internet Services Gateaway ISG Web	Stiebel Eltron	1	461	461
DF 6 Solar collectors	AS100 DF 6	2	995	1990
Junction set	AS100AS	1	91	91
Connection set	AS100VS	1	41	41
Roof installation package for 2 modules (30° absorber, flat roof)	AS1002M-F	1	228	228
Antifreeze (LS 20 l)	ASTY-LS-20	2	103	206
				20998

Cost of installation per item

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URL: http://www.stiebel-eltron.de/erneuerbare-energien/produkte/lueftung/integralgeraete-mit-zentraler-zuluft/lwz-304-404-sol/ (Stand: 21.10.2013)

5.3.8 BUILDING INTEGRATED ACTIVE SYSTEMS

Introductory thoughts on the cooling system

To use PCM as a means of cooling is an innovative solution for overheating problems. Due to the exposed location of our Rooftop Building on the one hand we reach a very high level of energy production with photovoltaics, on the other hand we have little possibilities for shading. Even though innovative shading façades are used the solar energy input will be too high to start from the assumption that the comfort temperature will be met. To avoid the energy intensive use of a conventional air-conditioning system, we have designed a low-energy system that will assure a comfortable climate inside the building at all time. In the following sections we will describe the chosen system and explain why we discarded other concepts that might have been even more low-energy.

Passive concepts

As stated in rule 4.1, especially in the section “Passive Evaluation Period”, passive strategies are encouraged. Pumps and fans are defined as passive systems. Due to this we have focused on passive concepts which will be presented in this section. They can be divided into air and water based concepts.

Air based (natural ventilation)

The easiest way of designing a passive PCM system is to use PCM modules as a suspended ceiling. During the day they absorb heat energy from the room, this way providing a cooler indoor climate. To provide cross ventilation during the night, windows would have to be opened to discharge the PCM. This increases the volume flow of cool air which cools down the PCM, but at the same time remarkably reducing the sleeping comfort because of the draught.

It is assumed for the average inhabitant that the following usage pattern takes place: At first, in the evening, the windows are opened to let in cooler air. The in-rush airing leads to a sudden drop of the indoor temperature close to the outdoor temperature for up to half an hour. After that, the inhabitant closes the windows to prevent draught. The rest of the night, ventilation is again solely maintained through the ventilation device. The amount of discharge for the scenario can be estimated:

A) In-rush airing for up to half an hour: With a heat transfer coefficient for slightly moving air of 10 W/m^2K the cooling is calculated with Newton's Law of Cooling. This leads to an approximate heat flow of 1000 W. So, in half an hour, 500 Wh can be discharged by means of the in-rush airing. This amounts to an approximate saving of 5% of the cooling ceiling's capacity total.

B) In the remaining night hours of approximately 9 hours, some amount of energy is given off through natural convection back into the room as well. Still air can have a heat transfer coefficient of 5 W/mK. Again, the cooling is calculated with Newton's Law of Cooling. This leads to an approximate heat flow of 500 W. During a time lapse of 9 h, 4500 Wh can be discharged by means of natural convection/heat loss into the room. This amounts to an approximate saving of 47% of the cooling ceiling's capacity total.

Evaluation: It was shown that approximately 52% of the total capacity might be transmitted back into the room or via in-rush airing using passive means of discharging. Nevertheless, they depend on many parameters, e.g. nightly outdoor temperature and the inhabitants' behaviour. Therefore, it is difficult to determine the natural discharging with certainty. In order to always be able to discharge the ceiling, an active cooling means is used, meaning here to connect the pcm plates with a pipe system transferring the heat to the reed bed. This is explained furthermore in the next paragraph.

Water based

As water is a highly efficient medium when it comes to heat transfer, we considered different concepts including capillary tubes filled with water as a cooling fluid attached to the back of the PCM panels. This way the heat stored in the PCM is transferred into the cooling water, which is then led outside the building to a heat exchanger. After cooling down the water in the heat exchanger it is led back into the PCM inside the building, this way creating a closed cooling circuit.

Thermal uplift

To create a completely passive cooling circuit we considered making use of the natural volume flow due to the thermal uplift of the cooling fluid. This would happen automatically after letting the cooling fluid absorb energy from the liquid PCM, due to the difference of the temperature between the water inside the capillary tubes and the cold water in the outside heat exchanger.

Examining the system a question poses itself: Is the natural volume flow big enough to discharge the stored energy?

The following considerations are based on the average outside temperature during summer nights, the PCM temperature during the discharge and the cooling load stored inside the PCM.

To analyse the question, the total mass of PCM is calculated which can be unloaded during the night time and compared to the mass actually needed. Seen as it is complicated to use a valid correlation for natural convection in pipes, an approximation is made based on the following boundary conditions and assumptions:

- During the discharge of the PCM material it manages a constant temperature of 26 °C due to phase change, $T_W = 26\,°C$
- We assume a constant temperature of 20 °C as a worst case scenario: Diurnal variation of air temperature in Potsdam in summer with period showing hours with cooling demand at 7 am) for the night during a time of $\Delta t = 7\,h$, $T_\infty = 20\,°C$
- The cooling load can be described as $Q_{load} = M \cdot \Delta H$, with $\Delta H = 110\,kJ/kg$ as the latent heat of the PCM.
- The diameter of the pipe shall be D=1cm.

The volume flow caused by natural convection is estimated by using the model of a heated plate which is tilted by the angle φ against the vertical (see Figure 127) and therefore causes natural convection. This is not accurately describing our situation, as it will have a higher volume flow as in a pipe due to the pipe providing much higher friction losses. Therefore, a ceiling volume flow can be calculated.

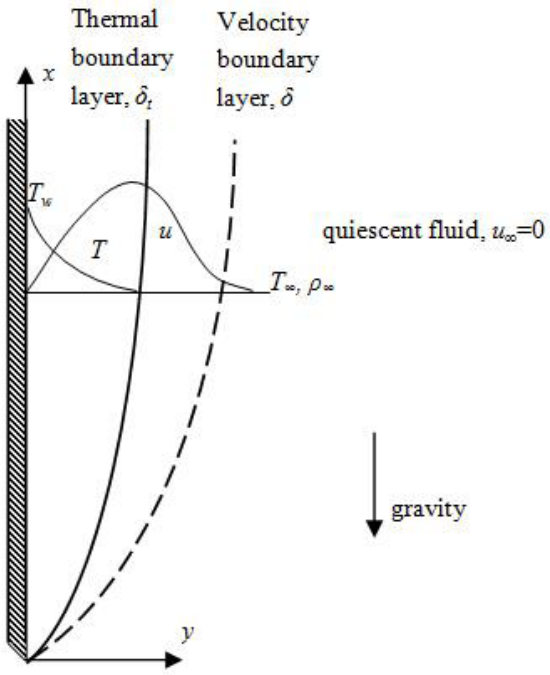

Figure 127: **Heated plate with velocity profile u due to natural convection**

Now, the velocity profile u reaches a maximum which can be estimated using the formula [Kraume 2009]

$$u_{ref} \sim \left(-\frac{(\rho_0 - \rho_\infty) g \cos\varphi L}{\rho_\infty} \right)^{\frac{1}{2}}$$

where ρ_0 is the density at the plates surface, ρ_∞ the density in the bulk phase of the fluid and L the length of the plate. Using this maximal velocity to calculate a volume flow in the pipe is done with the simplified model of one pipe of the length L which is also tilted against the vertical by the angle φ. This leads with

$$\dot{V}_{ref} = u_{ref} A = \frac{u_{ref}\pi}{2} D^2 \approx 0,135 \frac{cm^3}{s}$$

to the maximum volume flow which could develop in the pipe with the given temperature difference.

The question is, how much of the PCM load can be unloaded with that maximal volume flow? For this, the heat transfer processes need to be analysed more closely. The heat transfer between the pipe wall and the cooling fluid is convective heat transfer which can be described as

$$\dot{Q} = \alpha \, A_{Pipe} (26°C - 20°C)$$

This leaves the heat transfer coefficient unknown. A correlation for the Nusselt number is used in order to calculate the heat transfer coefficient:

$$\bar{Nu} = \left(0,825 + \frac{0,387\, Ra^{1/6}}{(1 + (0,492/\,\mathrm{Pr})^{9/16})^{8/27}} \right)^2 = 1407$$

With the Rayleigh number

$Ra = Gr \cdot \mathrm{Pr} = 1,04 \cdot 10^{12}$,

the Grashof number

$$Gr = \frac{g\, \beta_\infty (T_W - T_\infty) L^3 \cos\varphi}{\nu^2} = 1,49 \cdot 10^{11}.$$

$$\nu_\infty = \frac{\eta}{\rho} = \nu\,(H_2O, 20°C) = 1,002 \cdot 10^{-6} \frac{m^2}{s},$$

$$\beta_\infty = 0,21 \cdot 10^{-3} \frac{1}{K}$$

and the Prandtl number :

$$\mathrm{Pr} = \frac{\nu}{a} = \frac{\eta}{a \cdot \rho} = 6,99$$

.

With

$$Nu = \frac{\alpha\, L_0}{\lambda}$$

it is clear that

$$\alpha = 292,1 \frac{W}{m^2\, K},$$

$\lambda = \lambda_{H_2O,\,20°C} = 0,6 \frac{W}{m\, K}$ and $L_0 = L$,since the correlation is for a plate. As before, we use a simplified value for a plate with the same properties since it delivers reasonably accurate values.

$$\dot{Q} = \alpha \, A_{Pipe} (26°C - 20°C)$$

The heat flow can be rewritten as

$$\dot{Q} = \frac{Q_{load}}{\Delta t} = \frac{M\,\Delta H}{\Delta t}$$

so that follows

$$M = \frac{\alpha\, A_{Pipe} \cdot 6K \cdot \Delta t}{\Delta H} = 32,70\,kg$$

with $A_{Pipe} = \pi\, D\, L$.

One can see that even in a good estimation the volume flow is much too little and there can only be unloaded a total mass of PCM of 32,7 kg, which is far less than needed. The mass needed is estimated in the next chapter.

Pump and reed bed

As demonstrated in the preceded chapter, a completely passive water based system is not capable of discharging the whole PCM during an average summer night. Due to this a pump is needed, which ensures an optimal volume flow rate of the cooling fluid at all times. This way the PCM gets discharged by transferring the heat into the cooling fluid. The cooling fluid gets pumped outside the building into a heat exchanger, where it is cooled down especially during the night time where a free heat sink is provided by the environment. Then, the cooling fluid is led back into the building to receive more heat from the PCM.

For grey water treatment a reed bed is installed outside of the building. The reed bed is used as a heat exchanger. The tubes of the cooling circuit lead through the bed filled with water and porous material. As the water inside the tubes is warmer than the water in the reed bed, free convection takes place, increasing the heat transfer between the cooling fluid and the grey water. Due to the average wind speed of 4 m/s heat transfer from the reed bed to the ambient takes place via both convection, radiation and evaporation. Furthermore, the reed bed function as an additional heat sink as it does not heat up as much even during a succession of hot days.

Active concept

The advantage of an active concept is that it is controllable. This attribute suggests designing an active concept as complementation of a passive concept to regulate peaks.

Heat pump

As there is a heat pump included in the heating concept we make use of it in the cooling concept too by running it in reversible mode. It was decided to use pure water without glycol as cooling fluid. This has several advantages: First, water is due to better heat transfer properties a more effective cooling fluid. Second, it is environmental friendly as opposed to glycol. Third, heat transfer losses can be avoided as a heat exchanger would be needed since the heat pump would not be able to process with a water-glycol fluid. The only

disadvantage lies in the fact that the system will have to be emptied before winter as water would freeze in the pipes and destroy the pipe system. The advantages outweigh the disadvantages justifying our decision.

Holistic concept

From the previous considerations and calculations it can bee seen that the PCM needs to be discharged by a semi-active system. During a larger part of the year it is possible to cool down the PCM in the night by pumping water through the cooling water circuit, which is then led to an outside heat exchanger, in this case a reed bed. Being aware of the fact that on really hot summer days the reed bed won't be able to absorb all the heat coming from the PCM, we integrate the heat pump to the cooling water circuit. As we use water for the cooling circuit, it is possible to connect the heat pump directly to the cooling circuit, saving a heat exchanger. This way we avoid an overheating of the building even on hot summer days with warm night air temperatures. At the same time we focus on a passive system (according to rule 4.1) to save energy and use the heat pump for peaks only. In Figure 128: Bioclimatic diagramm Team Rooftop you can see the cooling circuit via heat pump and via reed bed.

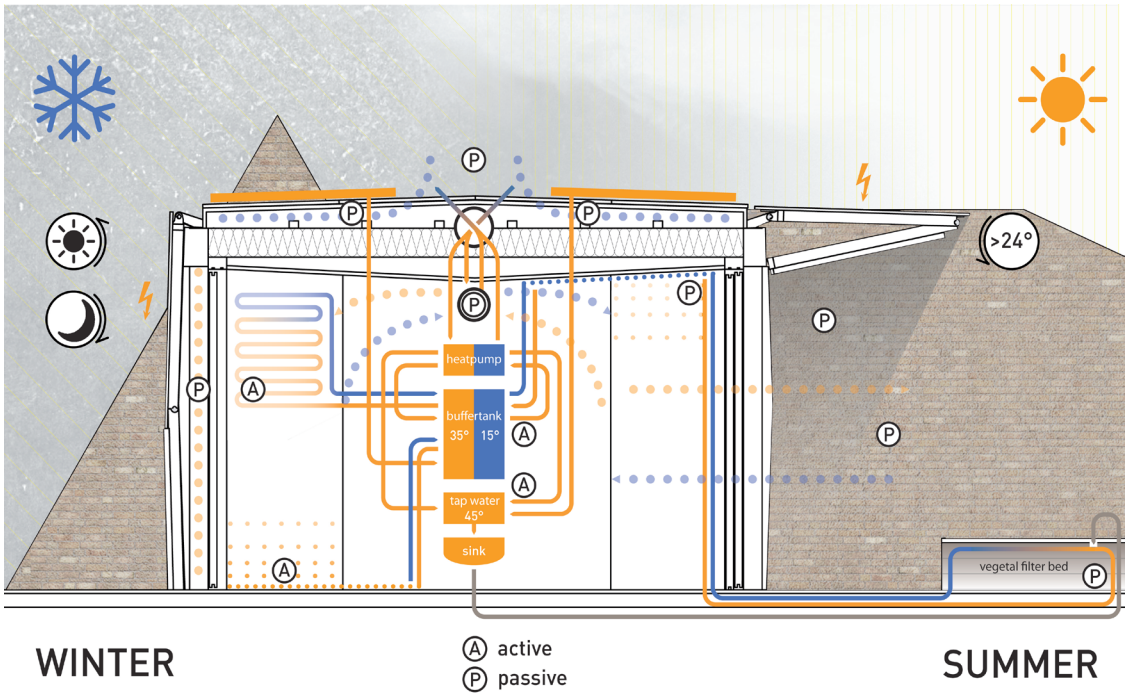

Figure 128: **Bioclimatic diagram Team Rooftop**

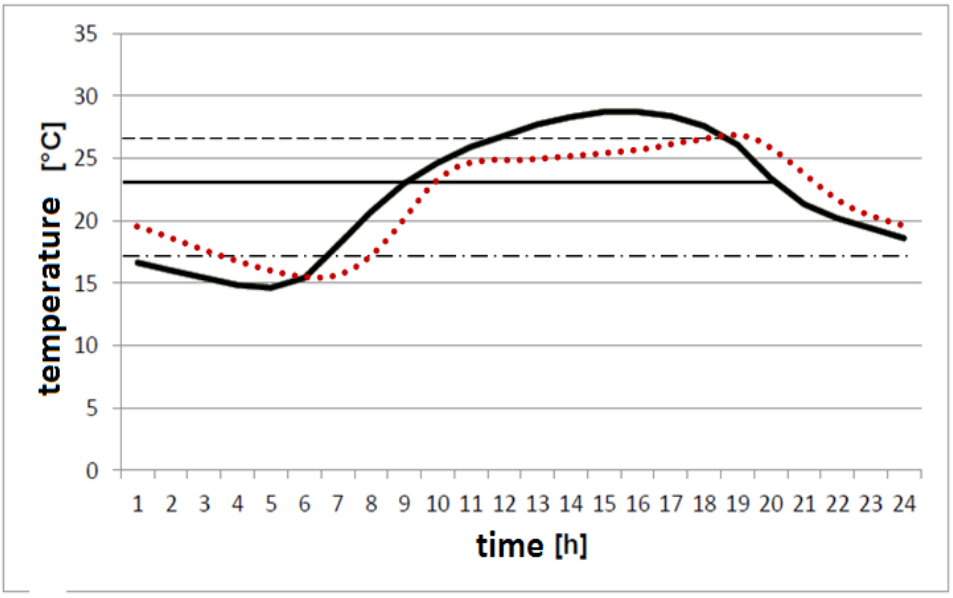

Figure 129: **Mean temperature curve during a hot summer day in july in Potsdam, Germany. Curves: outdoor temperature (thick black line), mean temperature during the night (dot-dash line), melting point 26°C (dashed line), melting point 23°C (thin black line), qualitative indoor temperature when using PCM with a melting point of 23°C (red dotted line).**

Chosen Design of Cooling Pipe System

Introduction

On hot days, the heat from the living space is absorbed by the cooling ceiling. It consists of a phase changing material (PCM), which is described in the next chapter. The thermal energy will be released in the night to the environment. The heat is transported to a heat exchanger in the reed bed. The latter serves to purify the gray water of the house. To increase the efficiency of the sewage treatment plant (STP), it is additionally used as a heat exchanger. Thus, a higher degree of utilization is given, which has a positive effect on the energy and cost efficiency, as the investment costs are lower and the heat transfer is more effective when using a liquid to liquid transfer as opposed to water to air transfer. If the room temperature is above the melting point of the PCM, it absorbs heat. In this report, the process of melting due to absorption of heat is called loading, the solidification due cooling is called unloading.

On hot days when the unloading is not possible due to high ambient temperatures, the cooling ceiling is discharged using the heat pump , which can be operated reversibly (ie, as a refrigerator). The heat pump is an air/water heat pump.

Design of the cooling system

On the free market, the melting points 26 °C, 23 °C and 21 °C (Micronal) are the most common. The company Lehmorange is a partner of team rooftop and offers the first two switching points ("Pcm 26" and "Pcm 23").

Hereafter, it is to be chosen between these two melting points.

Pcm 23 provides a more useful temperature as opposed to Pcm 26. Pcm 23 has the disadvantage that it may be prematurely filled. Then there will be a failure of the cooling system, since the cooling capacity of the ceiling is reached. This will be evaluated below.

The average night temperature is 17 °C. The average discharge period, i.e. the period during which the outdoor air is assumed to be cool enough to serve as a sink, is the period 22-7 clock with about 9 h, in which the average temperature is 17 °C.

time	Cooling requirement [W]
11	748
12	881
13	982
14	1050
15	1084
16	1075
17	1051
18	1071
19	1079
20	1002
21	803
22	619
sum:	**11446**
mean:	**954**

Table 28: **Cooling requirements during the day**

The available ceiling area is 47.76 sqm. Therefore,

$$Q_{pcm23} = 9552Wh$$

can be stored theoretically when assuming a density of 6 kg PCM/m². The amount of heat that cannot be stored when using the Pcm 23 equals to 2074 Wh (see Table 28) which corresponds to about 3 hours in which to expect the cooling to fail (20-22 clock, see below). When considering Figure 7 it can be noted that the outside temperature already decreases in that time period (dotted curve shown). Thus, it is possible that due to the inertia of the heating-up a pleasant, uniform room temperature can be ensured nevertheless. If this is not the case, an intelligent control can foresee this point and turn the chiller on in advance to unload the PCM partially. Thus, the synergy effect of the night air can still be used.

In collaboration together with our partner lehmorange new pcm plates were developed using aluminium which increases the heat transfer efficiency. Their density amounts to 5 kg/m². Therefore, an approximate

amount of 240 kg PCM is used which can store about 23880 kJ/m² or 6633 Wh. In addtion, pcm plates will be attached to the walls with magnet stripes in order to increase the amount of pcm used.

It was therefore decided to use the active PCM plates with the melting point of 23 °C.

The total amount of heat stored must be delivered at night during a period of nine hours. Thus, the nominal heat flow results in

$$\dot{Q}_{N,pcm23} = \frac{Q_{pcm23}}{\Delta t_{Entladung}} = 1041,3W.$$

Determining the cooling fluid flow rate

It is assumed that the fluid experiences a minimum temperature change of 3 K. It will be shown later on that if the fluid temperature is higher than 20 °C, the cooling task can no longer be fulfilled. Thus, the average maximum volume flow results in

$$\dot{V}_{N,pcm23} = \frac{\dot{Q}_{N,pcm23}}{c_{p,f} \bullet \rho_F \bullet \Delta\vartheta} = 78\frac{cm^3}{s}$$

Analysis of the heat transfer processes

In order to design the system, the heat transfer processes are analysed. Therefore, the nominal operating point is defined as the state with the highest outdoor temperature at which the cooling ceiling can still be fully discharged.

Figure 130 shows the main heat transfer processes.

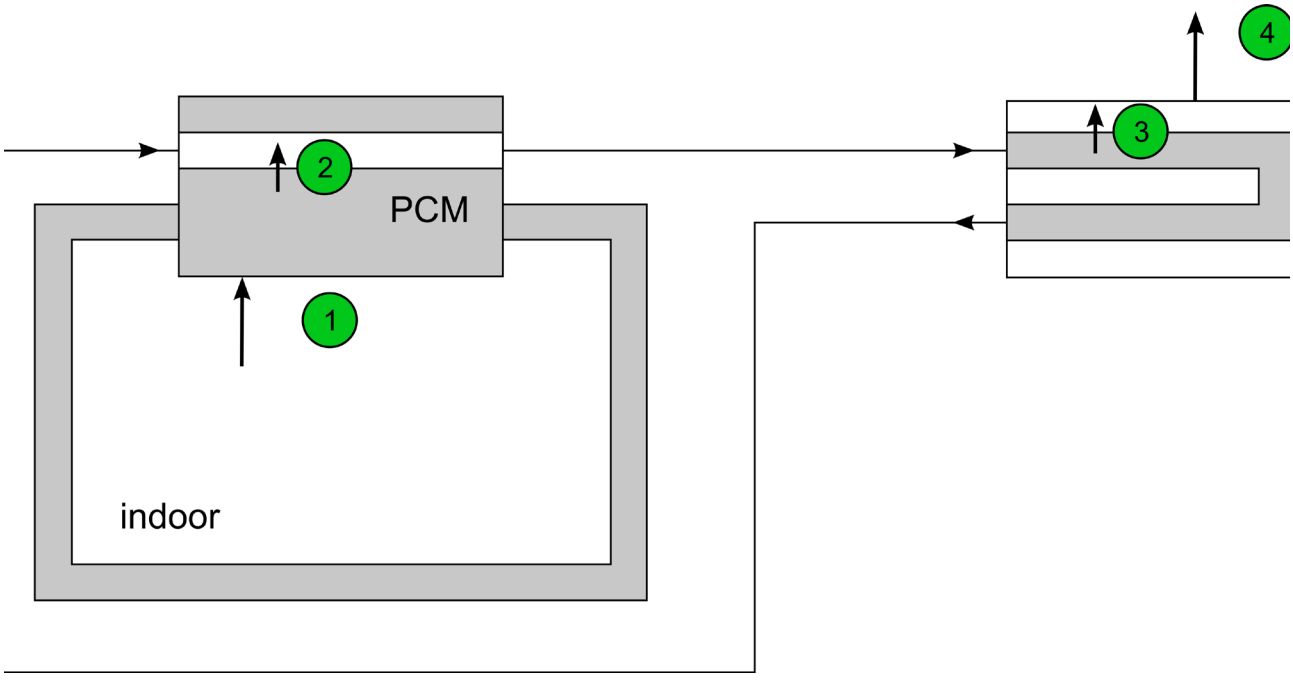

Figure 130: **System with the main heat transport processes**

(1) heat transfer between indoor air and cooling ceiling

The transfer process between the indoor air and the cooling ceiling is done by convection. With an average cooling load of 954 W and an assumed temperature difference of 5 K results in a heat transfer coefficient of

$$\alpha = \frac{\dot{Q}}{A \bullet (\vartheta_{PCM} - \vartheta_{Raum})} = 3,99 \frac{W}{m^2 K}$$

This is low and easily reached for still air. The nominal specific cooling capacity is

$$\dot{q} = \frac{\dot{Q}_{pcm23}}{A} = 19,79 \frac{W}{m^2}$$

(2) heat transfer between cooling ceiling and cooling fluid

The cooling fluid has the task to unload the cooling ceiling during night time. The question is, how low the inlet temperature has to be in order to fully unload the cooling ceiling during the nightly hours. Therefore, the following assumptions and calculations serve the purpose of designing the reed bed heat exchanger.

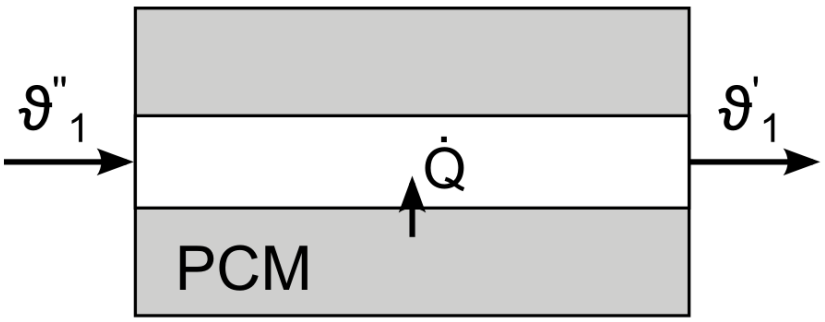

Figure 131: **Sketch of the heat transfer from the pcm to the cooling fluid**

The progressing phase boundary increases the heat transfer resistance in the ceiling, which increases the time required to discharge the PCM layer.

It is assumed to be homogeneous. Since this does not correspond to reality, the relevant material properties (thermal conductivity, etc.) are averaged mass proportionally with the substances involved. Cooling is comparatively homogeneously distributed over the upper surface. It is believed a driving temperature difference of 3 K is appropriate. The values listed here are valid for the combination PCM/clay. Since a change of material was done since the fourth deliverable, which lead to a improved heat transfer (PCM/metal combination), the following specified requirements are overestimated and hereby designed for the worst case through the use of inferior material values.

	paraffine (fluid)	paraffine (solid)	clay	effective values
thermal conductivity [W/mK]	0.26	0.26	0.47	0.42
density	900.00	-	1200.00	1121.74
specific isobaric heat capacity [kJ/kgK]	2.10	-	1.00	1.29
temperature conductivity				2.88E-07

Table 29: **Effective material properties**

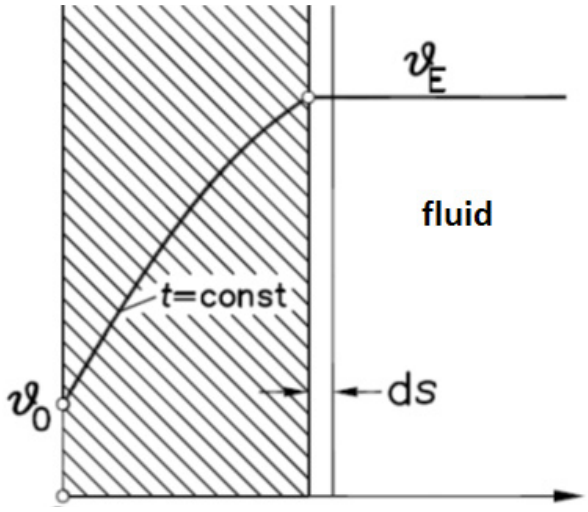

Figure 132: **Temperature curve (for t = const.) during solidification of a planar solid with s as the distance from the phase boundary of the cooled surface at x = 0 (Stefan, 2010)**

Table 29 shows the physical properties used. In (Stefan, 2010) it is shown that the thickness s of the solidifying layer grows with

$$s = 2 \cdot \sqrt{at}$$

where the constant γ is

$$y^2 = \frac{1}{2} Ph^{-1} - \frac{1}{6} h^{-2}$$

The size of Ph is the so-called phase transition number:

$$Ph := \frac{h_E}{c(\vartheta_E - \vartheta_o)}$$

For the time to solidify a layer of thickness s is

$$t = \frac{s^2}{4a \cdot y^2}$$

The material values are calculated according to the following form:

$$X_{Eff} = A_1 \cdot X_1 + (1 - A_1) \cdot X_2$$

with A_1 as the proportional content of the PCM (see datasheet page 45) and X_i as the relevant pa-rameters. The results are shown in Table 29.

	unit	26°C	23°C
enthalpie of solidifying	kJ/kg	110.00	**100.00**

Table 30: **enthalpie of solidifying**

	unit	value
phase transition number Ph	-	**28.5**
γ²	-	**0.02**
solidification time	s	**31322**
solidification time	h	**8.7**

Table 31: **Values of the Stefan problem**

The cooling temperature is varied in a range from 5 to 22°C. It turns out that even with an assumed to be constant fluid temperature of

$$\vartheta_0 = 20,4°C$$

the cooling task can be accomplished in a period of 9 hours (see Figure 133). The calculation was done using

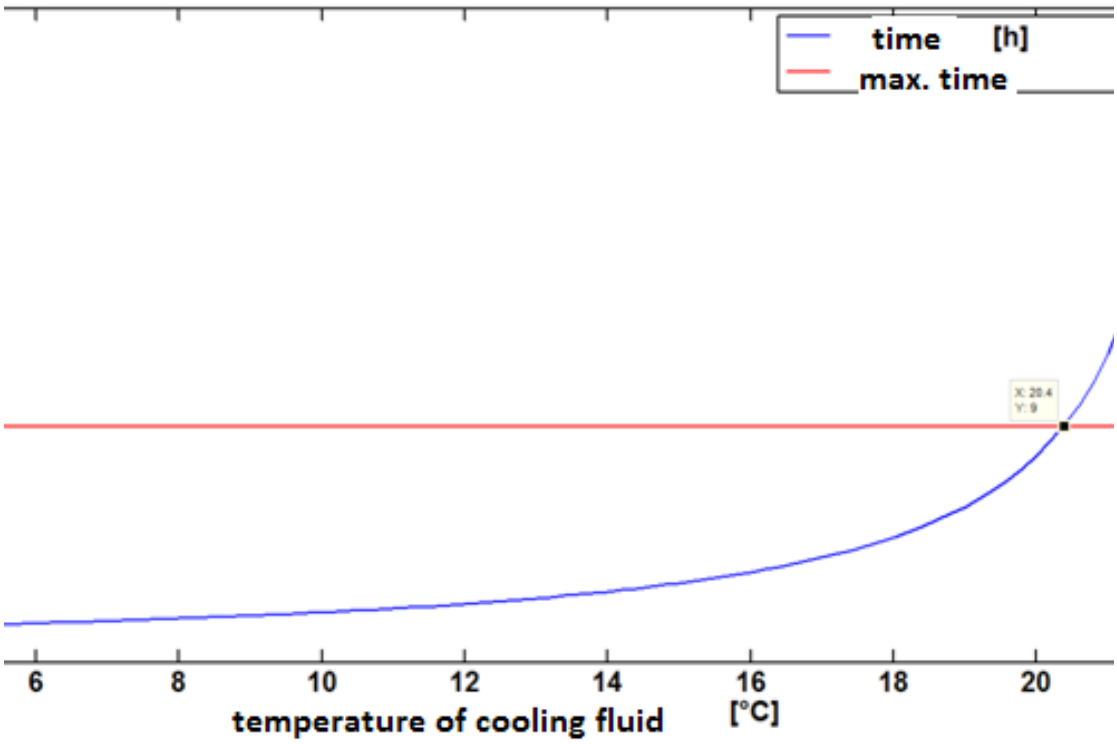

Figure 133: **required cooling time**

It shall now be taken into consideration that the fluid is heated during the passage. To this end, in the following the minimum required temperature spread per plate (n_p ... number of parallel strands) is determined. The nominal cooling load per plate is 65 W/plate (because of 16 plates). The nominal volume flow is then 4.88 ccm/s per plate. The minimum required temperature spread per plate is then calculated to

$$\Delta\vartheta_{\min} = \frac{\dot{Q}_1}{c_{PW} \bullet \acute{M}_1} = 3,19K$$

It is now assumed that the previously calculated minimum input temperature must be maintained only in the mean - because a lower temperature is having a positive impact, for example, at the inlet, and a higher temperature at the outlet is having a negative effect, so less heat is transferred than calculated. It is thus assumed that these two effects offset each other.

Accordingly, the required maximum inlet temperature can be calculated:

$$\vartheta''_{1,\max} = \vartheta_{fluid} - \frac{\Delta\vartheta_{\min}}{2} = 18,8°C$$

and the maximum inlet temperature is

$$\vartheta'_{1,\max} = \vartheta_{fluid} + \frac{\Delta\vartheta_{\min}}{2} = 22°C$$

Therefore, the inlet and outlet temperatures of the heat exchanger in the reed bed have been defined.

(3) heat transfer between cooling fluid and reed bed

It is required to determine the transfer area of the heat exchanger. The filter tank consists of a gravel-water bed. For the basin, it is assumed that it is heated only slightly due to its size. The system is designed for the peak load condition in which the system is still running at an approximately steady state.

The heat transfer from the fluid to the PKA fluid is modelled as a heat exchanger with a flow that does not change its temperature throughout the heat transfer length. The "flow rate" of this current adjusts itself by free convection flow . Therefore, the heat exchanger is placed at the bottom of the PCA. The fluid is heated , rises, cools off at the surface by convection, radiation , etc. and falls again . Due to this mixing the temperature of the pool at steady state is considered as constant. In Figure 134, the heat transfer process is illustrated. he heat transfer coefficient of the outside α_a will be determined.

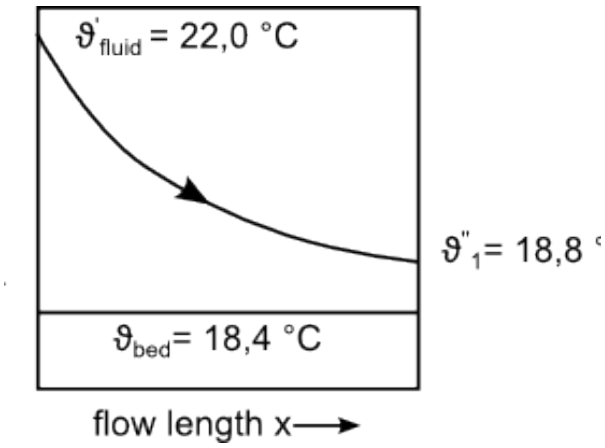

Figure 134: **entrance temperature und exit temperature in the heat exchanger of the PKA**

The calculation is performed according to (Chang, 2001). Since free convection occurs, the Grashof number is determined first, which is a measure for the heat transfer due to free convection. For the following calculations, gravel 16/32 is assumed (which means a grain size between 16 and 32 mm). The porosity is (gravel 16/32)

$$\varepsilon_{bed} = 0,379$$

The flow pattern can be classified using the maximum Reynolds number, which is based on the maximum speed at the surface of the cylinder. The Grashof number equals to approx. 60:

$$\mathrm{Re}_{\max} = \frac{g\beta_{fl} K d(\vartheta_W - \vartheta_\infty)}{v_{fl}^2} = Gr_{\max} = 58,27 \backsimeq 60$$

The effective thermal conductivity of a gravel/water bed was measured and is approximately

$$\lambda_S = 2\frac{W}{mK}$$

The driving temperature difference between the pipe surface and the pool temperature at infinity is unknown because it is not known which pool temperature would occur at steady state. For the following calculations, it was assumed that the driving temperature difference is 3 K. Then

$$\vartheta_{bed} = 17,4°C$$

The nusselt number of the reed bed fill is determined by using ***figure 13*** and leads to a nusselt number of two. Then the heat transfer coefficient is

$$\alpha_a = 157\frac{W}{m^2 K}.$$

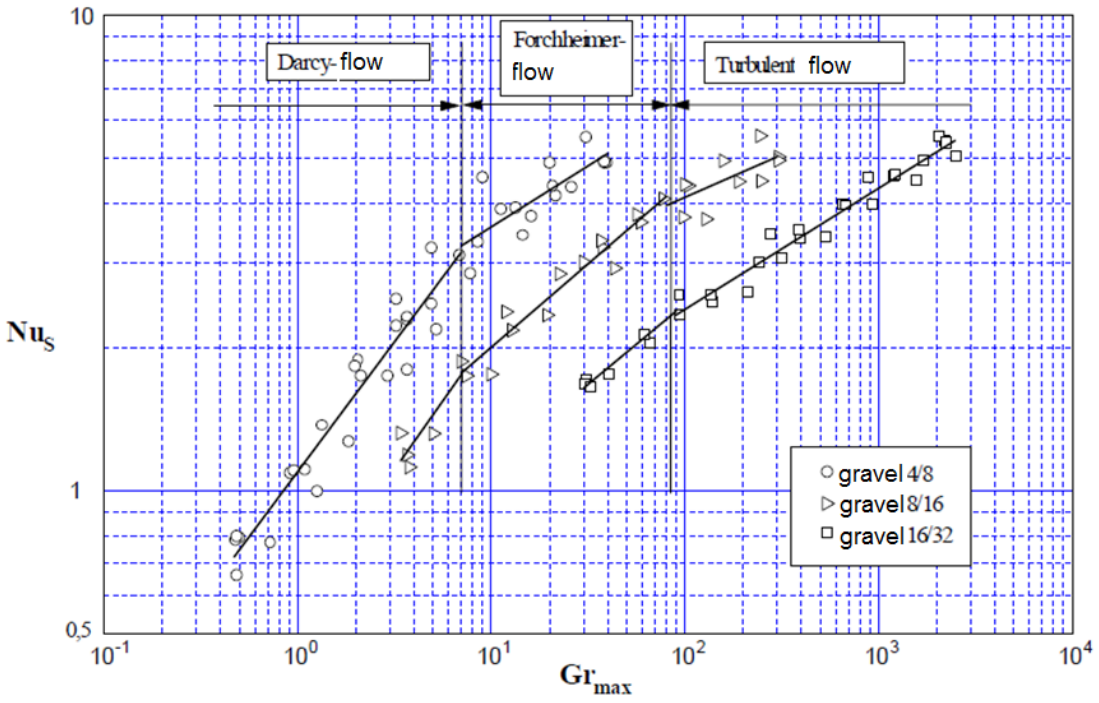

Figure 135: **Nusselt numbers in the single tube in the bed as a function of the Grashof number and the respective regression lines. (Chang, 2001)**

The heat transfer surface can be calculated under the assumption that the local heat transfer coefficients do not change locally and thus correspond to the global heat transfer coefficient. The logarithmic mean temperature difference for the design point amounts to:

$$\Delta\vartheta'_{\log} = \frac{\Delta\vartheta_{links} - \Delta\vartheta_{rechts}}{\ln\left(\frac{\Delta\vartheta_{links}}{\Delta\vartheta_{rechts}}\right)} = 2{,}7$$

First, the design is done for medium high finned tubes of Wieland (finned tube GEWA-D D-1135.18100-00). The required tube length for the transfer of heat is calculated for this specific prod-uct. Next, the required pipe length is derived for other geometries.

The heat transfer coefficient k is calculated through (Böckh, 2014)

$$\frac{1}{k} = \frac{A}{A_0 + A_{Ri} \bullet \eta_{Ri}} \bullet \frac{1}{\alpha_a} + \frac{D_A}{2 \bullet \lambda_R} \bullet \ln\left(\frac{D_a}{D_i}\right) + \frac{D_a}{D_i} \bullet \frac{1}{\alpha_i}$$

with A as the outer surface of the tube (without fins). The tube length required for a given pipe inner or outer diameter is calculated by using a modified transition coefficient equation. It is modified by extracting the length L and one obtains:

$$\frac{1}{kA} = \frac{1}{(kA)_{\text{mod}}} \bullet \frac{1}{L} \text{ with } \frac{1}{(kA)_{\text{mod}}} = \frac{1}{\alpha_i \pi D_i} + \frac{1}{\alpha_a \left(\frac{A_0}{L} + \frac{A_{Ri}}{L} \bullet \eta_{Ri}\right)} + \ln\left(\frac{\left(\frac{D_a}{D_i}\right)}{2\lambda_W \pi}\right)$$

It is

$$\dot{Q}' = L \bullet (kA)_{\text{mod}} \bullet \Delta\vartheta_{\log}$$

The parameters given in Table 32 apply to the Wieland fin tube. Using these one can calculate the modified heat permeability. The heat transfer coefficient on the inside is much greater than on the outside, so that the ribbing must be on the outside. The calculation of the heat transfer coefficient on the inside is done by using a correlation for flows in pipes.

L		m
height of fins	0.004	**m**
thickness of fins	0.001	**m**
fin partition	0.002	**m**
outer pipe diameter	0.019	**m**
total area per meter	0.260	**m²/m**
inner pipe diameter	0.017	**m**
number of fins per meter	433.071	**1/m**
total outer diameter	0.0255	**m**

Table 32: **fin parameter**

The average flow velocity and the Reynolds number are found to be:

$$w = \frac{\dot{V}}{\pi D_i^2} = 0,36 m/s$$

$$\Re = \frac{w D_i}{v} = 6 \cdot 10^4$$

Thus the flow state is in the transition between laminar and turbulent. However, the heat exchanger pipes are neither straight nor undisturbed. On this subject, (VDI, 2006): "In the transition region the nature of the inflow and the shape of the tube inlet affect the flow pattern." At the flow inlet of the tube constriction takes place. That and the deflections lead to the presumption that here, these disturbances lead to an earlier change in a turbulent flow even at a Reynolds number of 6000. This effect could be enhanced by the usage of a diffuser. It is

$$Nu_{m,T} = \frac{\frac{\xi}{8}\Re \,\mathrm{Pr}}{1 + 12,7\sqrt{\frac{\xi}{8}}\left(\mathrm{Pr}^{\frac{2}{3}} - 1\right)}\left[1 + \left(\frac{d_i}{L}\right)^{\frac{2}{3}}\right] = 624$$

with

$$\xi = (1,8 \log_{10} \Re - 1,5)^{-2} = 0,04 .$$

Thereby it is

$$\frac{1}{(kA)_{\mathrm{mod}}} = 0,038$$

and the resulting length would be 15 meters for a guessed reed bed temperature of 17,4 °C.

For a higher temperature of 18.4 ° C (point 2) it can be cooled down up to an outside temperature of 16.5 ° C (see next section). Because this is advantageous, the calculation is again performed for the point 2. The result is a needed length of approx. 27 meters. Then a heat exchanger can be designed which is shown in the project drawing ME-034. Taking the limited space in the reed bed into account the maximal length of the heat exchanger is 3.25 m which amounts to a total of eight pipes used. Assuming an unfinned tube, the factor D_a*L gives a characteristic value of the required heat trans-fer area depending on the pipe outside diameter.

	total area [m²]	factor D_a*L [m²]	Length of fin pipes [m]	number of pipes
point 2, turbu-lent	7.082	2.254	27	8

Table 33: **Results of heat exchanger dimensioning**

Subsequently, the absorbed heat of the reed bed is discharged to the environment. Here, too, it is designed for the steady state, with a reed bed temperature of 18.4 ° C. The outside temperature is unknown and is sought, however, it is assumed to be constant.

The loss mechanisms are heat losses due to radiation, evaporation, convection, and to a lesser degree also due to conduction to the surrounding geometries (side walls):

$$\dot{Q}_V = \dot{Q}_{conv} + \dot{Q}_{rad} + \dot{Q}_{evap} + \dot{Q}_{side}$$

Each of these transfer processes is calculated by using at least one of the parameters of length L, width W and height H of the reed bed. These are constant. The convection is determined by the Newton's law of cooling, the radiation losses can be determined by the radiation balance of the reed bed system. To account for the non-uniformity of the surface, the formula is separated into the respective areas occupied by gravel and water. The evaporative heat loss is determined from the evaporated mass flow rate and the enthalpy of the vaporization of water. The side walls are composed of a wooden planking and a PET layer.

The formulas can be rewritten to

$$\dot{Q}_V = L \bullet (\alpha_L B \Delta\vartheta_U + BK_3 \bullet (\varepsilon_p \varepsilon_w + (1-\varepsilon_p)\varepsilon_{gravel}) + B \bullet \varepsilon_p \dot{m}_{Verd} \bullet \Delta H_V + 2kH\Delta\vartheta_U) + 2kHB\Delta\vartheta_U$$

The calculation was done using the simulation program Mathlab. The result is that the minimum difference to the outside temperature has to be 2,4 K as shown (see Figure 139). Thus, the mentioned steady state operating point for the outdoor temperature can be determined to be

$$\vartheta_{U,stat,\max} = 16,4°C$$

From this point on, the peak cooling load can no longer be removed completely and in steady state within the night time. Is this maximum outdoor temperature exceeded, the heat pump acts as a secondary cooling system. So this is an important switching point for the controls. Heat loss back into the living room as well as sensible heat storage were neglected. Thus better results are achieved in reality than as set out here which was done on purpose in order to set up an upper limit.

Practical design of the pipe system

The primary flow from the heat exchanger flows from the constructed wetland to the cooling circuit distributor. From there, four circuits fork off and supply each one field of PCM panels with cooling fluid (see project drawing ME-031 for a detailed depiction of the ceiling circuit). This relatively small amount of circuits was chosen out of practical reasons. It facilitates the building phase and is on top more economical since less pipes and less fittings have to be used. The cooling task can still be carried out and the pressure loss remains low compared to a system with more parallel branches which would have an even lower pressure loss. It was decided not to use glycol solution, so the cooling fluid can be drained without endangering the environment. Instead, drain valves exist and emptying the ceiling is scheduled for autumn.

In the following, the pressure loss is calculated and the pump will be designed as well as the heat exchanger of the reed bed.

The pressure loss calculation was made on the basis of Project Drawing ME-032 and ME-033 (Scheme of pipe system with pipe numbers) . First, the line losses were calculated , see Table 9. The pressure losses through fittings can be neglected, with the exception of the Viessmann distributor with 500 Pa, according to the manufacturer.

pipe no.	length [m]	volume flow [l/min]	w [m/s]	Reynolds number [-]	pressure loss [mbar]
1	6	4.68	0.248	4951	3.532
2	1	1.17	0.062	1238	0.045
3	6	1.17	0.062	1238	0.239
4	1.5	1.17	0.062	1238	0.075
5	6	1.17	0.062	1238	0.298
6	3	1.17	0.062	1238	0.149
7	8	1.17	0.062	1238	0.360
8	3	1.17	0.062	1238	0.135
9	8	1.17	0.062	1238	0.318
plates field 1	27.3	1.17	0.062	1238	1.228
plates field 2	27.3	1.17	0.062	1238	1.228
plates field 3	29.07	1.17	0.062	1238	1.307
plates field 4	29.07	1.17	0.062	1238	1.307
14	6	4.68	0.248	4951	3.532
15	4	4.68	0.248	4951	2.355
16	4	4.68	0.248	4951	2.355

Table 34: **pipe friction losses in the system**

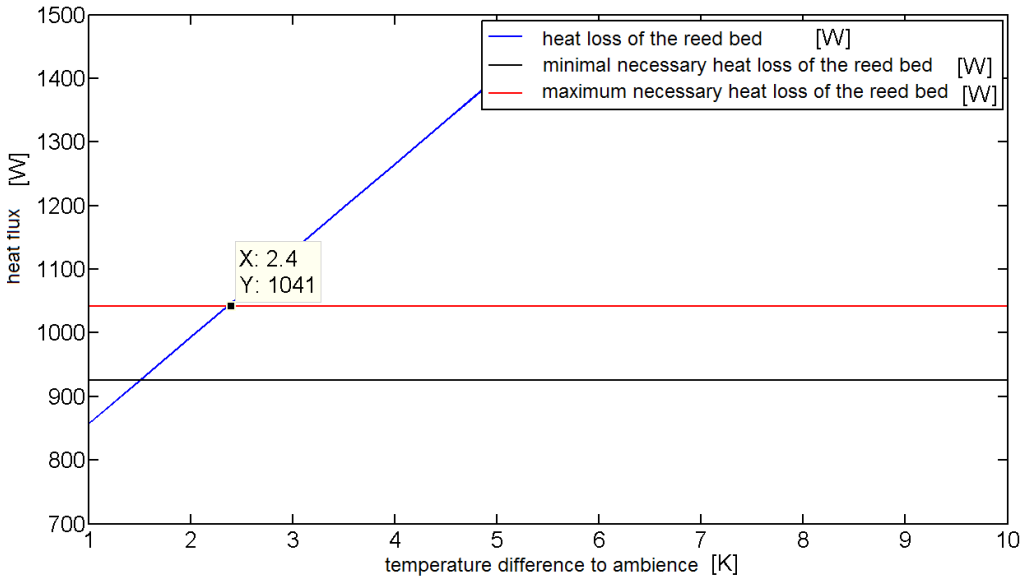

Figure 139: **Determination of the minimum needed driving temperature difference for the reed bed**

The equivalent circuit is:

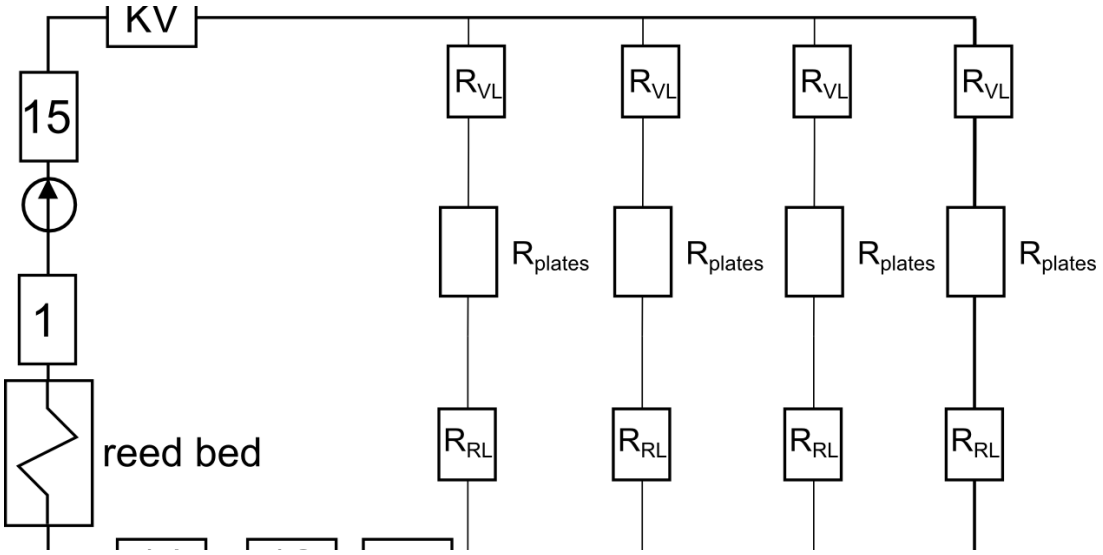

Figure 136: **equivalent circuit**

The circuit is divided into the individual resistors. Due to the similarity of the geometry, the total resistances of field 1, 2 and 3,4 respectively are the same to a good approximation. It applies to parallel and series resistors in fluid mechanics that resistors in series can be added up whereas resistors in parallel need to be added with the reciprocal of their square root value. The resistor of a flow is defined as the pressure loss

divided by the square of the volume flow:

$$R = \frac{\Delta p}{\dot{V}^2}$$

The resulting individual resistors are added to determine the total pressure drop, see Table 35. It results in a total pressure drop of approximately 6.3 kPa or 0.063 bar. This is really low and is a result of the low volume flow nd the relatively low amount of pipe length.

	pipe 1	pipe 15	distri-butor (feed)	fields in parallel	distri-butor (return flow)	pipe 16	pipe 14	reed bed	sum
pressu-re loss [Pa]	353	235	500	165	500	235	353	3922	**6264**
pressu-re loss [bar]	0.00	0.00	0.005	0.002	0.005	0.00	0.00	0.04	**0.063**

Table 35: **Individual resistances of the series circuit**

Pump Dimensioning

As a result from the previous considerations, the pressure curve of the pipe system has to be determined. It can be assumed that the changes in the pipe friction coefficient via varying the velocity are negligible compared to velocity w_i. Therefore, a "nominal Zeta" of the system can be found which amounts to approx. 203.6 1/m. Hence, via varying the velocity the system curve can be determined (see Figure 137).

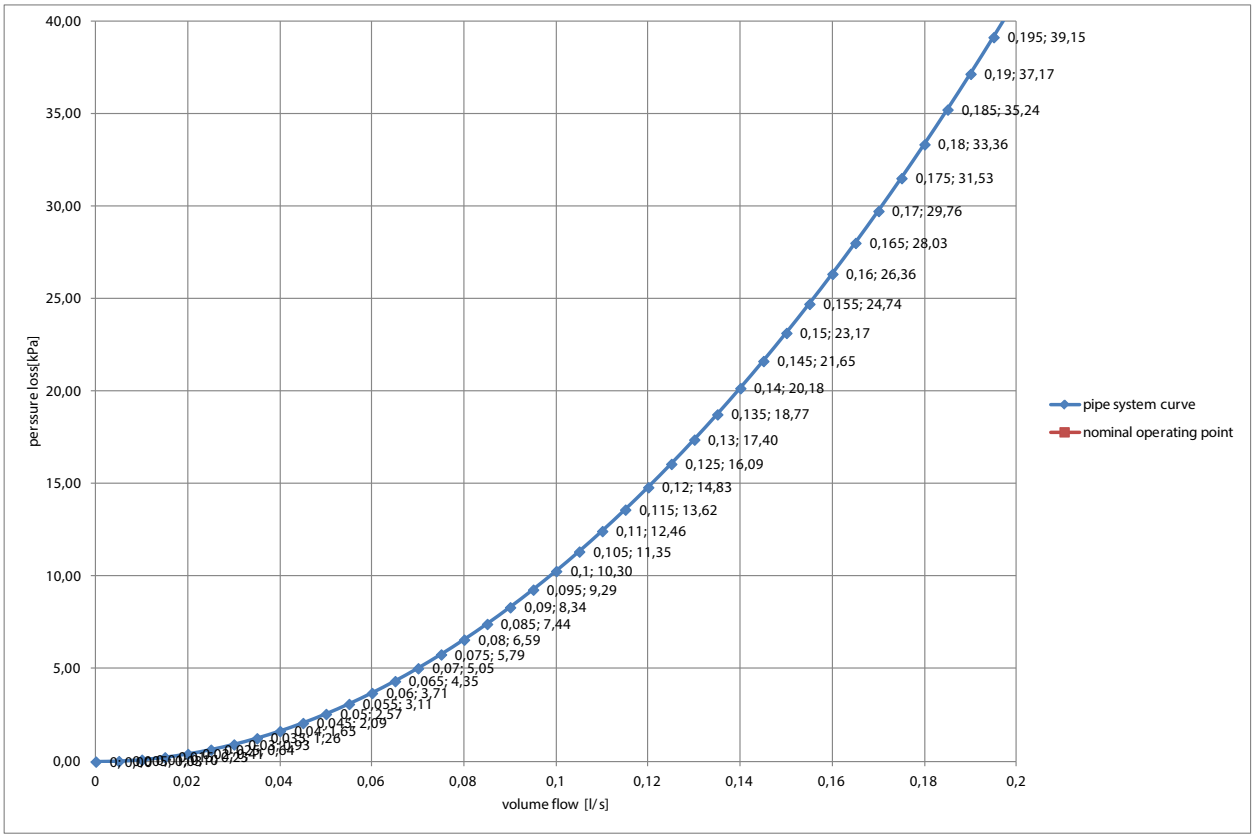

Figure 137: **system pressure curve**

Subsequently, a suitable pump is selected. The selected type is a Grundfos pump of the type Alpha1 25-40, whose characteristic is shown in (see Figure 138). That type of pump has the factory-made setting of the line PP2 (upper proportional pressure control strategy). The resulting operating point is at 0.11 l/s and a pressure loss of 15 kPa. Then the pump uses up an amount of electrical energy of 7.5 W which is very low as opposed to an active cooling system using the heat pump in reversible mode.

System Values	value	unit
Nominal Volume Flow	4.68	**l/min**
Nominal Volume Flow	0.078	**l/s**
Nominal Volume Flow	0.28	**m³/h**

Table 36: **nominal volume flow**

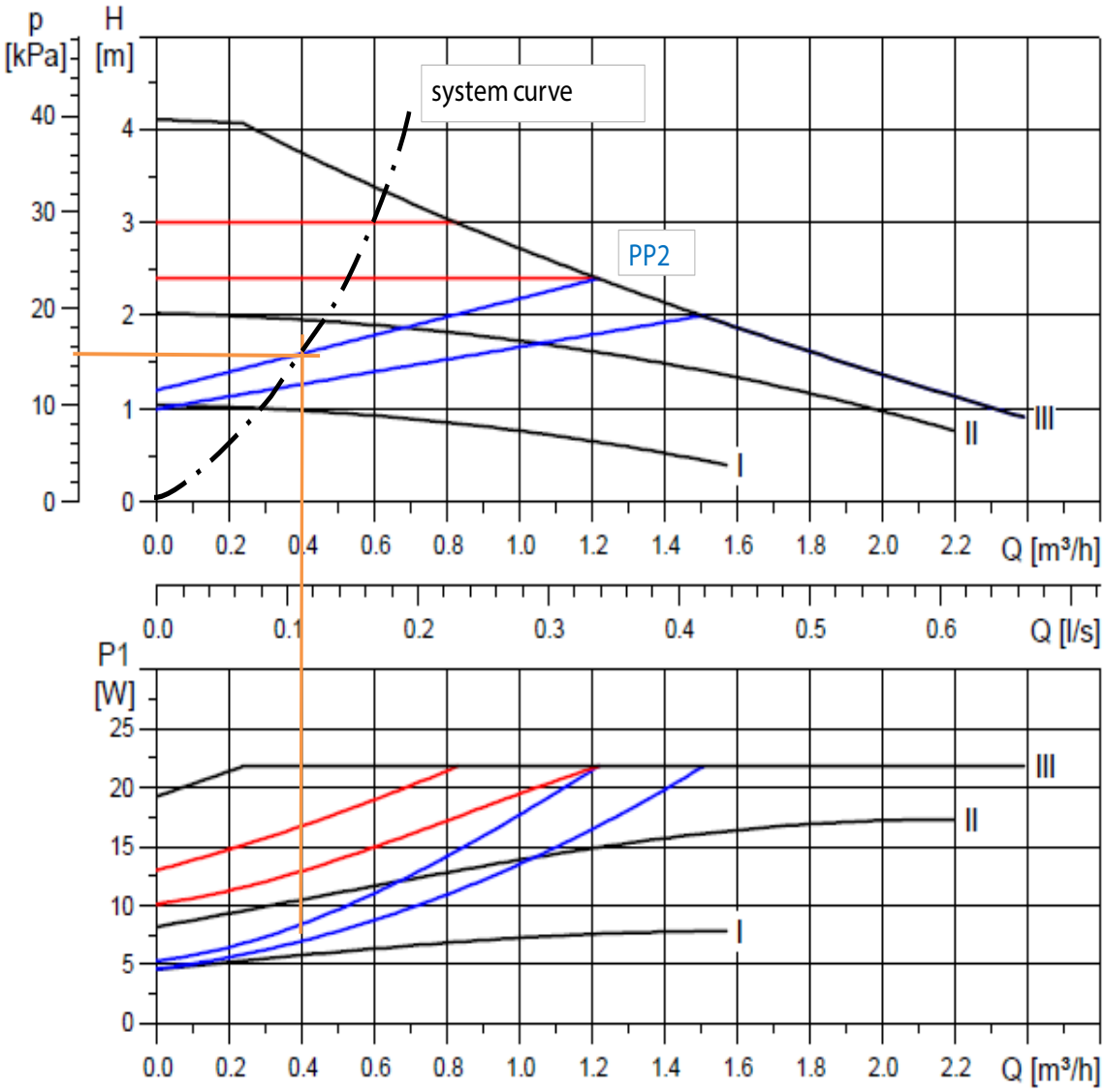

Figure 138: **system and pump curves for pump Grundfos Alpha1 25-40**

Dimensioning of the Reed Bed

With the required minimum length the heat exchanger can be built in the reed bed dimension. The dimensions of the reed bed are as follows:

	Heigth	Width	Length
reed bed dimensions [m]	0.9	2	3.4

Table 37: **reed bed dimensions**

Thus, for the heat exchanger pipe(s) follows:

width	1.00	m
effective length	3.25	m
number	6.00	pipes

Table 38: **reed bed heat exchanger dimensions**

Therefore, a quantity of eight finned tubes with about 3.25m in length has to be used.

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VENTILATION

Our ventilation concept works as a central ventilation system, in detail a combined ventilation and head pump device (Stiebel Eltron LWZ 304) in the core module supplying the living and the sleeping room via two vent slots (Berliner Luft WSA-ZS 151 – A – 1200, see Figure 141/Figure 142). These are located in the walls of the core module, in a distance of 100 mm from the lowest point of the ceiling and provide a length of 1200 mm in the middle of the walls.

The exhaust air is removed through the core module as well. It is ventilated through vent slots with a length of 800 mm in the bath and the kitchen (see red dots in Figure 140) which are embedded seamlessly into the shadow gap of the ceiling. They are custom made by our team as a wooden box coated with tinfoil from the inside and hidden above the ceiling.

Each of the vent slots is connected to the air distributors via two pipes (Stiebel Eltron LVS system) to reduce the air flow in each of the pipes and therefore reduce the airflow generated noise. These distributors are connected to the ventilation unit of our heat pump. This connection is made by a sound absorber, reducing the sounds coming directly from the ventilation / heat pump. To reduce the influence of other sound sources located in the mechanical room there are additional sound absorbers in the ventilation outlets.

The ventilation of the mechanical room is provided by separated fresh air supply and separate exhaust air removal which are located in the air distributors in the room. Therefore, the support of the cooling process of the technical devices in the room is assured and more energy is gained, that can be reused due to the heat exchanger.

There is also the opportunity to provide a passive natural ventilation of the building by manually opening the windows to provide a fast rush airing when needed or desired. By opening windows manually in the summer nights the air in the rooms can be cooled, which helps to save energy by supporting the cooling system of the PCM-materials in the ceiling while discharging. This support is depending on the habits and preferences of the inhabitants opening the windows of the building. We assume that the average inhabitant will open the windows on warm summer days for at least 30 minutes, which is enough to reduce the temperature of the room to a value close to the outside temperature. Then the windows are being closed and ventilation is again solely maintained by the ventilation device.

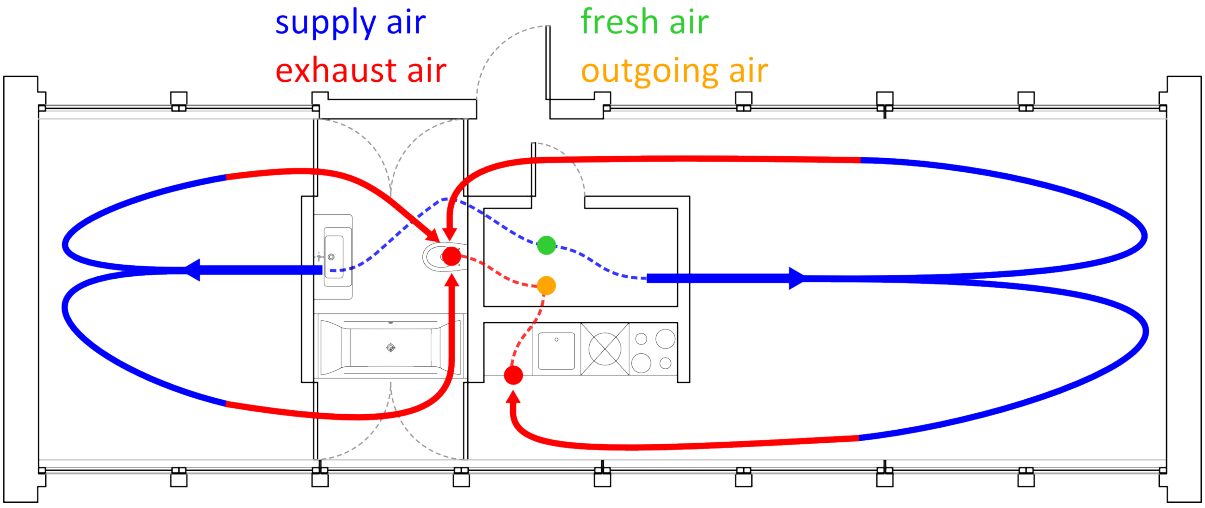

Figure 140: **Airflow sketch**



Figure 141: **Vent slot WSA-ZW151-A-1200 [Berliner Luft: Produktbeschreibung Walzenschlitzauslässe]**

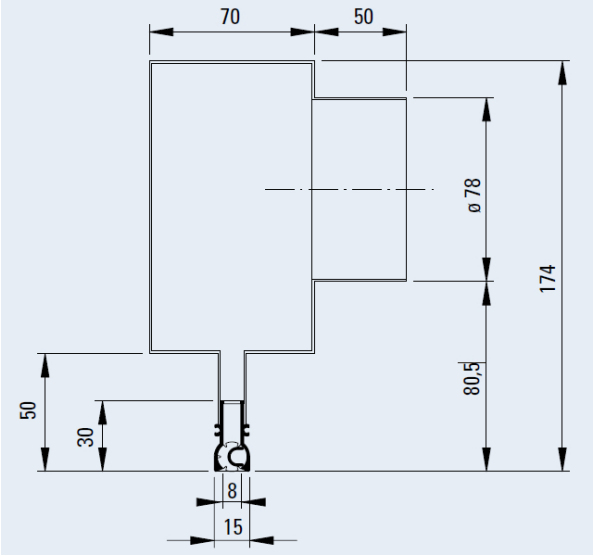

Figure 142: **Technical drawing vent slot WSA-ZW151-A-1200 [Berliner Luft: Produktbeschreibung Walzenschlitzauslässe]**

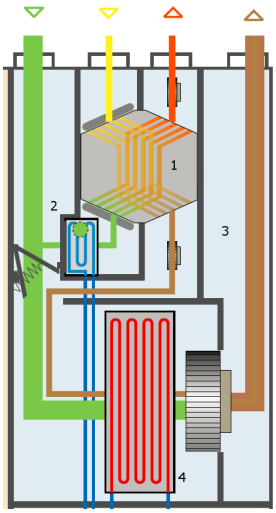

Figure 143: **schematic diagram of the ventilation device (heat exchanger 1, preheating device 2, vents 3, heatpump 4) [Stiebel Eltron: Planung und Instalation Lüftung March 2013]**

Our ventilation device is integrated in the heat pump we use for heating and cooling. Thereby, not only space in the mechanical room but also costs for installation maintenance and material can be saved because many of the installed parts can be used for both systems, the heat pump and ventilation, in comparison to a combination of two separate systems. The heart of our ventilation (see Figure 143) consists of the cross-flow heat exchanger with an efficiency up to 90 percent [Stiebel Eltron LWZ 304 product data sheet]. There are also two vents consuming only 60 W together with the vent that is needed for the heat pump and a preheating device needed for frost protection in the winter times and also regulating the humidity of the inflowing outside air to a norm value according to rule 7.7 of the Solar Decathlon Europe. The ventilation is combined with sensors for humidity and carbon dioxide located in the exhaust air pipes from the bathroom and the kitchen to regulate the airflow rate by the ventilation system. It will increase the airflow whenever a high humidity or carbon dioxide concentration is detected.

We do not use a humidification system as there are concerns regarding development of mould because of the high humidity normally needed in such a device. Also we have concerns about the standard of hygiene we can achieve, not only because of mould, but also the development of germs in the water used by the system especially in times the system is not running. There is also high energy consumption and a great effort of maintenance resulting out of such a system.

Although we have a central ventilation system the friction losses of the piping needed for the distribution of air compared to convenient systems are reduced by minimizing the piping length as a result of the integration into the core module. As a side benefit, modularity is enhanced by this integration of the complete ventilation system into the core module. Furthermore, it enables a discrete appearance of the ventilation system by giving us the opportunity to use small and very discrete types of ventilation openings and minimizing the visibility of the ventilation system. As seen in Figure 141, the ventilation slots have no need of flaps to direct the airflow but using a system of integrated rollers.

Directing the airflow up to the ceiling, the phenomenon of Coanda is used to regulate the indoor airflow. Therefore, the flow attaches longer to the ceiling because of negative pressure forming between both (see Figure 144). The air drops near the end of the room, forming an air rotation, enabling a balanced airflow and

constant conditions throughout the room.

This method of circulation improves the comfort of the inhabitants as there is less draft in the comfort zone of the people especially near the floor. Furthermore, the airflow below the ceiling, induced by the Coanda effect, leads to an improved heat transfer coefficient for the passive cooling (PCM-ceiling) by generating a forced convection. This leads to a better heat transfer between the room and the PCM-ceiling.

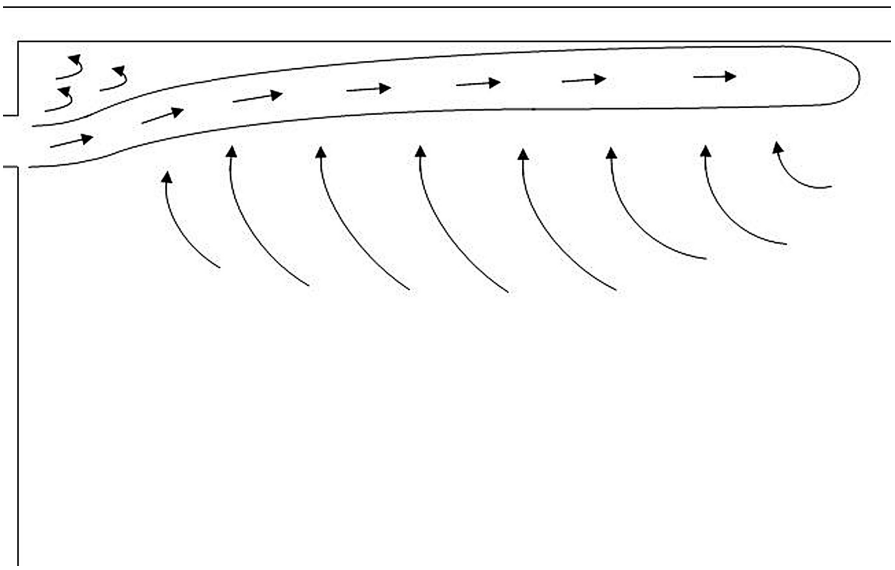

Figure 144: **Coanda effect**

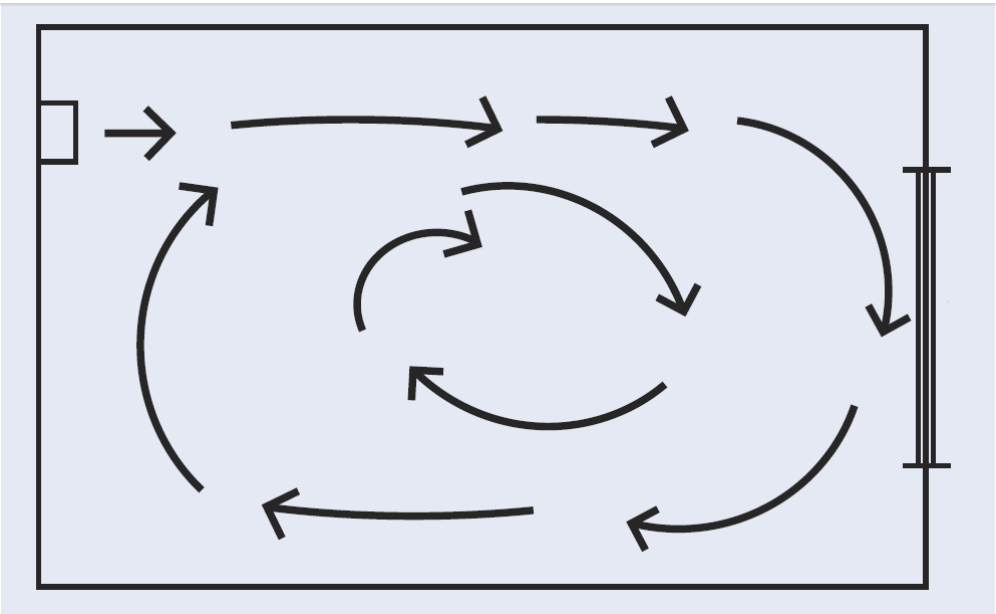

Figure 145: **Fresh air distribution**

Unfortunately, during construction phase we got some problems with the controlling system and so it couldn't be used for the regulation of the ventilation system like intended.

Instead we used the internal controlling system of the heat-pump, which is only capable of measuring the humidity of the exhausted air in the heat-pump. But these measurements were influenced by dry air sucked out of the technical room and the controlling systems weren´t able to increase the airflow in the way the intended would have done.

But it is not able to react to high level of carbon dioxide. There was no opportunity to monitor the carbon dioxide level with the systems intended to do this and so the only way to collect reliable carbon dioxide data was to use the monitoring system installed for the competition. But these values had a considerable delay so it was very difficult to react to it manually.

FOLDING FAÇADES

The folding façades of the Rooftop House form an integral part of our design, concept and motivation. The idea of a house that somehow changes with its environment has captivated us and driven us to create a house that would dynamically adapt to its changing environment, both on a daily basis and on a more abstract level related to our planet's problem with climate change.

The main purpose of the façades, as has already been stated, is to increase the surface area of the house during the day to generate more electricity and provide cooling. Conversely at night or during the winter they will be used to decrease the surface area in order to insulate and shield the house from the cold outside.

When we came up with the concept almost two years ago we obviously used a divergent form of thinking and came up with some very ambitious solutions. Below are some of the concepts that we studied.

The "Roman Blinds" façade

In retrospect this was the most obvious façade design as it mimicked the commonly used roman blind concept that all of us use in our homes and offices. As illustrated in fig.1, the façades were slender and long with a length of 3m and a width of 0.8m.

The horizontal lamellas were to be lined with high efficiency silicon solar cells and each lamella could be pivoted about its axis which would enable the user to open it and let some sunlight into the house. The back face of the façade would have been constructed using a double walled glass pane to provide for a tight insulation when closed. The façade would have been made considerably light using an aluminum frame and the drive mechanism involved only a simple geared motor drive that would directly rotate the façade from

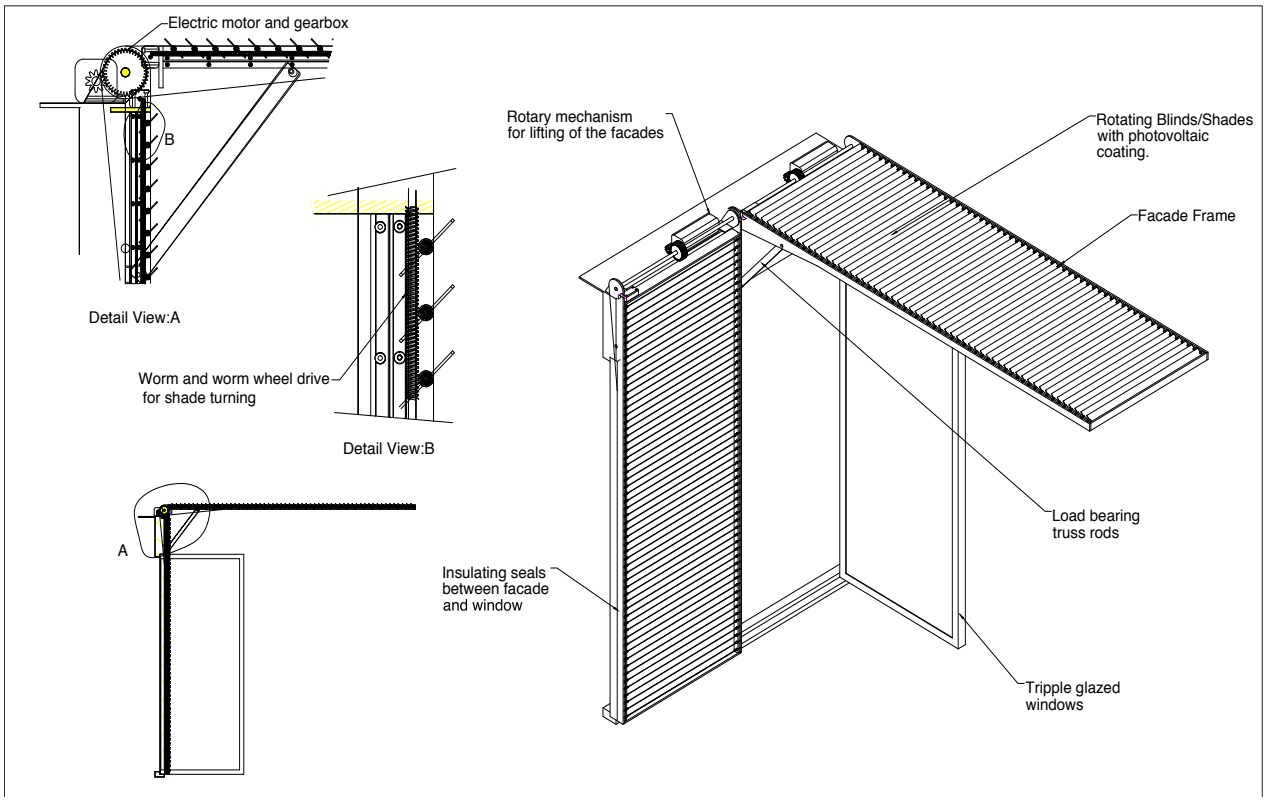

Figure 146: **The "Roman Blinds" façade**

its pivot point at the top of the house. It would have been a big engineering challenge to construct the PV lamella as they needed to be both sturdy as well as light weight.

This design was ultimately discarded because of the complexities involved in constructing an efficient solar module out of so many PV layered lamella. Also architecturally we realized that the visual effect of this façade did not really fit into the overall design of the house.

The “Leaf” façade

The “leaf” façade concept was one of the more fantastical ideas that we had and we took inspiration for it from nature. In the summer the leaves of a tree are turbid and bright green, full of life and vitality while in the winter they wilt and wither away. Each façade would have been made of interconnected links similar to that of a bicycle chain. Each link would consist of a flexible PV layer on its upper surface and a flexible transparent layer beneath. Joined together, all the links form a composite yet flexible structure. The novelty of the idea would have been in how we would raise it up and lock it in place. We thought of using compressed air that we would generate using a solar thermal compressor to inflate a rubber bellow that would line the periphery of the façade. The façade would then directly mirror nature by rising up when it became very hot and closing down when the temperature cooled.Needless to say most of the idea would have been impossible to create given our limited budget and resources. But more importantly the idea lacked functionality; even if it did work it would have served to be more of a gimmick than anything else.

The Vertical lamella façade

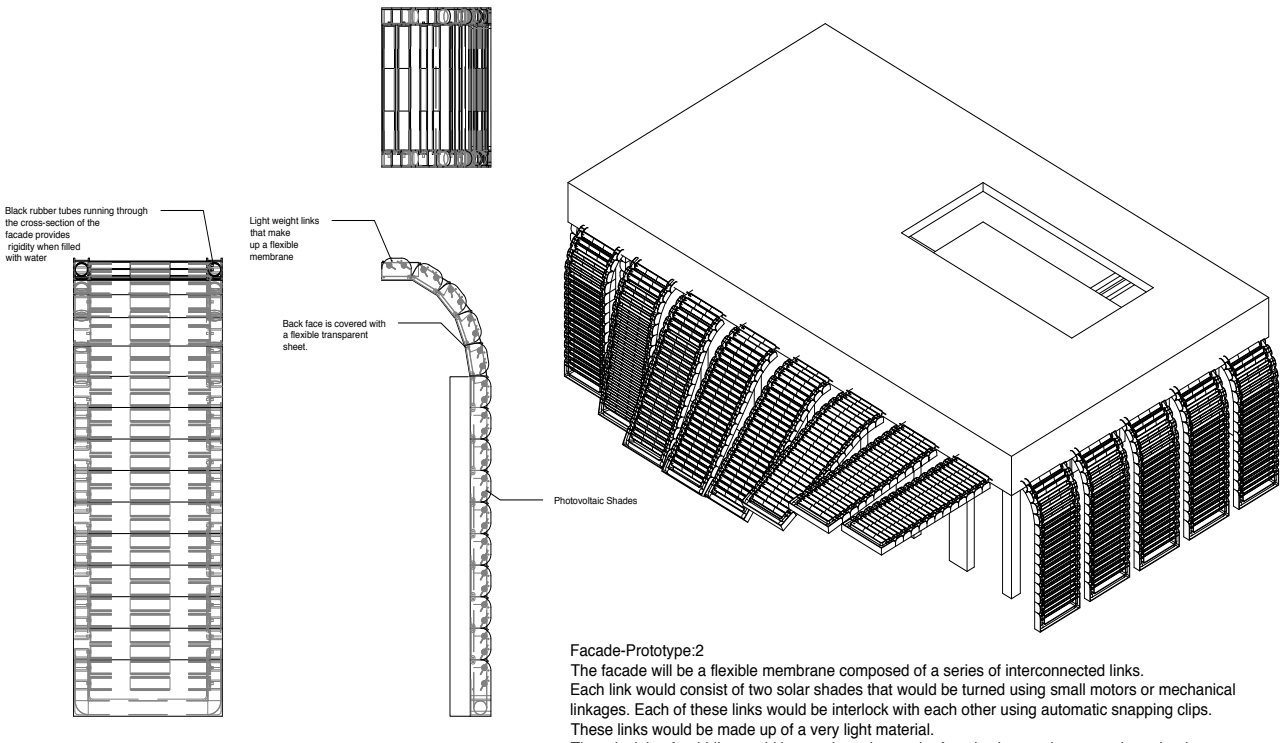

Figure 147: **The "Leaf" façade**

Following from the roman blinds idea we realized that changing the orientation of the lamella would eliminate a lot of the problems that we had with that design, both architecturally and technically. Each lamella would be much broader (about 300mm) and the façade would be wider at 1750mm. By inverting the lamella we were also able to effectively achieve two axis tracking. The rotary motion of the entire façade coupled with the pivoting of each lamella would enable the PV cells on the lamella to be oriented normal to the sun at all times. To lift these façades we designed an innovative trapezoidal screw drive that would convert the rotary motion of the motor into a linear translation of the lifting truss of the façade.

Structurally this design was quite massive and required large sections of steel to support it. Also the overall area of the façade was quite huge at 3000x1750mm. This is what ultimately led to the demise of this idea. The façade seemed to be too imposing of a structure and it completely dwarfed the rest of the house.

The Linear Fresnel Façade

Another ambitious idea that we came up with was to use the façade to generate solar thermal energy rather that only electricity. We conceived of an idea to mount a linear Fresnel collector on top of the façade so as to create high enough temperatures which could be primarily be used for cooking purposes. The collector consisted of vertical mirrors made of anodized aluminium that would concentrate the suns light onto a central evacuated tube collector. The temperatures that could be produced are in excess of the minimum requirement of 230°C set out by the Solar Decathlon.

The design would have required us to use a thermal fluid to transfer the high temperatures from the collectors to the high temperature thermal storage/oven. A detailed calculation was conducted, and over an entire summer day in Versailles it would have generated more than 3kwh of energy which is roughly 2.5 times the amount of energy that would have been generated by the façade with PV panels.

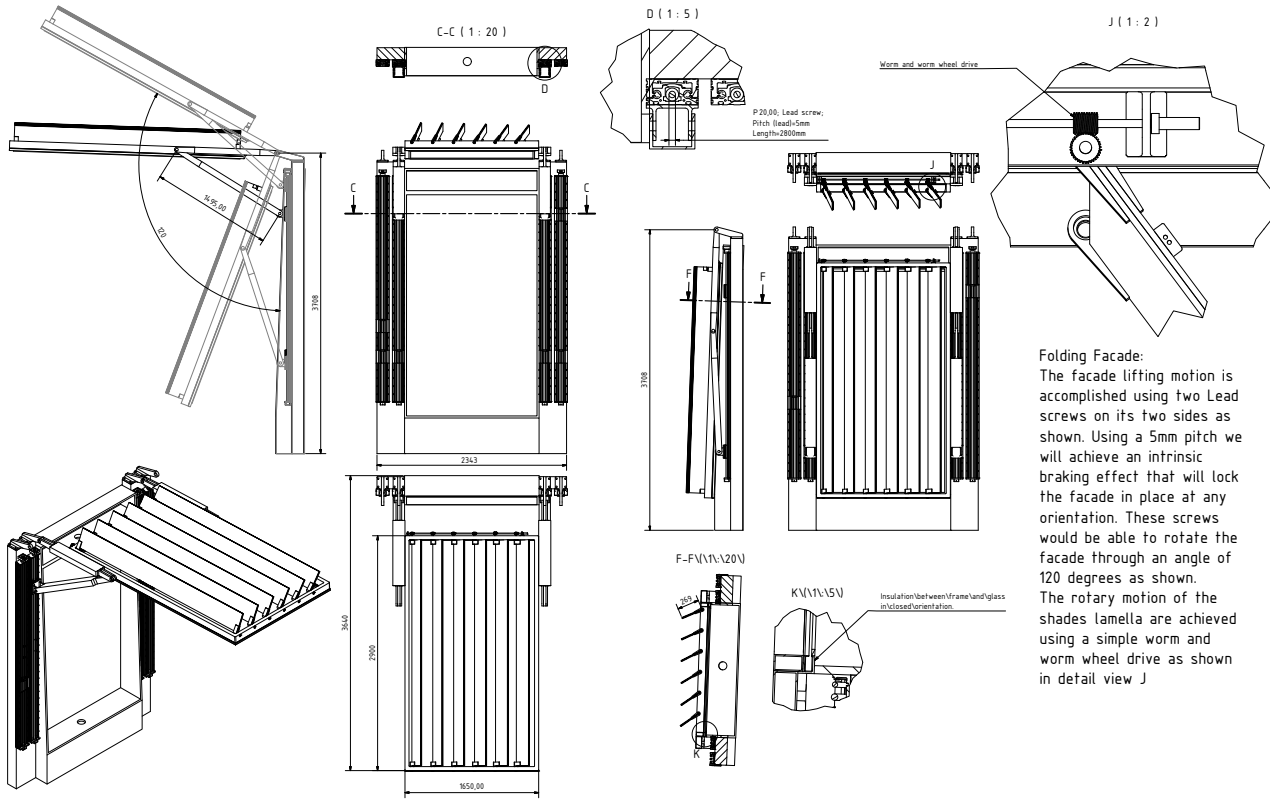

Figure 148: **The vertical lamella façade**

But eventually the staggering cost to manufacture such a system as well as the technicalities involved in the transportation of the thermal fluid through the house dissuaded us from pursuing this any further. Although, it did result a very comprehensive scientific report on building integrated concentrated solar power.



Figure 149: **The Linear fressnel façade**

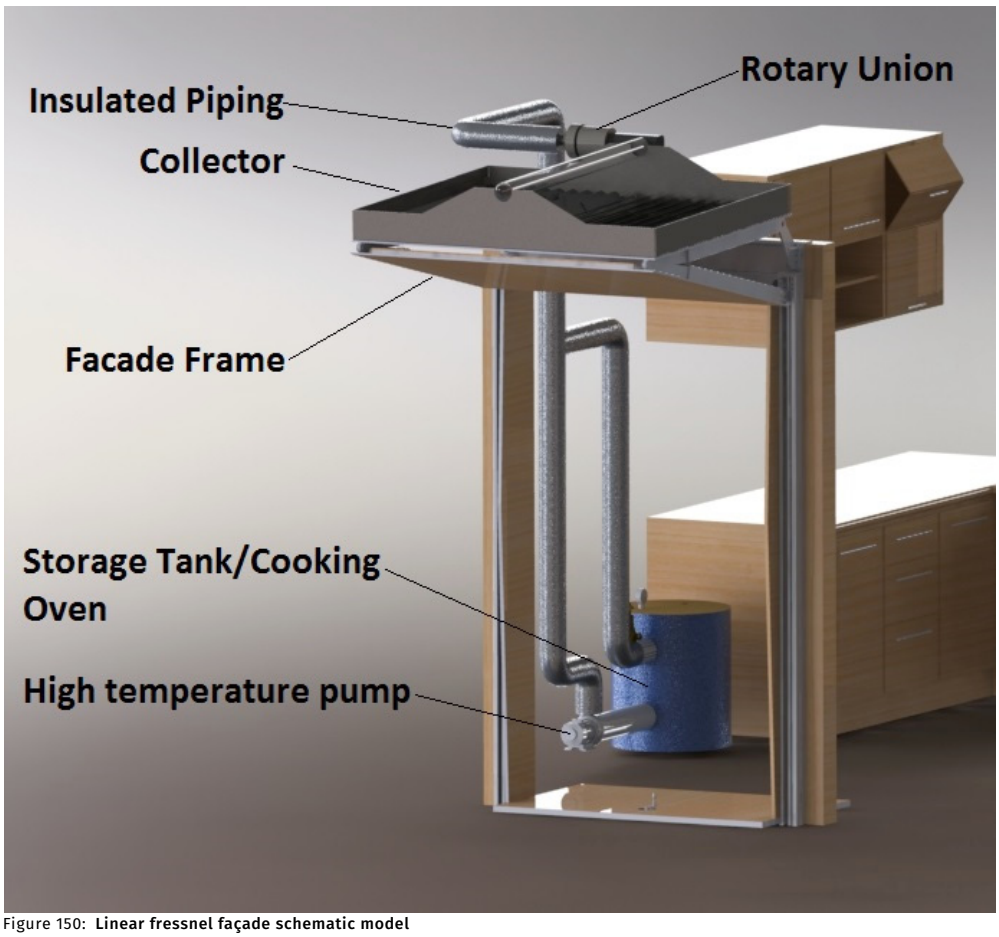

Figure 150: **Linear fressnel façade schematic model**

En route to the final design:

Up until this point we encountered a lot of problems in our quest for the perfect façade system that would satisfy all the objectives that we set out to achieve. Some of the points that we needed to address were

To reduce the size and weight

To increase the structural sturdiness so as to withstand hurricane level wind forces

To use standard “off the shelf” solar modules.

To increase the safety and integrate fail safe devices into the design

To reduce costs - At this stage our projected cost were exceeding 150000 euros just for the façades

To simplify the system, both technically and visually.

To better merge the façade into the whole architectural concept of the house.

Eventually we had to make a compromise between innovation and feasibility. We had to consider the environmental sustainability, economic viability and the aesthetics of our system. We could have made a very awesome and innovative façade that would look outright ugly or make an architectural masterpiece that had no functionality. After many a heated debate between the engineers, architects, designers and financiers we came up with our final design.

The Final “Folding” Façade design

The final façade design did away with the whole concept of the lamella and instead used the same PV panels that were being used on our roof. We also reduced the effective length of the façade by half so as to reduce the wind loads that would act on it. This in turn reduced the sections of the structure considerably which also had a positive impact on the life cycle of the façades as they consume far less steel and aluminium as before. The power required to lift the façades were also halved which bolstered the energy balance of our house. We also decided against tracking the sun as it went against the overall aesthetic of the house.

Some of the key aspects of the design are



Figure 151: **The final Folding façade design**

- The length of the façade was halved.
  - The support truss is converted into an architectural facet by supporting the lower insulation panel
  - The transparency of the façade is removed so the home owner would need to raise the façade in order to look outside.
  - The sections of the steel structure are much smaller
  - Standard solar panels are used resulting in a much simpler electrical design

As the house is aligned in the South-North configuration the tracking functionality of the façades were negated. This resulted in a very simple control system which needs only an open (top) and a closed configuration.

More wood is used resulting in a better environmental balance.

A smaller motor and drive is used which reduces the overall electricity consumption

Actuation Mechanism of the façade

We arrived at three possible actuation systems for the façade

1. Linear lead screw actuator: Using a standard linear actuator along with two gas struts we designed a simple slider crank mechanism. This concept required the least power and it utilized only a 130W motor.

2. Trapezoidal screw drive: This design used two vertical trapezoidal screws to convert rotary motion of the motor into linear motion. It was the most energy intensive requiring a 250 W motor.

3. Chain and pulley drive: This system uses a series of chains and pulleys to lift up the trailing edge of the façade. It uses more energy than the linear actuator but less than the trapezoidal screw.

Eventually we decided to opt for the chain and pulley system as we were able to purchase a ready-made system from a manufacturer.

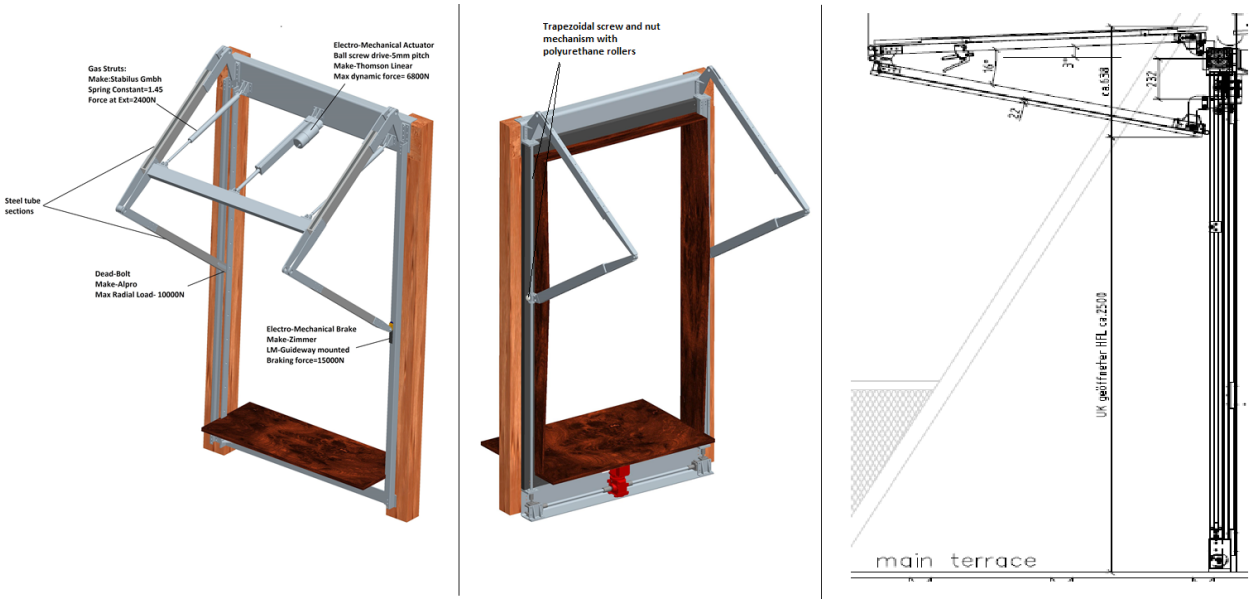

Figure 152: **Actuation mechanisms**

Insulating properties of the façade

One of the main objectives of the façade was to provide an additional insulating layer to the house when they are closed down. To achieve this we will line the upper and lower panels of the façade with an insulation layer which has a thermal resistance of 2.22 K*sqm/W. This results in an overall U value of 0.45 W/sqm K. The effect of this added insulation has been calculated in the overall energy balance of the house.

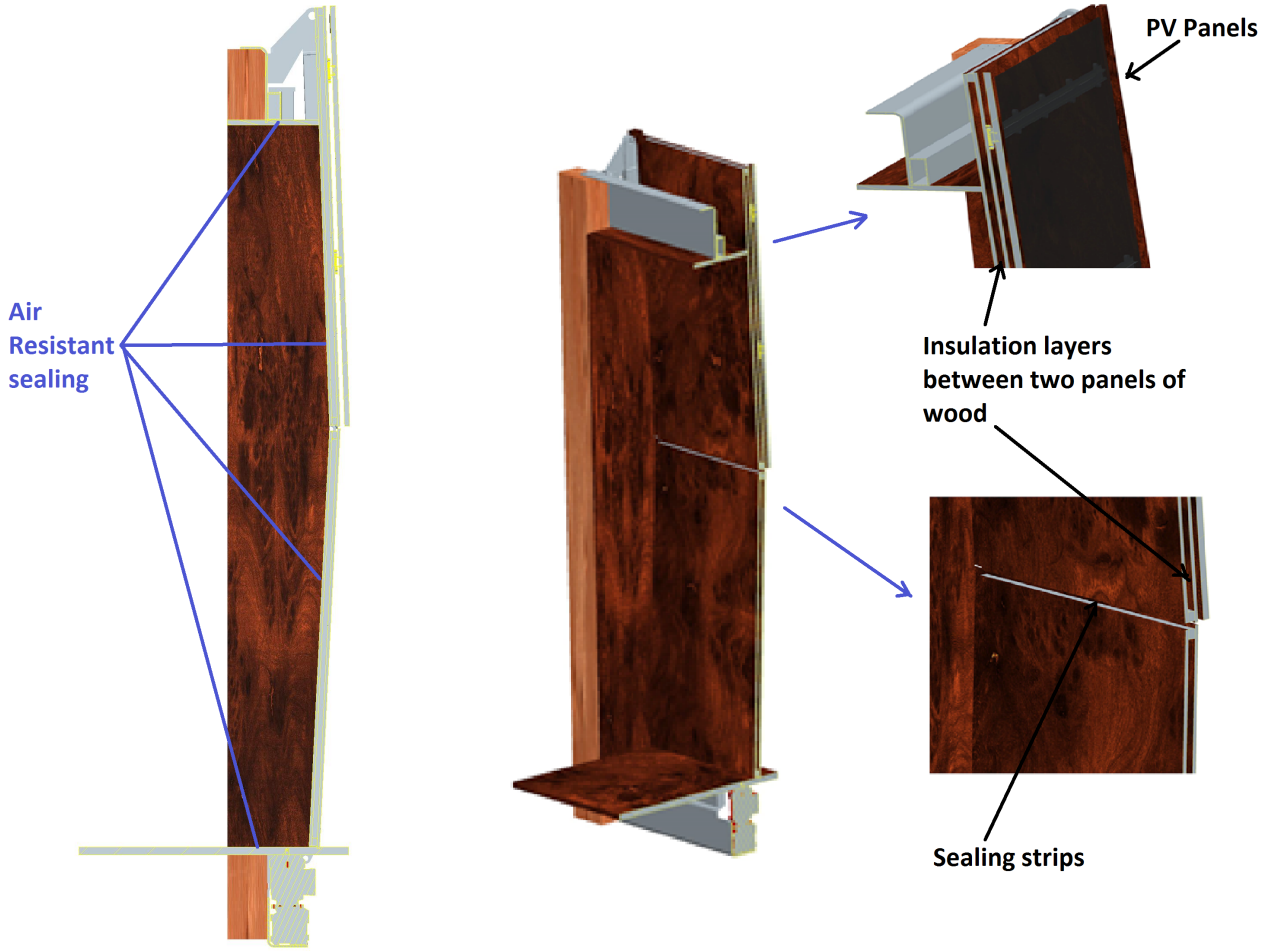

Figure 153: **Insulation layer of the façade**

Solar PV gain using the façade

Using the façade we are able to achieve seasonal tracking of the solar panels. We can optimally orient our solar panels to the south and change the angle with the incremental variations in the solar zenith angle. In the summer months the solar zenith angle is larger so correspondingly the façade would be oriented closer to the horizontal position. As winter approaches, the sun moves closer to the horizon and hence the façade would be oriented at its furthest from the horizontal position.

Fig.9 illustrates the difference between seasonal tracking and simple horizontal orientation for our façades in Versailles. The red line indicates the seasonal tracking and the blue lien indicates horizontal orientation. As can be seen, the additional electricity gain for the month of June is almost 60 kWh which is quite substantial and this more than offsets the energy needed to lower and raise the façades which is about 5 kWh per month.

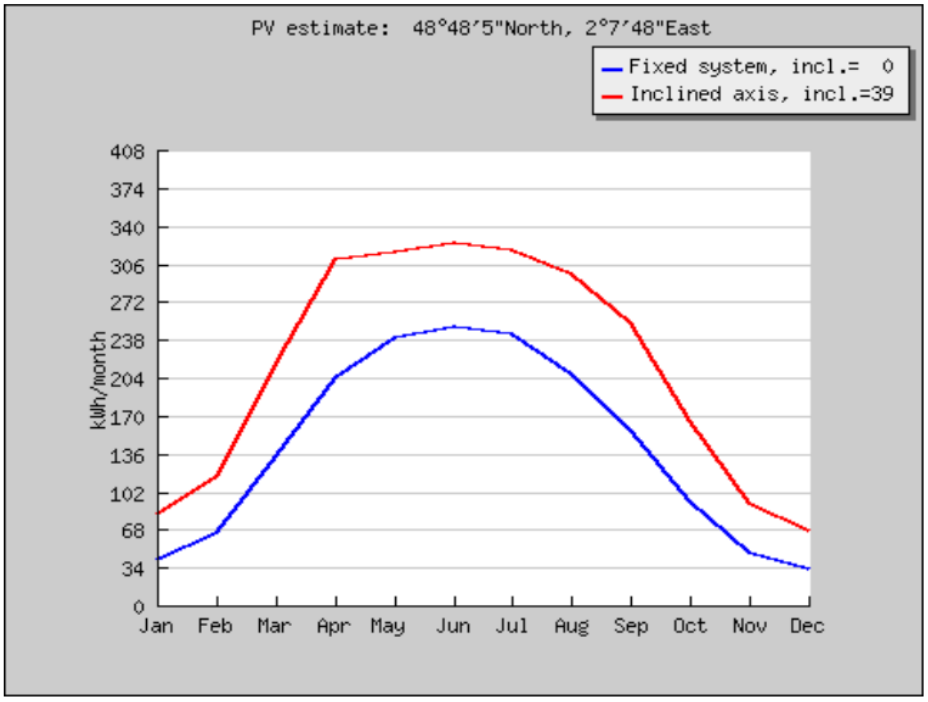

Figure 154: **Comparison between seasonal tracking vs horizontal. (Generated using PVGIS)**

5.4. ENERGY EFFICIENCY DESIGN NARRATIVE

We will implement innovative and energy saving solutions for the applicable features of our house. All the house appliances and building services are chosen based on energy efficiency.
A detailed energy efficiency analysis of our building shows the potential for energy savings in the heating and cooling sections.

5.4.1 TECHNICAL PROJECT SUMMARY

TECHNICAL SUMMARY FOR THE IMPLEMENTATION IN BERLIN

1. Project Dimensions

Gross area: 69.27 m²

Net floor area: 55.36 m²

Conditioned Volume (m³): 145.6 m³ (netto)

2. House envelope

Walls area 32.82 m²

Floor area 63.68 m²

Roof area 63.68 m²

Glazing area 53.851 m²

SHGC 0.5

3. HVAC Systems

Heating System

Type: reversible Air to Water heat pump with exhaust air using and solar thermal support

Model: LWZ304 SOL

Heating capacity: 4.2 kW

Heating efficiency: EN 14511 (A2 / W35, spread 5 K) = COP 3.3

Cooling capacitiy: 4.5 kW

Cooling efficiency: EER = 3.8

Terminal Unit

Type: same heat pump

Model: LWZ304 SOL

Refrigerant: R407 C

Heat Recovery Ventilation:

Type: integrated central ventilation system

Model: LWZ304 SOL

Efficiency: heat recovery up to 90 %

4. Domestic Hot Water

Drink water tank in the LWZ304 heat pump with solar thermal support

Pouring quantity domestic hot water (45 °C) 235 l

Solar thermal collectors

Type: evacuated tube collector

Model: DF6 collector Augusta Solar

Total area: 3.024 m²

5. Electrical Energy production

PV Modules (Type)	84 x Solibro SL2 Thin-Film modules à 120 W
PV panels area (m²)	100.27 m²
Installed PV power (kWp)	10.08 KWp
Estimated energy production (kWh/year)	9000 KWh/year

6. Energy consumption

Estimated energy consumption: 3480 kWh/year

Estimated electrical consumption per conditioned: 62.8 kWh/year per m²

Energy Use Characterization

Heating: 31 %

Cooling: 4 %

Ventilation: 16 %

Domestic Hot Water: 9 %

Lighting: 7 %

Appliances and Devices: 33 %

7. Energy Balance

Estimated energy balance: 1125 kWh/year (end energy)

Estimated CO_2 emissions (end energy): 1.05 Tn/year

8. List of Singular and Innovative materials and systems

PCM passive cooling

Folding façade (building integrated solar active system/ shading device)

Vegetal filter bed (support the passive cooling system)

shading device regulation (over heating prevention at 24 °C)

Compact heating, ventilation, cooling and DHW system with solar thermal support

Isolation of the glass façade with the shading devices

Using of the exhaust air heat and core module heat loss for the evaporator of the heat pump

$LiFePO_4$ batteries with smart energy management system to maximize own consumption

TECHNICAL SUMMARY FOR THE COMPETITION IN VERSAILLES

1. Project Dimensions

Gross area: 69.27 m²

Net floor area: 55.36 m²

Conditioned Volume (m³): 145.6 m³ (netto)

2. House envelope

Walls area 32.82 m²

Floor area 63.68 m²

Roof area 63.68 m²

Glazing area 53.851 m²

SHGC 0.5

3. HVAC Systems

Heating System

Type: reversible Air to Water heat pump with exhaust air using and solar thermal support

Model: LWZ304 SOL

heating capacity: 4.2 kW

heating efficiency: EN 14511 (A2 / W35, spread 5 K) = COP 3.3

cooling capacitiy: 4.5 kW

cooling efficiency: EER = 3.8

Terminal Unit

Type: same heat pump

Model: LWZ304 SOL

Refrigerant: R407 C

Heat Recovery Ventilation

Type: integrated central ventilation system

Model: LWZ304 SOL

Efficiency: heat recovery up to 90 %

4. Domestic Hot Water

Drink water tank in the LWZ304 heat pump with solar thermal support

Pouring quantity domestic hot water (45 °C) 235 l

Solar thermal collectors

Type: evacuated tube collector

Model: DF6 collector Augusta Solar

Total area: 3.024 m²

5. Electrical Energy production

PV Modules (Type)	41 x Solibro SL2 Thin-Film modules å120W
PV panels area (m²)	48.95 m²
Installed PV power (kWp)	4.920 KWp
Estimated energy production (kWh/year)	4600 KWh/year

6. Energy consumption

Estimated energy consumption: 3480 kWh/year

Estimated electrical consumption per conditioned: 62.8 kWh/year per m²

Energy Use Characterization:

Heating: 31 %

Cooling: 4 %

Ventilation: 16 %

Domestic Hot Water: 9 %

Lighting: 7 %

Appliances and Devices: 33 %

7. Energy Balance

Estimated energy balance: 1125 kWh/year (end energy)

Estimated CO_2 emissions (end energy): 1.05 Tn/year

8. List of Singular and Innovative materials and systems

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Folding façade (building integrated solar active system/ shading device)

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shading device regulation (over heating prevention at 24 °C)

Compact heating, ventilation, cooling and DHW system with solar thermal support

Isolation of the glass façade with the shading devices

Using of the exhaust air heat and core module heat loss for the evaporator of the heat pump

$LiFePO_4$ batteries with smart energy management system to maximize own consumption

APPLIANCES REPORT

For the appliances we took very efficient, energy saving devices. Most of them have an energy rating class of A++. Here is a list of all the appliances we took. The kitchen appliances are sponsored by Miele.

Appliances

Refrigerator + freezing combination:

Miele KFN 37452

Refrigerator size 196 l > 170 l (SDE rule)

Built in freezer size is 59 l > 57 l (SDE rule)

Takes about 228 kWh/a

220-240 V AC, 50 Hz

Connected load: 90 W

Washing machine + dryer combination:

Miele WT 2789I (A)

3.7 kWh per washing and drying program at 60°C

0.8 kWh per washing cycle

196 kWh/a for 53 standard washing cycles per year (once a week)

220-240 V AC, 50 Hz

Water-consumption: 69 l

Connected load: 2200 W

Dishwasher

Miele G 4860 SCVi

Energy-consumption: 0.84 kWh

Water-consumption: 8 l

guessed energy-consumption per year 102 kWh/a by running it 122 times/year

220-240 V AC, 50 Hz

Connected load: 1280 W

Fuse Protection: 10 A

Oven

Miele H 6860 BP

0.89 kWh per standard meal

Takes 288 kWh/a if the oven runs every day

220-240 V AC, 50 Hz

Connected load: 3700 W

Hob

Miele CS 1222 I

0.79kWh per standard meal

Takes 288 kWh/a if one cooks every day of the year

220-240 V AC, 50 Hz

Connected load: 3700 W

TV

LG 32LA6678

Takes 14.5kWh/a if it runs every second day for 2 hours

220 - 240 V AC, 50/60 Hz

Connected load: 40 W (Standby 0.4 W)

The fridge is a combination of a refrigerator and a freezer. It fulfils nearly perfectly the requirements of the SDE Rules concerning the volumes of the cool rooms. It consumes approximately 228 kWh in one year (A++). It fits our wooden kitchen, which can be simply assembled in front on it. Due to the fact that all our kitchen devices shall be integrated into our kitchen, we needed to choose a flat, built-in washing machine which had the function of thermal spinning. This reduces the energy needs due to reduction of the water content with a combination of warm air flow and spinning before the actual drying cycle. To wash and dry one full load it will take 3.7 kWh (A). The dish cleaner takes 0.84 kWh per wash cycle (A+++). It has a timer function for a starting delay, so that the owner can also run the dish cleaner at midday when PV delivers the most power although he/she leaves the house in the morning. It also recognize the amount of dishes inside the cleaner so that it adapts the water and energy consumption. The oven is able to use the residual heat for finish the cooking and so it switches off earlier for saving energy. It takes 0.89 kWh per standard meal. The hob is flush with the working area and consumes in average 0.79 kWh, but it is still depending on the meal the owner cooks. Another appliance we need according to the rules of the SDE is a television. The SDE organization allowed us not to have an extra DVD-Player due to the reason that the television we use (LG 32LA6678) has a video player feature integrated. The television is mounted on the wall of the core module and fits between the two moveable racks (screen diagonal 80 cm). The TV runs with 40 W.

5.4.2 COMPREHENSIVE ENERGY ANALYSIS AND DISCUSSION REPORT

SECTION I – INFLUENCE OF ENERGY ANALYSIS ON HOUSE DESIGN AND COMPETITION STRATEGY

1. INTRODUCTION

a) Energy analysis objectives and methodology

The aim of a building energy analysis is to reduce the energy demand by optimizing the project design and the HVAC system technology. Such choices are determined by a number of factors such as preliminary architectural planning, location's climate, rules, etc. In the Rooftop Building the overall goal is to grant an adequate comfort for the users at the lowest energy price. In order to achieve such a goal a full range of energy-saving measures will be implemented and renewable energy technologies maximized. In particular, the energy concept of Rooftop is based on solar energy, as prescribed in the competition.

Nowadays it is essential to perform a building energy simulation (BES) at the very start of the design process. By using the BES as a design tool, it is possible to increase the time and cost efficiency in the developing phase. Moreover, it allows to test the actual efficiency of the design and technology choices and variations. The regulation is also taken into account and optimized while performing the BES.

As the project includes various disciplines and constraints, all choices were made in synergy between architects and engineers . This allowed us to optimize the energy efficiency without compromising the aesthetics.

All simulations were performed using IDA Indoor Climate and Energy (IDA ICE), an equation based modeling and simulation software. Such software allows whole-year and dynamic multi-zone simulation for the study of thermal indoor climate as well as the energy consumption of the entire building. Among the interesting features of the software is the easy import of 2D and 3D models and the possibility of combining information on the thermal envelope. This includes information such as materials, thermal bridges, connection to the soil, infiltration and surroundings. Plant engineering, lighting, window control, shade control and heating/cooling loads can also be defined and determined.

ICE handles two types of weather data: design days and yearly weather files.

The methodology consists in 1) understanding what design/HVAC system options are possible in practice, 2) modeling such options in the simulation environment, 3) verifying resulting energy demands. Once such process is completed, final choices are taken in consultation with other teams in order not to compromise other important aspects of the project.

b) Climate Data and Weather Analysis

In IDA ICE , integrated weather data and wind profile data from nearby weather stations (which are interpolated to the exact location using Meteonorm) provide the system's energy simulation.

Among other things it allows to calculate the indoor climate and energy requirements of the system technology under specific weather conditions.

Therefore, the local climate files are generated by interpolation with Meteonorm , using data of weather stations near the desired location. In particular, the weather information include: air temperature [°C], relative air humidity [%], wind prevalent direction [°], wind speed [m/s], direct solar radiation [W/m²], diffuse solar radiation [W/m²].

For the set of simulations performed in Berlin the climate dataset of Potsdam is used. Such dataset is used for Berlin with coordinates: latitude 52.38 °N, longitude 13.06 °E.

On the other hand, the climate dataset of Paris is used for the simulations performed in Versailles. The coordinates: latitude 48 °N and longitude 2 °E are used for the interpolation.

Berlin: whole year simulation (2013)

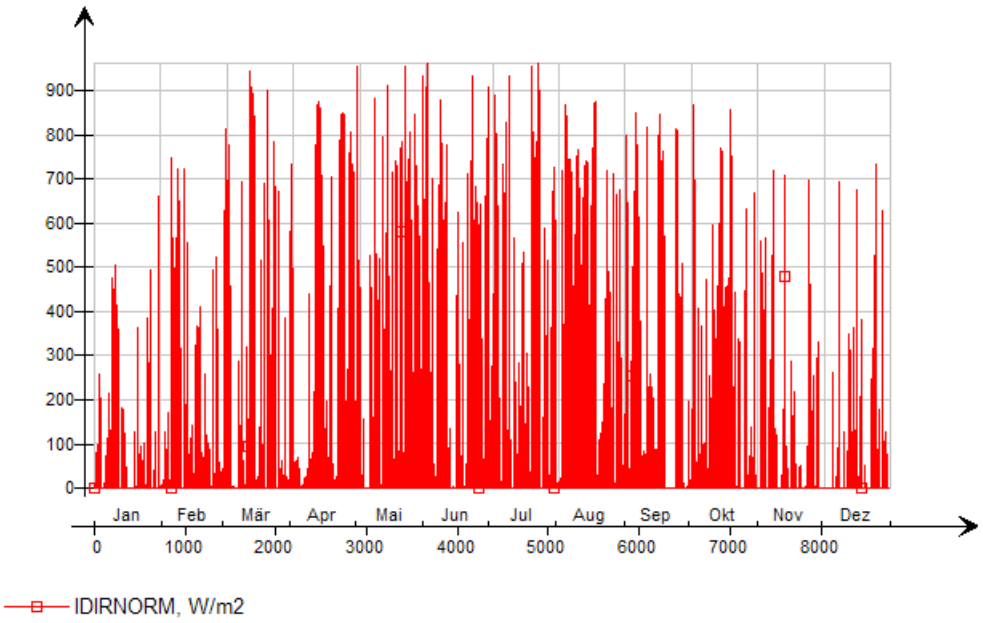


Figure 155: **Direct Solar Radiation [W/m²] as registered in Berlin in 2013**

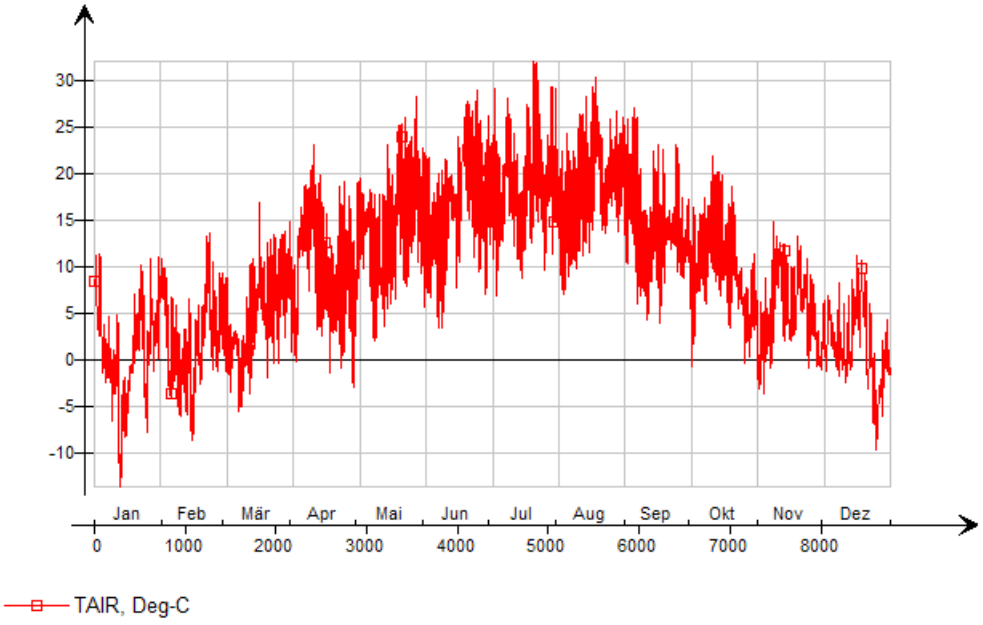


Figure 156: **Outdoor Air Temperature [°C] as registered in Berlin in 2013**

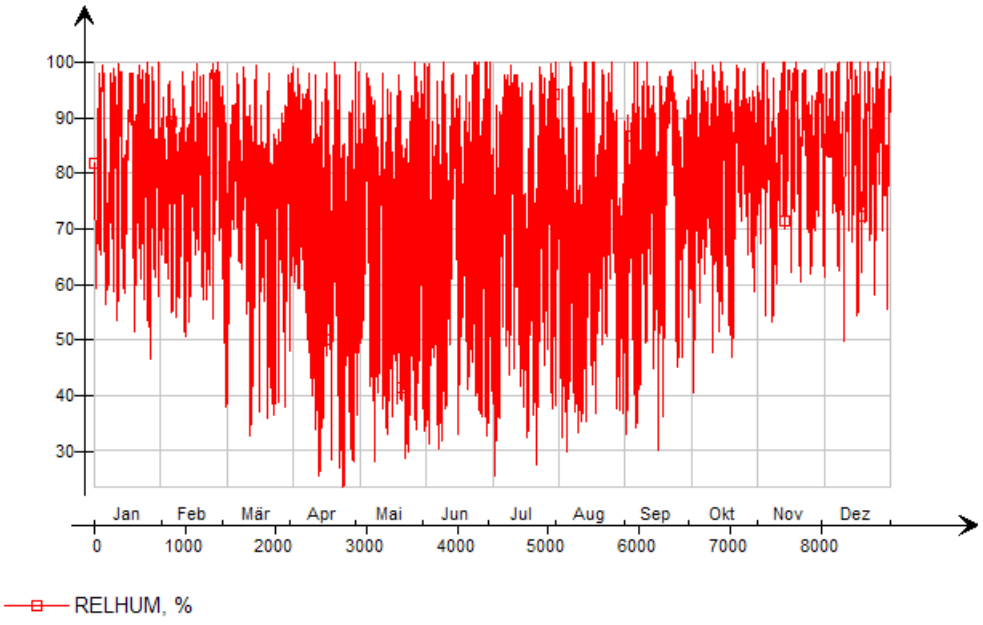


Figure 157: **Outdoor Air relative Humidity [%] as registered in Berlin in 2013**

Versailles: whole year simulation (2013)

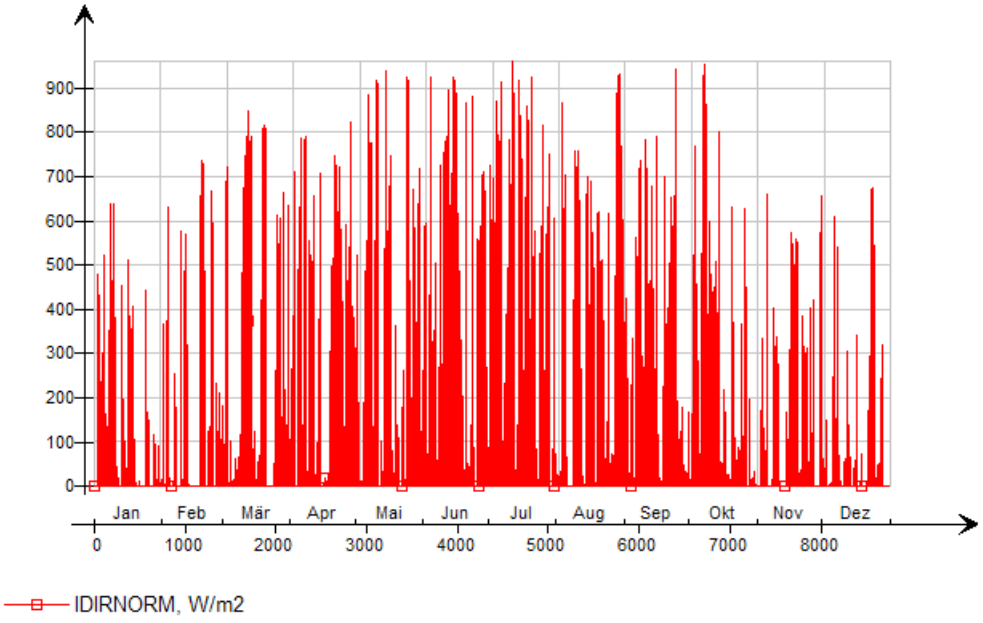


Figure 158: **Direct Solar Radiation [W/m²] as registered in Versailles in 2013**

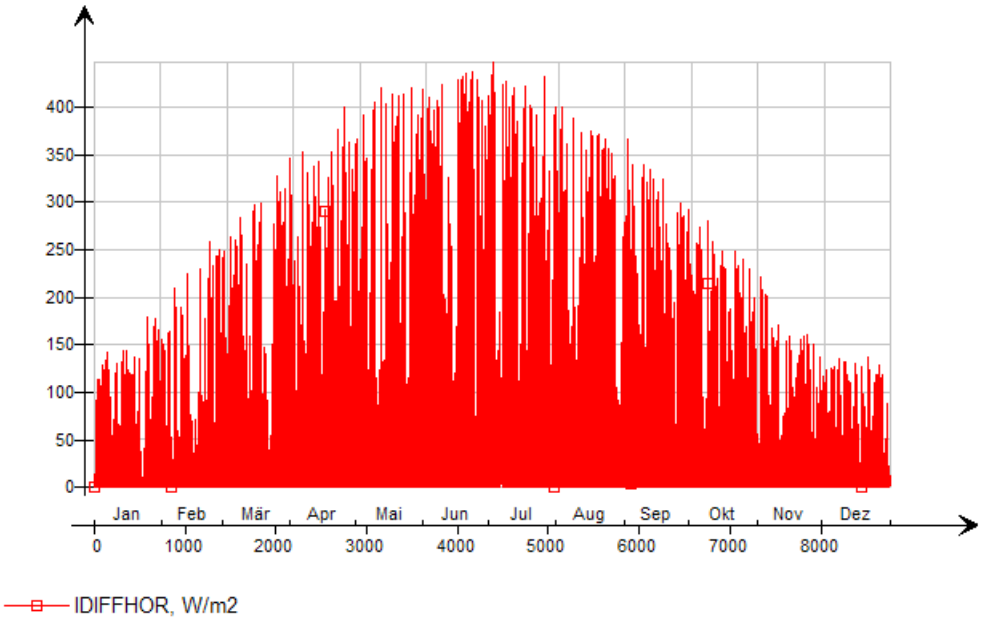


Figure 159: **Diffuse Solar Radiation [W/m²] as registered in Versailles in 2013**

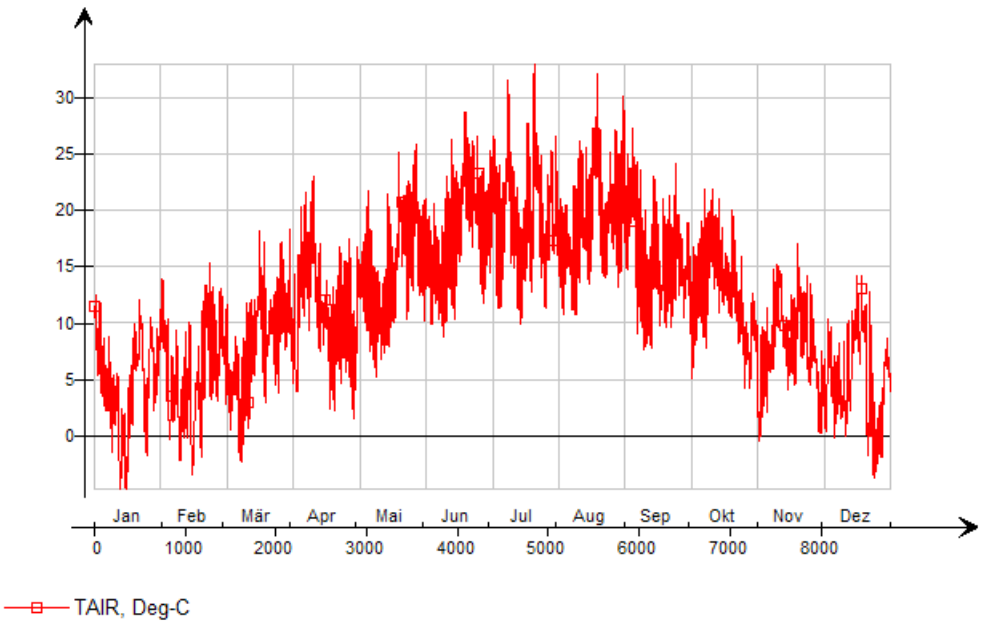


Figure 160: **Outdoor Air Temperature [°C] as registered in Versailles in 2013**

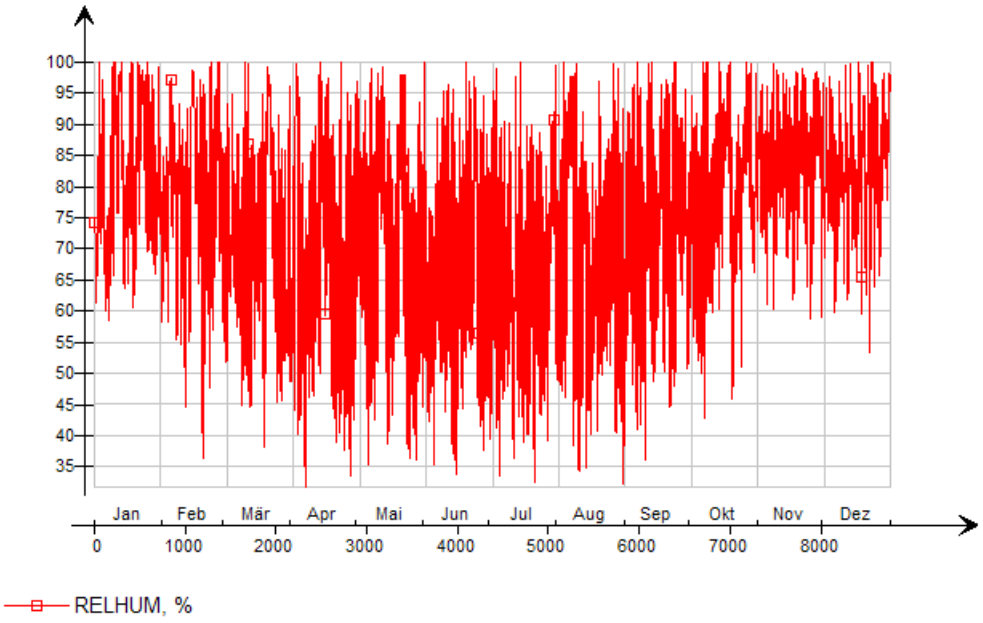


Figure 161: **Outdoor Air relative Humidity [%] as registered in Versailles in 2013**

In general, it can be noted that the average temperatures in Berlin are lower than those in Versailles. For example, during the coldest month (January) the average high/low temperature in Berlin is 2/-2 °C. In Versailles it is 7/2 °C respectively. The differences reduce during the summer. During the hottest month (August) the average high/low temperature in Berlin is 23/14 °C, while in Versailles it is 25/15 °C.

The relative humidity in Berlin ranges from 36% (comfortable) to 94% (very humid), rarely dropping below 23% and reaching as high as 99%. On the other hand, the relative humidity in Versailles typically ranges between 46% and 97%.

c) Team Energy Strategy

The Solar Decathlon 2014 rules specify that solar energy has to be the only source of energy for the houses taking part in the competition. Outdoor air use (such as air heat pump systems) is also allowed, while geo-thermal heat pumps cannot be used. Because of the competition constraints and the boundary conditions given by the planned urban environment on top of an existing roof, only ambient air is used as energy source and is supported by solar thermal collectors. Heating and cooling transfers are efficiently performed using water pipes.

Furthermore, the photovoltaic system produces electrical energy, which is stored in the battery and used by the whole building technology.

The building and system simulation aims to achieve an energy demand reduction of 50 % . It is hoped to achieve this through architectural design development and system regulation optimization.

2. INFLUENCE OF THE ENERGY ANALYSIS IN THE PROJECT DESIGN[1]

The energy analysis was essential in the project design. In particular, simulations were performed in order to determine: the shading strategy (material, geometry, control), the optimal orientation of the building, the design of the glass façades (glass thermal and solar transmittance, fraction of transparent surfaces) and the building position on the roof in order to take environmental shading into account. By doing so the energy analysis becomes a real design tool as it allows to test ,in a time-efficient manner ,the outcomes of various strategies. The impressive reduction in the energy demand achieved with the project design only is outlined at the end of this Section.

Shading Optimization

The shading was originally 2.7 m long and would open horizontally. The shading included sun-driven fins with a photovoltaic coating. The first step towards optimization concerned the variation of the regulation options and a comparison of net energy demands according to different regulation strategies. With this method a new efficient scheme was designed. The new regulation does not simply respond to the light intensity, but also to the indoor air temperature; in this way the risk of overheating is reduced. However, the design of the shading structures still posed a challenge: an optimal solution between internal room shading and electricity production by the PV modules was to be found. A new design of the shading system, now limited to 2 m and with a new opening strategy in two halves, proved to be effective. This option allows more direct radiation to enter the indoor spaces during the winter and provides shading in the summer as an overhang. The shading contains no more fins and its opaque finissage allows a good insulation of the south façade in case of overheating. Thus, cooling loads are reduces to a minimum. The new regulation through temperature sensor

1 All results shown in sub-chapter 2 and 3 are referred to the location of Berlin, on top of an existing old building with flat roof, with environment shading from the fire walls of neighboring buildings.

has only been adopted on the south façade, which closes from a room temperature of 24 °C to prevent overheating. The north façade is controlled by irradiation intensity only (open during the day and closed at night) and it grants a good amount of natural light.

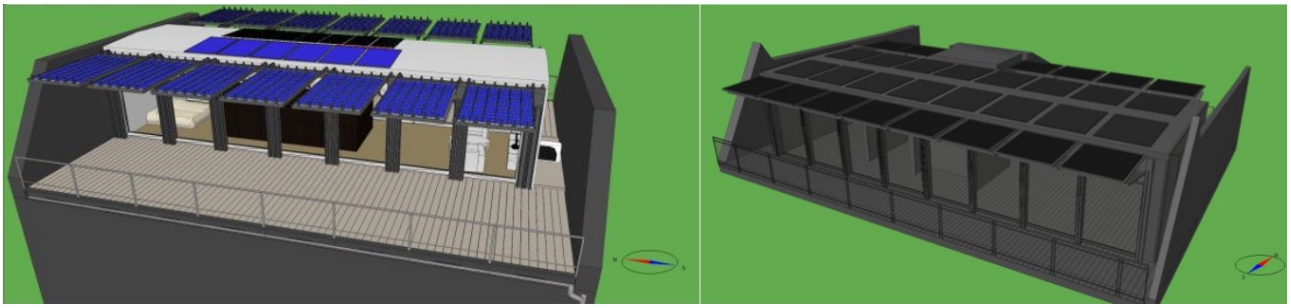


Figure 162: **Old (left) and new (right) shading concepts**

Orientation Optimization

The variation of different alignment options of the building showed that the preferred orientation with respect to cooling and heating requirements was when the largest window surface has a southern exposure. While being a very efficient way to reduce heating demand during the winter, during the summer this solution corresponds to very high solar gains, which would lead to high cooling demand. For this reason, this solution proves to be optimal only in combination with effective shading and controlling strategies, especially in well-insulated houses. Otherwise it would result in overheating of the indoor environment.

The following pictures show the energy demand for cooling [kWh] and heating kWh] for different building orientations. In order to perform the simulation, the building is simulated with two identical opaque and transparent façades. The data is recorded at a rotation of 360° with 45° increments. The orientation where cooling and heating demands are minimized in the South (180°).

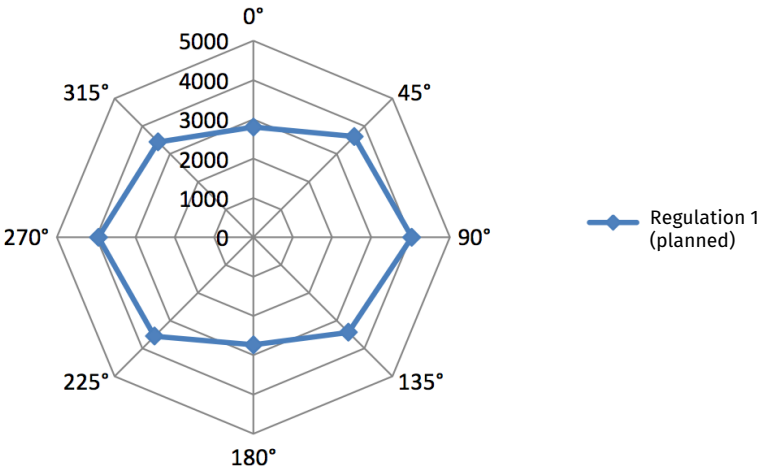


Figure 163: **Energy demand for cooling [kWh] at various building orientations**

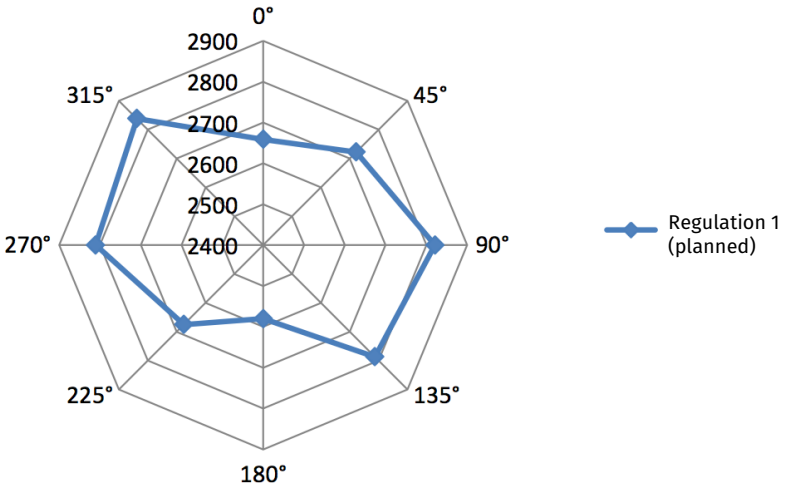


Figure 164: **Energy demand for heating [kWh] at various building orientations**

Glass Façades Optimization

The glass façade performance can be optimized by choosing an appropriate glass. At first, a glass with a g-value of 0.5 and a U-value of 0.8 was selected. The g-value measures the solar energy transmittance of a glass (also called Solar Factor [%]), while the U-value represents the coefficient of heat transmission, or the rate of non-solar heat loss or gain through a given material.

After the simulation-based efficiency forecast, it was shown that the optimum glass was characterized by a g-value of 0.6 and a U-value of 0.7. The following Figures show how the cooling energy demand actually rises when increasing the g-value. However, this side effect is counterbalanced using an appropriate shading regulation with indoor thermal sensors (red curve).

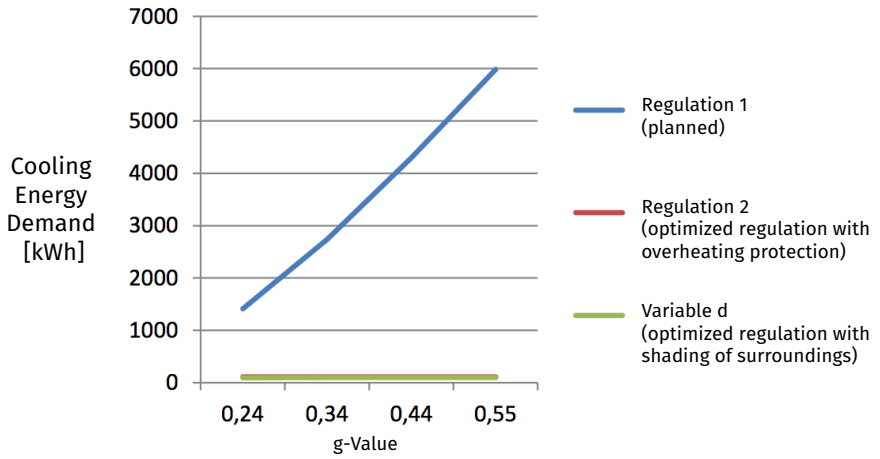


Figure 165: **Energy demand for cooling [kWh] at varying g-Value**

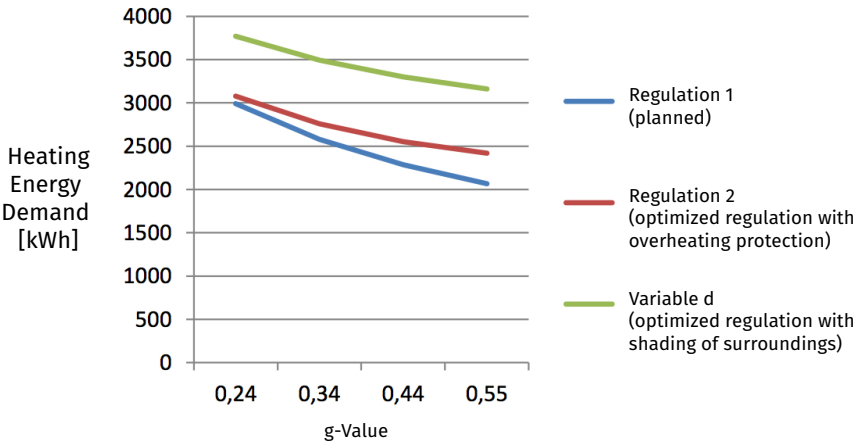


Figure 166: **Energy demand for heating [kWh] at varying g-Value**

For buildings with a good shading system and shading control, having a big glass façade on the wall facing south is an efficient energy strategy to maximize solar gains during the heating season. On the contrary, on the northern façade the transparent components should be reduced to a minimum.

The figure below shows the benefits of reducing the glass surface on the north façade. In fact, the solar gains through the north façade are very low and poorly contribute to the heating demands; at the same time, in spite of a triple-glazing, the window still has much higher heat loss than a solid wall with a passive house standard U-value. If the northern façade were to be completely opaque the heating energy requirements would reduce of 42%. However, in the Rooftop Building this is not possible as two of the walls (eastern and western, which are not simulated) are already obscured by the fire walls. In accordance with the architects, only two windows in the northern façade are substituted with a wall. This allows an 8% reduction of the heating energy demand.

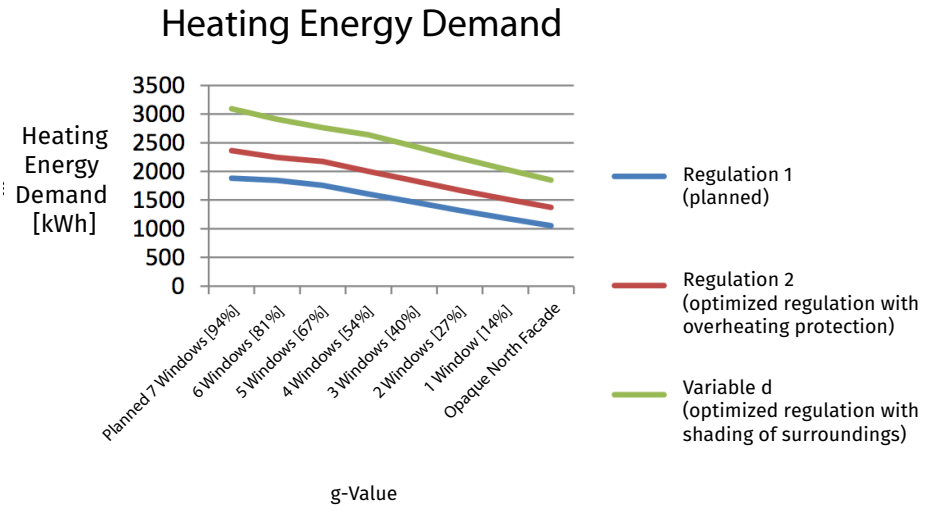


Figure 167: **Energy demand for heating [kWh] at varying transparent surface %**

Building Position Optimization

The position of the Rooftop Building on top of the existing building can be changed as much as possible towards the south. By choosing such strategy the shading effect of the neighboring fire walls can be limited.

Total Savings

From the first model design in June 2013, the cooling energy demand has been reduced by 81% through the use of overheating protection controlling and the new shading design with opaque material. Such an achievement allows to exclude active cooling technologies. A passive cooling system via PCM ceiling will be sufficient to reduce the low summer cooling demand. The southern exposure and the building orientation on top of the existing building, the optimization of the glass material with appropriate U- and g-values and the reduction of the glass surface on the northern façade have reduced the heating energy requirements by 28%.

The following figure shows the impressive difference in the energy performance between the first non-optimized model and the actual solution (Model 2).

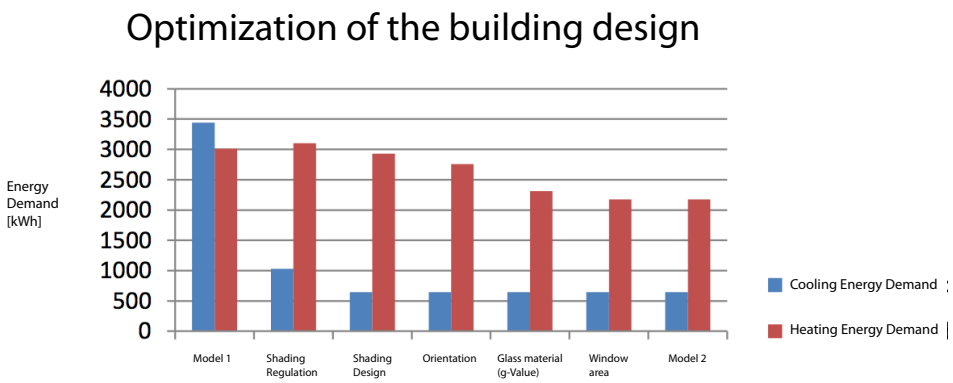


Figure 168: **Optimization of total energy demand [kWh] at varying key parameters: shading regulation, shading design, orientation, glass material (g-value), window area.**

Individual Contributions

The shading control optimization with overheating protection on the south façade results in a reduction of the cooling energy demand by 70%, as the strategy optimally reacts to the internal temperatures. A small increase of the heating energy demand (3%) is due to the smaller amount of radiation entering through the windows.

The use of opaque shading designs results in a further reduction of the cooling energy demand by 11%; furthermore, the shorter overhangs allow more solar gains in the winter season and cause 6% of heating energy savings.

The southern exposure grants a further 5% of heating energy savings, the g-value optimization 15% and the glass area reduction (11 m²) on the north façade 5%.

3. INFLUENCE OF THE ENERGY ANALYSIS IN THE HVAC SYSTEMS

A number of considerations were made to choose the appropriate HVAC system for the Rooftop Building. First of all, the energy fence was not possible as it requires depth into the soil and it is hence not compatible with a Rooftop solution. A compact outdoor unit would have been possible, but such option did not fit the concept of one compact technical module. Also an exhaust air heat pump was not a solution. It would have had insufficient heating power with the resulting risk of high power consumption due to the intense use of the electric auxiliary heater. The only option was then to use an air-water heat pump.

Two possibilities were addressed: a decentralised outdoor unit (evaporator and fans outside, compressor inside) and a compact indoor unit (supply and return air duct) with exhaust air use.

The compact indoor unit was preferred as it would result in shorter, more efficient pipelines, would prevent the high power consumption of the fan due to the pressure losses in long channels, and would allow an

increased efficiency of the pump by re-using the exhaust air's heat.

In contrast with the building design optimization, the building technology system optimization mainly concerns the characteristics of the planned technical installations. These characteristics are the system temperatures and the heat pump configuration for the heating system and the heat supply system for the ventilation system.

The first decentralised energy concept (Model 1) had very high system temperatures. The heating system included a buffer tank with fresh water station which required a DHW flow temperature of 55 °C. The underfloor heating required a flow temperature of 45 °C.

In order to reduce such high temperatures in the new centralised concept (Model 2), a separate buffer at 35 °C and a DHW cylinder at 45 °C were chosen. Furthermore, a wall heater could increase the heat exchange surface hence reducing the temperature level.

The heat pump of the first decentralised concept had a coefficient of performance (COP) of 3.1 (A2/W35), while the new heat pump centralised system has a COP of 3.3 (A2/W35). A central exhaust air use provokes an increase of the heat source temperature and a resulting energy efficiency improvement if compared to the old concept.

Ventilation

The decentralised fans of the decentralised concept are replaced by central fans which require more energy for ventilation. However, central ventilation results in an overall energy demand reduction through the exhaust air use, thereby improving the heat pump COP.

The COP of the old decentralised approach (Model 1) is increased from 2.6 in the new centralised concept (Model 2) to 3.1 due to the more efficient use of the heat pump and the lower temperature exchange. With an exhaust air use, the manufacturer indicates a further improvement of the COP to 3.3. As a result, the heating energy demand is reduced by 21 %. Such value increases to 27 % when exhaust air is used. In order to consider the overall performance it is necessary to take also the ventilation into account. The final design of the heat supply and ventilation system results in a total energy saving of 14%, as shown in the following figures.

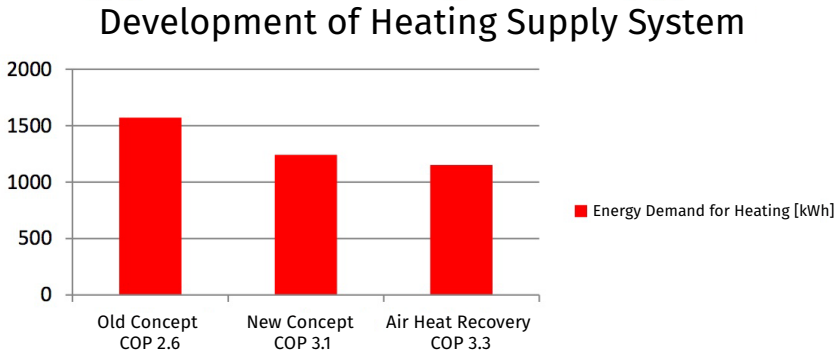


Figure 169: **Energy demand for heating [kWh] at varying HVAC concepts: old decentralised concept, new centralised concept, exhaust air heat recovery**

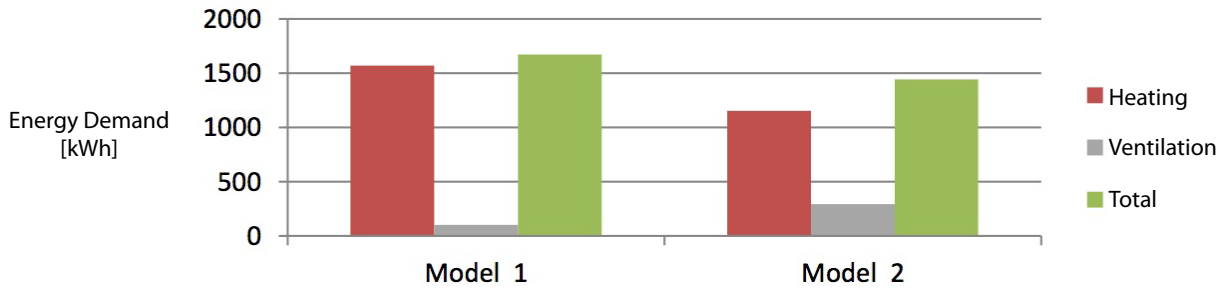


Figure 170: **Energy demand for heating, ventilation and total [kWh] at varying HVAC concepts: old decentralised concept (Model 1) and new centralised concept (Model 2)**

As a conclusion, the following chart compares the final energy demand of the first concept of HVAC system and building design (Model 1) and the optimized energy and design concept (Model 2). Through the simulation-based energy analysis it was possible to reduce the overall energy demand of the building of 44%.

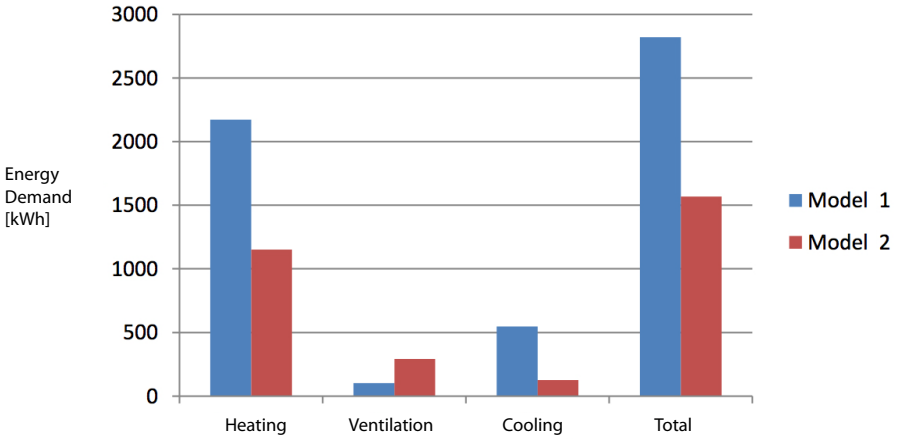


Figure 171: **Energy demand for heating, ventilation, cooling and total [kWh] for Model 1 and Model 2**

Over the years, the energy balance of the Energy-Plus house will be exceeding of 36% the demands due to the power supplied by the PV system.

The simulations have shown that there would be an even greater potential for savings. However, as energy efficiency is only one of the weighting factors of the competition, it is necessary to come to an agreement with the architecture and engineering teams. Results also highlight the importance of BES in the very first stages of the design process of an innovative, energy efficient house.

SECTION II – PROJECTED PERFORMANCE OF FINAL HOUSING UNIT DESIGN

1. Housing Unit and Systems' Description

a). Overall description of the project's geometry, envelope, air-tightness and any singular element that could contribute to the house energy efficiency.

See: Technical Project Summary and Innovation in Energy Efficiency (cross reference)

b). Passive design strategies and Energy efficiency measures (EEM) analysed

The passive design strategies are clearly shown in the bioclimatic diagram:

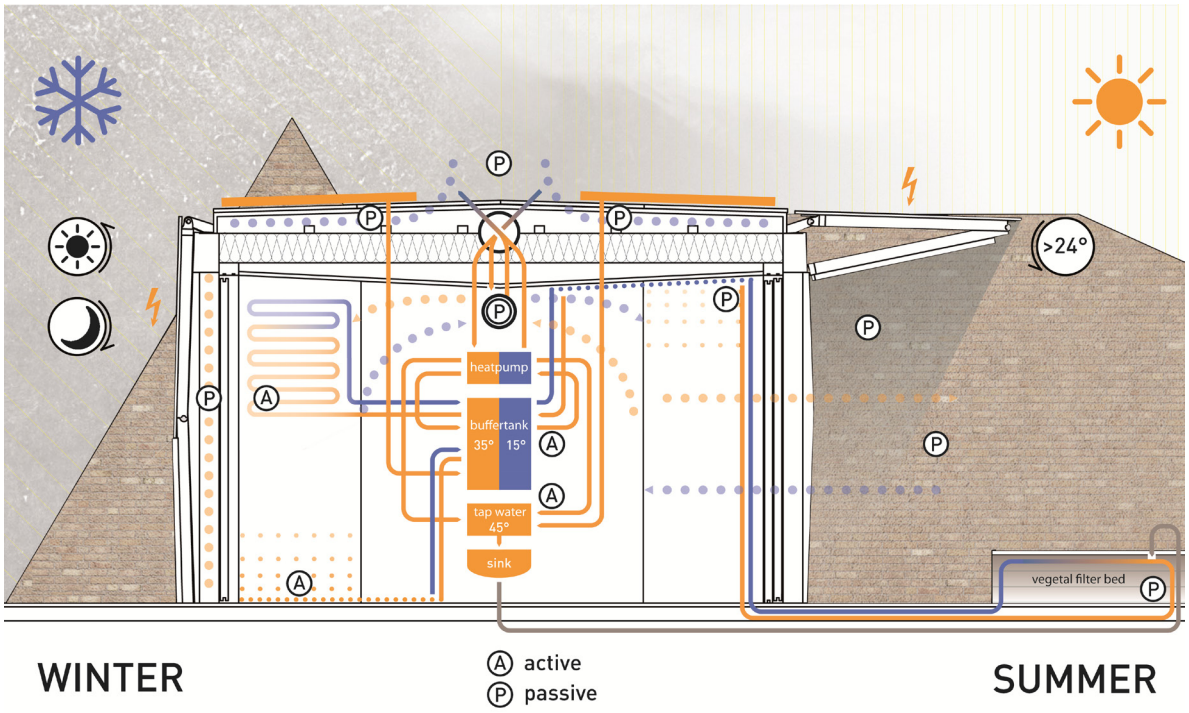


Figure 172: **Bioclimatic diagram**

For more on this (see section 5.6.2)

The system simulation aims at an energy demand reduction of 30 %. With the changes from the first system design we save 17 % in heating energy demand (worst case calculation).

2. House, Appliances and HVAC Simulations (Annual Simulation)

a). Brief simulation descriptions, tools used (capabilities and limitations).

The free web based application IDA Indoor Climate and Energy (IDA ICE) was used throughout the project to perform the building energy modeling and simulation. It is an extension of the more general IDA Simulation Environment. IDA ICE allows an accurate description of the building, its systems and controllers, always keeping in mind the goal of a lowest possible energy consumption and the best comfort for the occupants. The combination of building and system simulation sets a new milestone in simulation programs. In fact, it makes it possible to analyse the development of the building structure with energy savings of the planned system, and vice versa system regulation changes have direct effects on the room climate.

The physical models included in IDA ICE result from the latest research and best models available, and the computed results show great matching with measured data. It permits whole-year detailed and dynamic multi-zone simulation focusing on the thermal indoor climate as well as the energy consumption of the entire building.

The advanced user has full flexibility and every underlying equation can be fully inspected. Also as far as it concerns import capability, IDA ICE is fully interoperable: all common 2D and 3D CAD files can be easily imported, and IFC BIM models are supported.

Despite the great flexibility and high potential to specify and adjust specific parameters, system deviations from the existing structure and predefined models have been feasible only through approximations. For example, the modeling of the battery, the solar thermal system and the detailed PCM cooling system was not possible. The heat pump use of exhaust air could only roughly be taken into account by using the improved COP stated by the manufacturer.

b). Housing unit modeling assumptions, including internal gains, occupancy behavior patterns, ventilation and comfort temperature.

The general assumptions in IDA ICE contain information about the global data, the central building system, the energy demand and zones.

Global data include all information regarding environmental and weather conditions, the thermal envelope and information related to the energy needs. The weather data consists of the location, climate and wind profile. The assumptions related to the thermal envelope are detailed in assigning a building model to all components (exterior walls, interior walls, floors, ceilings, roof, roof tiles, windows, doors, shading devices). The description of opaque components generates a layered structure with a given U-value. The transparent components are assigned a certain g-value, t-value and U-value.

Thermal bridges are specified as linear thermal coefficients in IDA ICE; in the present project they are manually input as in the catalogue by the Bundesamt für Energie BFE (DIN V 18599-2) as follows.

Thermal Bridge	IDA ICE Standard [W/mK]	BFE Catalogue [W/mK]
External Wall/External Wall	0.08	0.07
Windows facing outdoor	0.03	0.02
Roof/External Wall	0.09	0.06
Floor/External Wall	0.14	0.07

The thermal bridges generate an additional annual heating energy demand of 628 kWh, which is largely due to the large proportion of the window frame. Therefore, in the building the frames must be installed correctly.

The CO_2 emission is determined from the final energy demand by using an emission factor. In this case, the emission factor is taken by the website of the Bundesumweltamtes (Federal Environmental Agency) and it is equals to 0.59 kg/kWh.

Control Set points

In order to simulate the energy behavior of the Rooftop project, the building was divided into 7 zones, namely: living room, bedroom, bathroom, technical room, corridor, hallway/kitchen, kitchenette. The following figure shows the plan zoning.

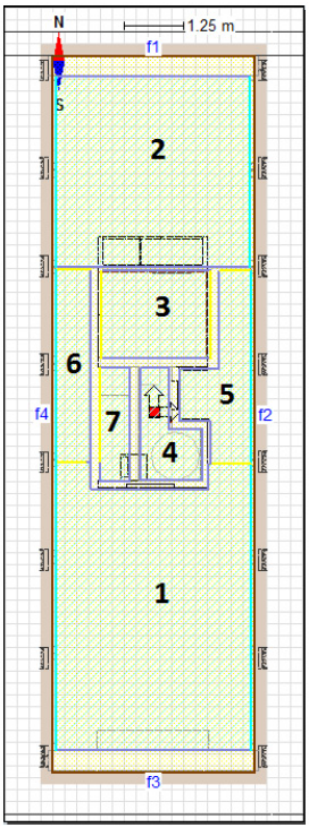


Figure 173: **Plan zoning**

For each zone an individual controlling strategy is applied. The following schemes report only the choices applied to the final centralised solution.

Zone	Description	Heated	Ventilation Control
Zone 1	Living room	YES	VVS, CO_2
Zone 2	Bedroom	YES	VVS, CO_2
Zone 3	Bathroom	YES	VVS, CO_2 (zone 1 & 2)
Zone 4	Technical room	NO	
Zone 5	Corridor	YES	
Zone 6	Hallway/Kitchen	YES	
Zone 7	Kitchenette	NO	VVS, CO_2 (zone 1 & 2)

With respect to the controlling set points, information must be given regarding the minimum and maximum range in which the zone is to be controlled. The minimum value is the target value and the maximum value represents the upper limit. The minimum temperature setpoint of the zones is 20°C and the maximum is 25°C (except for the technical room). The humidity is controlled within a range of 20 to 80% and the CO_2 content between 400 and 800 ppm.

Zone	T [°C]	Supply air [m³/h]	Exhaust air [m³/h]	Humidity [%]	CO_2 [ppm]
min/max					
Zone 1	20/25	14.4/62.4		20/80	400/800
Zone 2	20/25	9.6/41.6		20/80	400/800
Zone 3	20/25		12/52	20/80	400/800
Zone 4	20/30				
Zone 5	20/25			20/80	400/800
Zone 6	20/25			20/80	400/800
Zone 7	20/25		12/52		

Modeling

The heating and cooling systems are modeled according to "ideal heating and cooling elements". They are used to obtain the heating and cooling energy demand without explicitly modeling the system.

Building Technology

The modelling for the building technology engineering was carried out according to the structure of IDA ICE. The old and new system could be compared in various fields such as: system temperatures, heat pump COP, resulting seasonal performance factor.

The building includes an air/water heat pump as a base heating, which maintains the buffer at a constant temperature. The COP of the new heat pump is 3.3 at an outside temperature of 2°C and heating water flow temperature of 35°C. The heating circuit pump is switched off from an outdoor temperature of 12°C, as it is usual for new constructions according to ENEV09. The additional heater was modelled with unlimited heating in order to calculate the maximum heating output required.

Internal loads

The internal heat sources are specified with detailed schedules. The internal heat sources include lighting, occupants and devices. The internal mass is represented by the furniture.

Zone	Illuminated	N of lighting bodies	Occupation Schedule Mo-Fr	Occupation Schedule Sa-Su	Electric power requirement [kWh]
Zone 1	YES	6	6-8; 17-23	17-23	178.5
Zone 2	YES	6	5:30-6; 22:30-23	23-0	24.0
Zone 3	YES	6	6-7; 22-22:30	20-20:30; 22-23	36.0
Zone 4	NO				
Zone 5	YES	2	6-8; 17:18	17-18; 22-23	21.7
Zone 6	YES	2	6-8; 17-22	17-23	53.8
Zone 7	NO				314.0

The lighting consists of 22 energy-saving lamps with a total annual energy consumption of about 315 kWh, under given time and control, which is intended to simulate the user's behavior. The occupants were modelled according to the zone, with the respective typical activity description and usual clothing, so that the heat dissipation and the person's comfort can be taken into account.

The activity level is defined according to the metabolic rate, which is expressed in met units and is defined as: 1 met = 58.2 W/m², which is equal to the energy produced per unit surface area from an average person while sitting. In this study, the energy assued for sleeping is 0.7 met (or 72 W) and 1 met (108 W) for sitting.

The clothing insulation is defined by the clo units, where 1 clo = 0.155 m²K/W. The value assigned for walking shorts, short-sleeved shirt is 0.36 clo, while 0.85 clo represents trausers and long-sleeved shirt/T-shirt.

The necessary details of the heat generated by appliances for IDA ICE is determined using the VDI 2078. The main input to the simulation program was the manufacturer reference. The power consumption is assumed to be the total heat output and it is scaled down to the annual consumption by using an approximate weekly schedule. Such schedules generate the following heat output for the electrical equipment:

Appliance	Number	Power consumption [W]	Yearly power consumption [kWh]	Usage
Oven	1	3700	288	everyday
Hob	1	3700	288	everyday
Dishwasher	1	2200	76	3 times/week
Washing machine	1	2300	255	2 times/week
TV	1	40	14.6	2 hrs/2nd day
Laptop	2	80	45	2 hrs/day

c). Housing unit energy loads

	end energy		
	kWh	kWh/m²	%
Lighting, facility	317	5,8	11
Electric cooling	125	2,3	4
HVAC aux	453	8,3	15
DHW	250		8
Electric heating	901	21,1	30
Electric Backup Heating	6	0,1	0
Equipment, tenant	947	17,3	32
total energy demand	2999	54,9	
PV production	-4672	-85,5	-156
energy balance	-1673	-30,6	

Figure 174: **End Energy loads per component**

3. RESULTS AND DISCUSSIONS

a). Housing unit energy performance on both, whole-house basis and system-by-system basis. Heat gains and losses by the building envelope

Two different energy analyses were performed: a passive energy analysis (without the technical building equipment) and an active energy analysis (with the technical building equipment).

Passive Analysis

The goal of the passive analysis is the study of the building structure and of its response to the external conditions in absence of an HVAC system.

The Zone 1 (living room) is taken as an example to show the energy flows through the building structure:

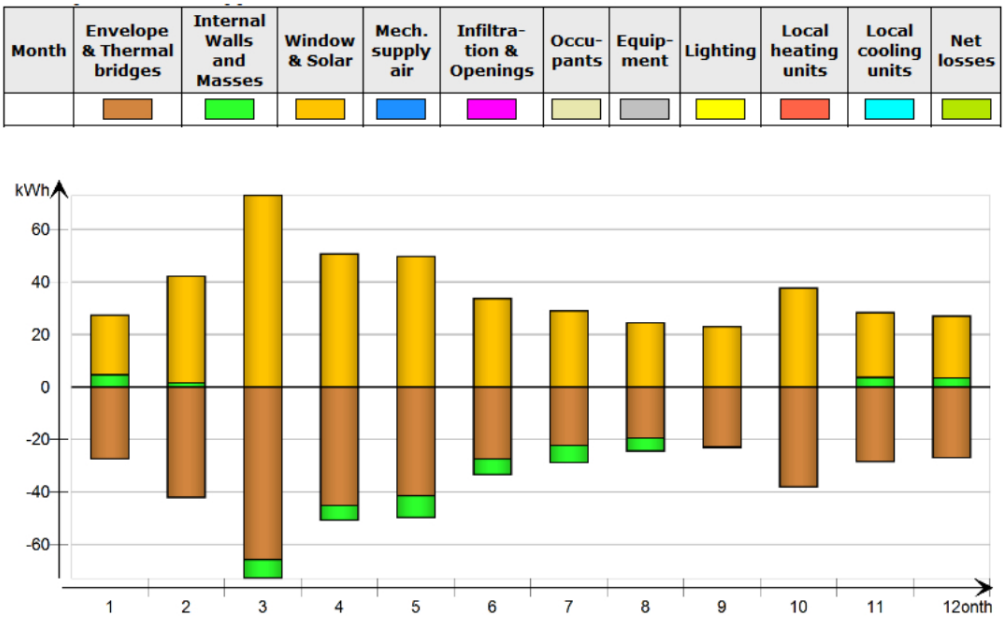


Figure 175: **Energy flows of Zone 1 [kWh]**

The graph above shows how the transitional seasons (March/October) are characterized by especially high, usable solar energy gains through the glass façades. The indoor temperature rises to 24°C only thanks to the solar gains; then the shade of the southern facing glass façade closes.

The following graph shows the transmission losses through the thermal envelope.

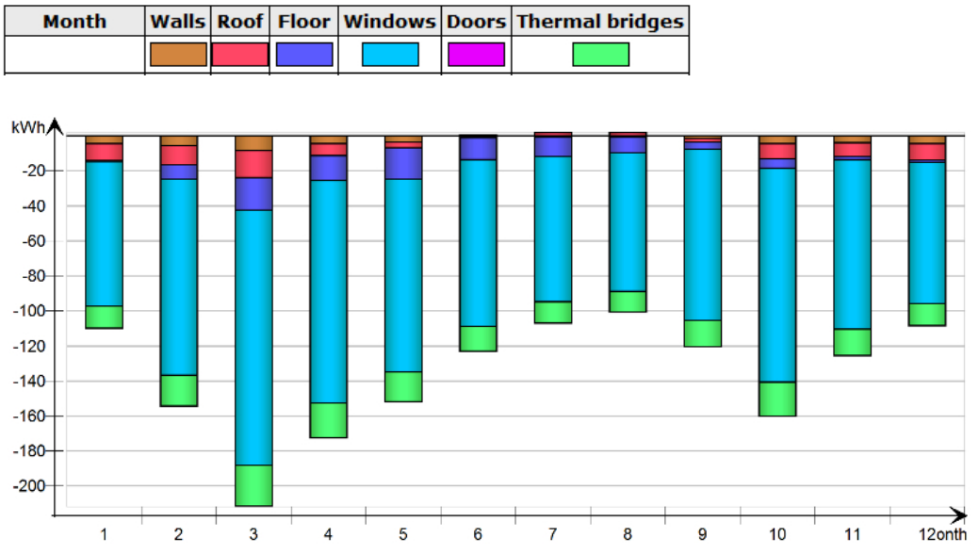


Figure 176: **Transmission losses through the thermal envelope [kWh] divided by source**

Also in this case, peaks are to be found in the transitional seasons (March/October). The reason is because in these months, the temperature difference between the outdoors and indoors,by solar gains , is greater in comparison to the other months.

This aspect shows that the building structure can best take advantage of the solar gains in the transitional months. The diagram also shows the weakness of the thermal envelope: the large window area has a very high thermal loss due to the lower U-value of the glass compared to a massive wall. A measure to improve the insulation is the compression of a think air layer when folding down the shades. Another option - not yet taken into account for simulation time reasons - would be to equip the opaque shade with an internal insulation, and thus approach the U-values of a massive wall.

Thanks to the shade control with overheating protection, during a normal summer day the temperature never exceeds 24°C. In fact, the thermal mass stores the solar gains; also the PCM ceiling thermal mass, which could not be modelled for this simulation, will contribute to such effect.

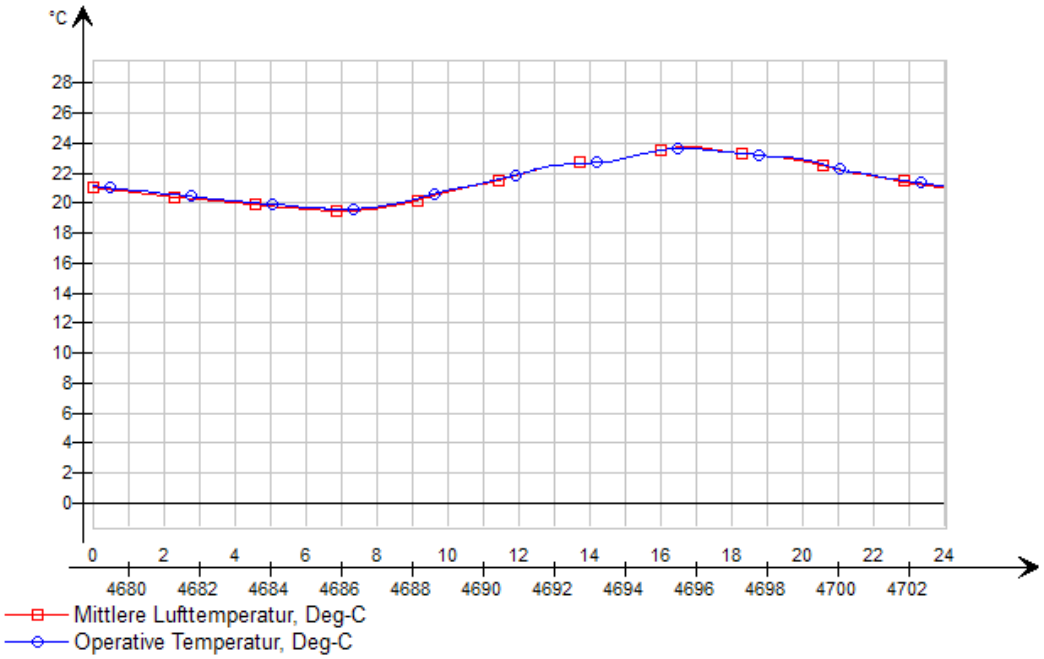


Figure 177: **Room Air Temperature [°C] in a typical summer day (passive analysis)**

At very high solar radiation, the room temperature can rise to 24°C due to the large glass façade. At this point, the shading of the southern façade folds down and prevents overheating of the room. This is achived by a system based on internal irradiation intensity and an internal temperature sensor.

The following chart shows the room temperature increase to 24°C and a consequent decrease of temperature due to the automatic closing of the shading on the southern façade with overheating protection scheme.

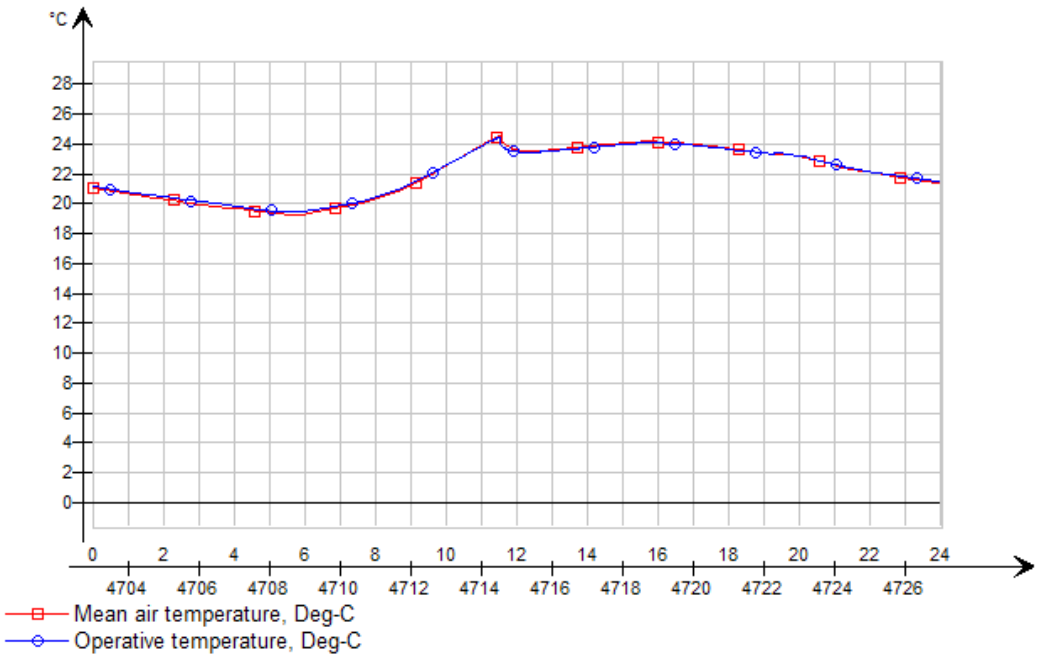


Figure 178: **Room Air Temperature [°C] in a typical summer day with overheat protection (passive analysis)**

The following heat balance diagram shows the solar gains through the glass façade to the desired temperature; also when the shading is folded down a small solar gain through the north façade and the heated window is recorded. The heat is absorbed by the thermal mass of the massive walls and of the floor and released to the zone during the night.

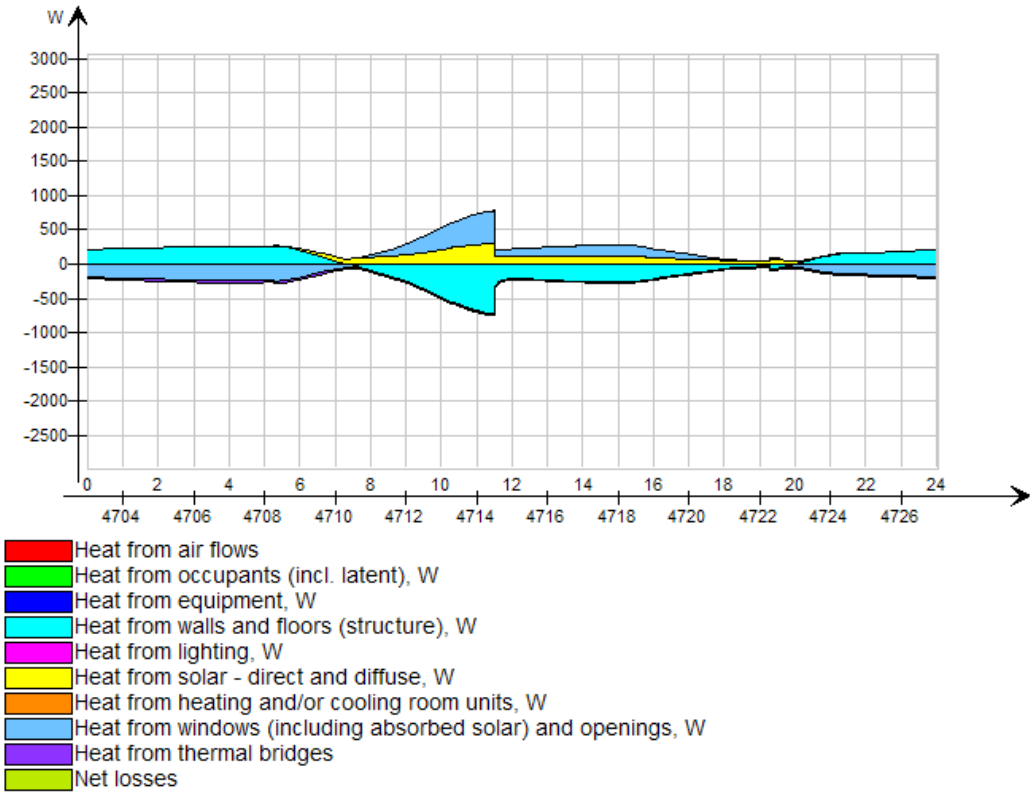


Figure 179: **Heat Balance [W] in a typical summer day (passive analysis)**

The northern glass façade, which stays open during the entire day, contributes to the indoor natural lighting. An illumination of about 1000 lx is granted throughout the day (Zone 1).

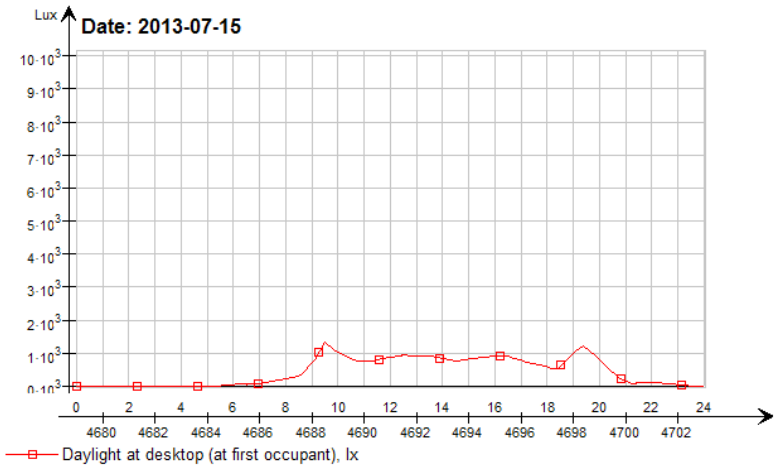


Figure 180: **Natural day lighting [lx] (Zone 1: Living room)**

Active analysis

The goal of the active analysis is the examination of the building envelope, the modified room air temperature and the final energy demand of the Rooftop Building, with reference conditions of Berlin and planned technical building equipment.

The following diagrams show the heat balance for a typical winter day (left) and for a typical summer day (right).

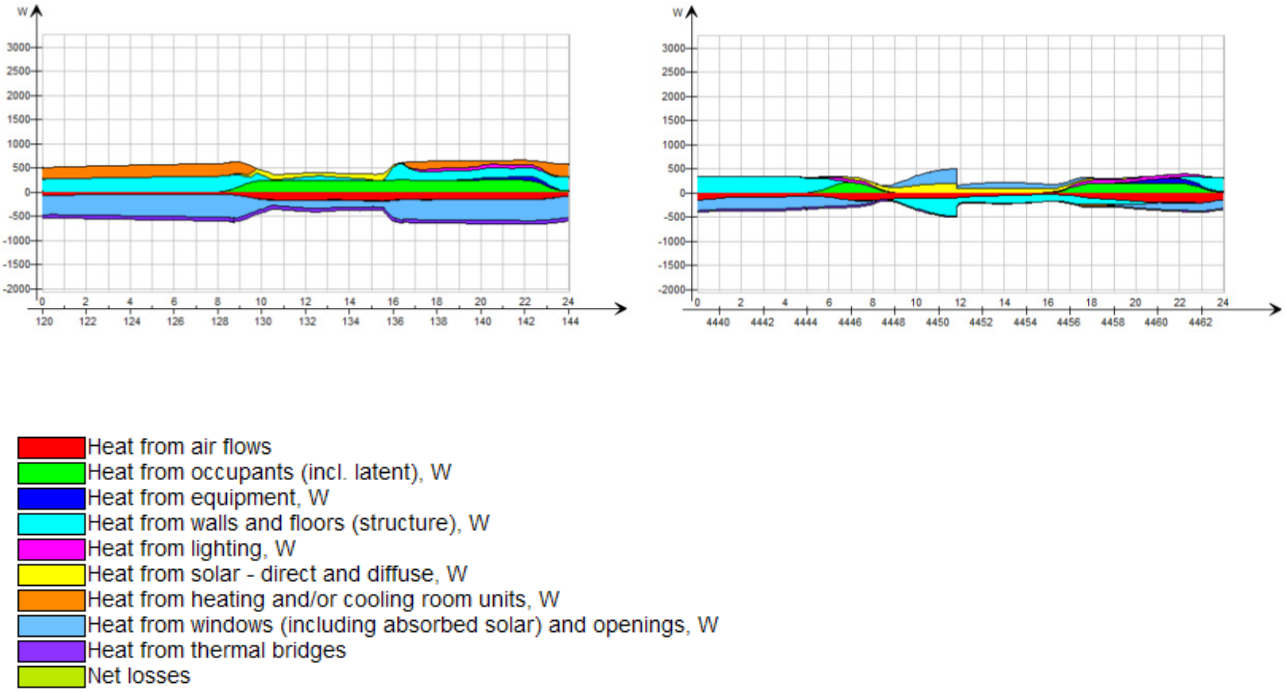


Figure 181: **Heat balance for a typical winter day (left) and for a typical summer day (right)**

In the heat balance of the typical winter day it is evident how the majority of the heat loss happens through windows. The solar gains, as well as internal gains and building's thermal mass, are released during the day.

On a typical summer day (right diagram) it is visible how the cooling elements are not really needed during the day, because the shading prevents overheating shortly before noon. The thermal mass of the building envelope absorbs the heat and it is a clear heat source in the diagram. Just as it happens in winter, the majority of the heat losses take place through the window to the outside air.

The following figures illustrate the energy balance for an example zone (Zone 1 - living room). Results are displayed both in numerical and graphical way.

Energy for "Zone 1 Wohnzimmer"

kWh (sensible only)

Month	Envelope & Thermal bridges	Internal Walls and Masses	Window & Solar	Mech. supply air	Infiltration & Openings	Occupants	Equipment	Lighting	Local heating units	Local cooling units	Net losses
1	-133.9	8.0	-228.2	-57.6	-0.0	52.4	8.1	15.4	336.5	-0.0	0.0
2	-116.8	9.1	-157.4	-48.8	-0.0	47.9	7.3	13.8	245.6	0.0	0.0
3	-112.0	10.2	-120.1	-58.2	-0.0	52.8	8.0	15.1	204.6	-0.0	0.0
4	-68.9	12.3	-48.8	-56.3	-0.0	48.6	7.8	14.8	91.0	-0.0	0.0
5	-47.3	11.6	4.4	-58.4	-0.0	46.7	8.1	15.4	32.7	-12.7	0.0
6	-30.9	13.6	19.2	-48.0	0.0	44.9	7.8	14.6	10.0	-30.5	0.0
7	-21.8	14.3	28.5	-45.3	0.0	43.8	8.1	15.4	0.2	-42.8	0.0
8	-23.1	14.2	14.4	-43.5	0.0	44.9	8.1	15.2	1.4	-31.5	0.0
9	-36.1	16.6	-20.1	-52.3	-0.0	48.9	7.8	14.7	24.4	-4.3	0.0
10	-72.8	12.5	-75.3	-58.2	-0.0	50.2	8.1	15.4	120.5	-0.0	0.0
11	-102.0	10.7	-156.2	-48.8	-0.0	52.1	7.8	14.7	222.4	-0.0	0.0
12	-131.3	9.9	-228.6	-50.2	-0.0	53.7	8.1	15.2	323.8	-0.0	0.0
Total	-896.9	143.0	-968.2	-625.5	0.0	586.8	95.1	179.5	1613.2	-121.8	0.0
During heating	-528.3	123.8	-1338.1	-280.6	0.0	280.3	43.0	86.1	1612.8	0.0	0.0
During cooling	-219.8	-30.1	325.3	-85.8	0.0	120.0	21.4	38.4	0.0	-121.8	0.0
Rest of time	-148.8	49.3	44.6	-259.1	0.0	186.5	30.7	55.0	0.4	-0.0	0.0

Figure 182: **Energy flows for Zone 1: Living room (active analysis)**

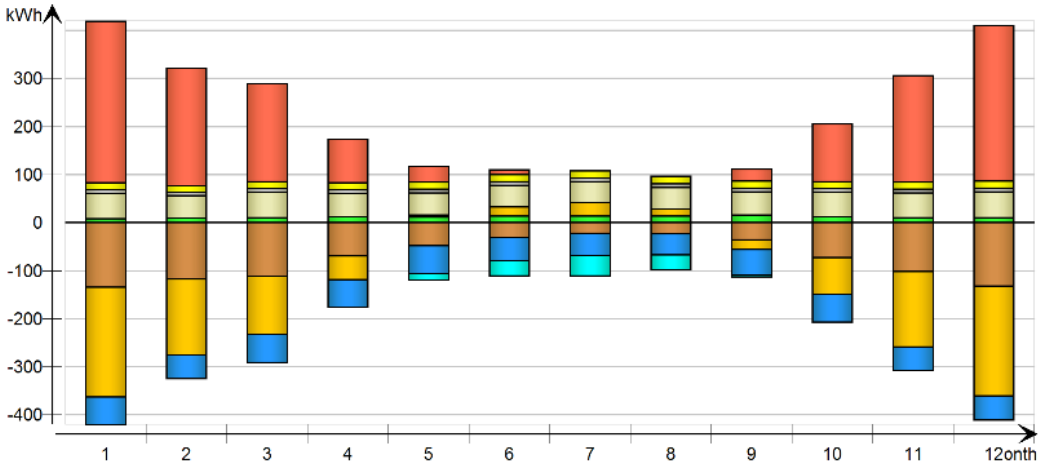


Figure 183: **Graphical representation of energy flows for Zone 1: Living room (active analysis)**

The graph clearly shows the energy loss through windows in the winter time, although the solar gains compensate such loss. This effect illustrates how the windows are actually not efficient from an energy point of view; the glass façades mainly serve a comfort and aesthetical purpose.

The other main losses concern the massive components and thermal bridges.

During the summer the rooms are well shaded and hardly any energy is required for active cooling. Energy for the fresh air supply through ventilation is required throughout the year due to the high spatial tightness.

The analysis of the transmission through the envelope shows the same weakness.

Envelope transmission

kWh

Month	Walls	Roof	Floor	Windows	Doors	Thermal bridges
1	-13.2	-38.4	-30.3	-309.3	0.0	-52.0
2	-11.0	-31.4	-29.2	-270.4	0.0	-45.1
3	-10.3	-28.4	-29.8	-263.3	0.0	-43.5
4	-5.4	-13.5	-20.6	-183.4	0.0	-29.4
5	-3.2	-5.3	-18.4	-132.7	0.0	-20.4
6	-0.9	-0.9	-13.6	-103.9	0.0	-15.5
7	-0.3	1.8	-11.3	-84.0	0.0	-12.0
8	-0.6	0.6	-10.6	-85.1	0.0	-12.5
9	-2.2	-6.0	-8.8	-120.9	0.0	-19.1
10	-6.2	-18.8	-17.4	-185.7	0.0	-30.4
11	-9.7	-28.4	-24.4	-237.7	0.0	-39.5
12	-12.9	-37.7	-30.5	-297.2	0.0	-50.2
Total	-76.0	-206.4	-244.8	-2273.7	0.0	-369.6
During heating	-50.2	-68.9	-151.3	-1546.1	0.0	-257.9
During cooling	-12.8	-100.1	-82.6	-170.3	0.0	-24.4
Rest of time	-13.0	-37.4	-10.9	-557.3	0.0	-87.3

Figure 184: **Monthly heat losses per transmission through envelope components [kWh] (active analysis)**

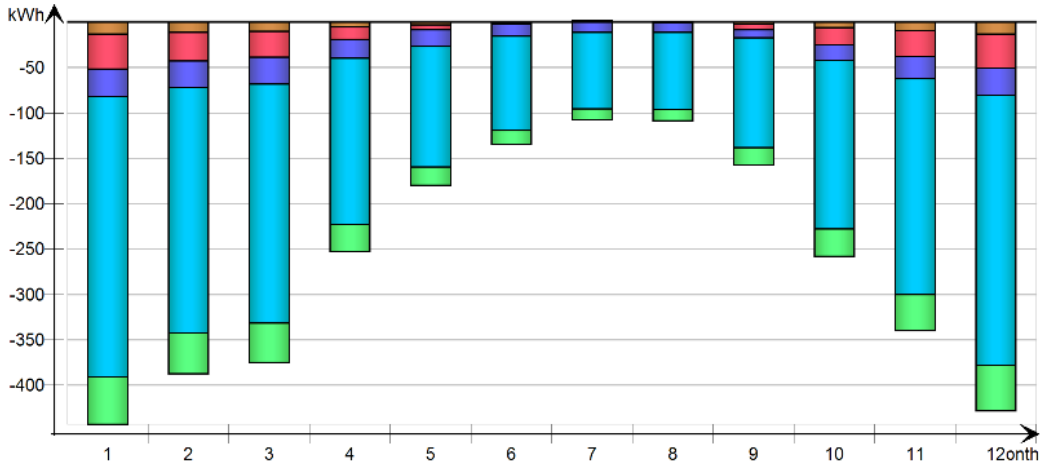


Figure 185: **Monthly heat losses per transmission through envelope components [kWh] (Zone 1: Living room; active analysis). The pale blue share shows how losses occur predominantly through windows.**

Once more, the large proportion of window area causes high transmission heat losses. The massive components have been designed according to the passive standard and therefore have a very good U-value, which limits transmission losses. The U-value of windows of 0.7 and the thermal bridges in correspondence of the frameworks lead to an important energy loss through heat transmission losses.

The following figure shows the energy demand on a yearly basis of the three main components of the heat supply system: the heat pump evaporator, condenser and compressor.

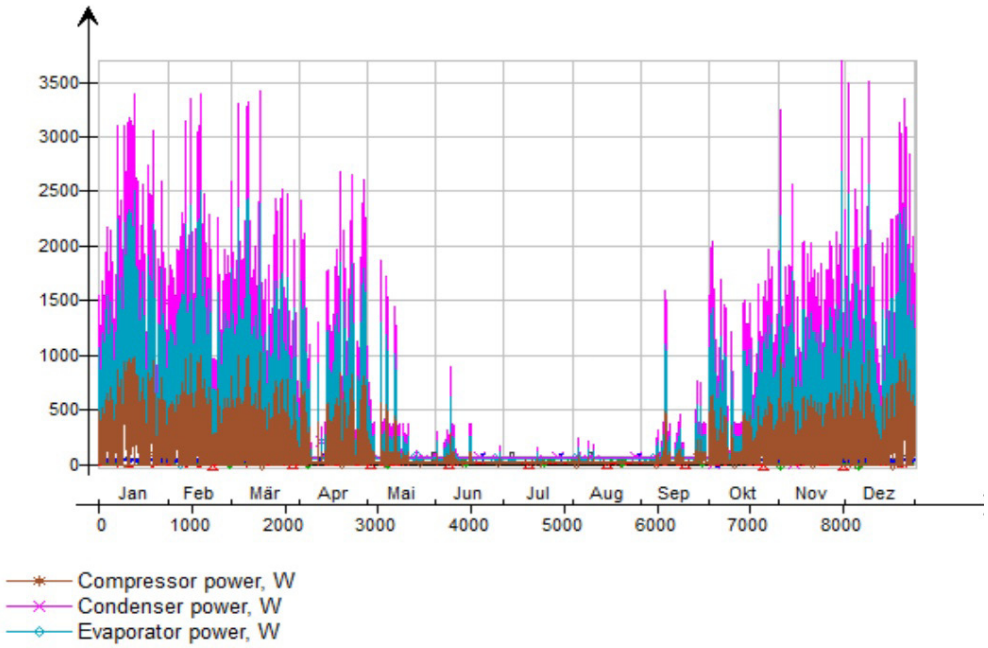


Figure 186: **Energy demand [W] of the heat pump components**

In winter the high energy demand of the heat pump is due to the high heat load and temperature swing between the required flow temperature and the heat source (environment) temperature. This means that the heat pump requires more electrical power than usual to provide the desired heating amount and has the highest energy demand of the year. Therefore, the energy efficiency is at its lowest peak in winter and the power demand is very high. The transitional periods are instead characterized by low power demands due to the lower heating load and consequently lower heating flow temperatures. The heat pump is working at its peak of efficiency. In summer the heat pump works in heating mode only to guarantee the hot water requirements for two people. The DHW requires high temperature level, which increases the temperature span and hence the power demand. However, the DHW demand for two people is relatively low.

The yearly simulation of the air/water heat pump shows that the best energy performance is achieved in the transitional periods. When the temperature span is increasing because of the decreasing outdoor temperatures in winter (or the need of DHW with very high temperature level during the summer), the energy efficiency inevitably worsens. The annual COP of 3.1 resulting from the simulation-based analysis is evidence of how the heat supply concept is efficiently designed and optimally tuned.

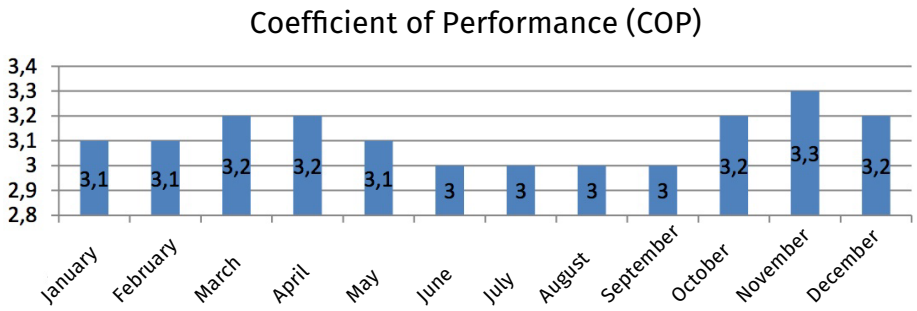


Figure 187: **Heat pump COP (*Arbeitszahlen*) evolution throughout the year**

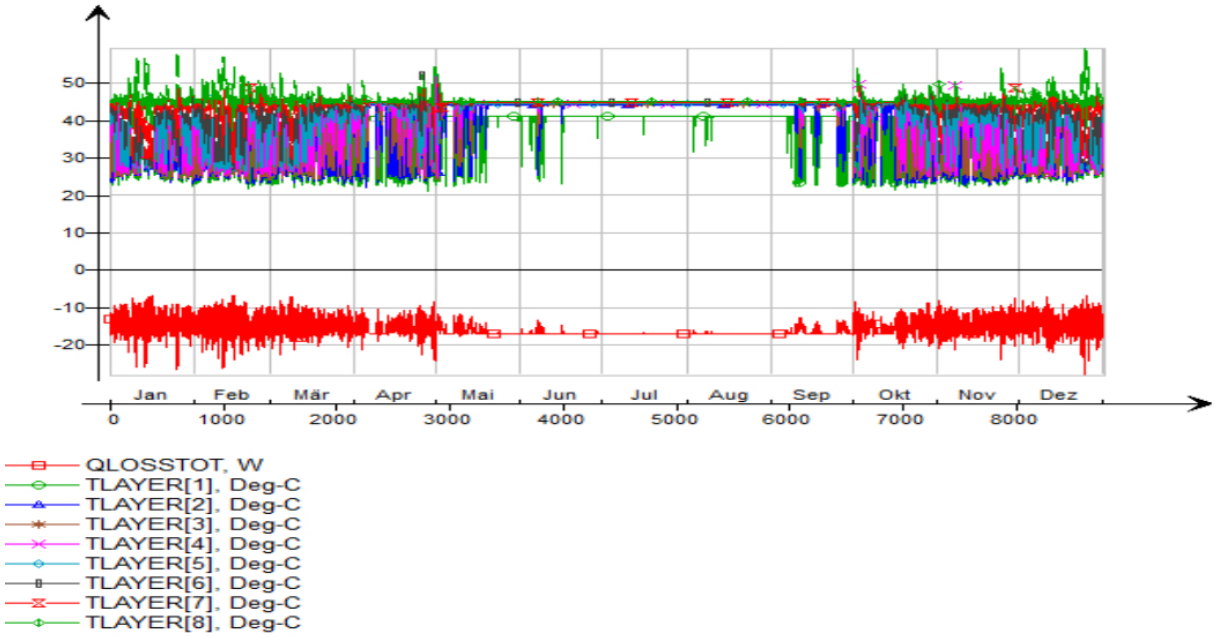


Figure 188: **Buffer tank temperature stratification**

Without the contribution of the solar thermal system, the buffer tank temperatures are at a system temperature of about 45°C. In winter and transition periods, the stratified temperature layers are easy to recognize. On the other hand, in summer the buffer cylinder temperature is maintained constant in order to supply the hot water tank with a flow temperature of 45°C.

With a solar thermal system the buffer cylinder would be heated at a temperature of 70°C during the summer: the heat pump can be switched off.

b). Predicted indoor temperatures in passive analysis.

The following diagram shows the indoor air temperature in passive analysis [°C] as compared to the environmental outdoor temperature.

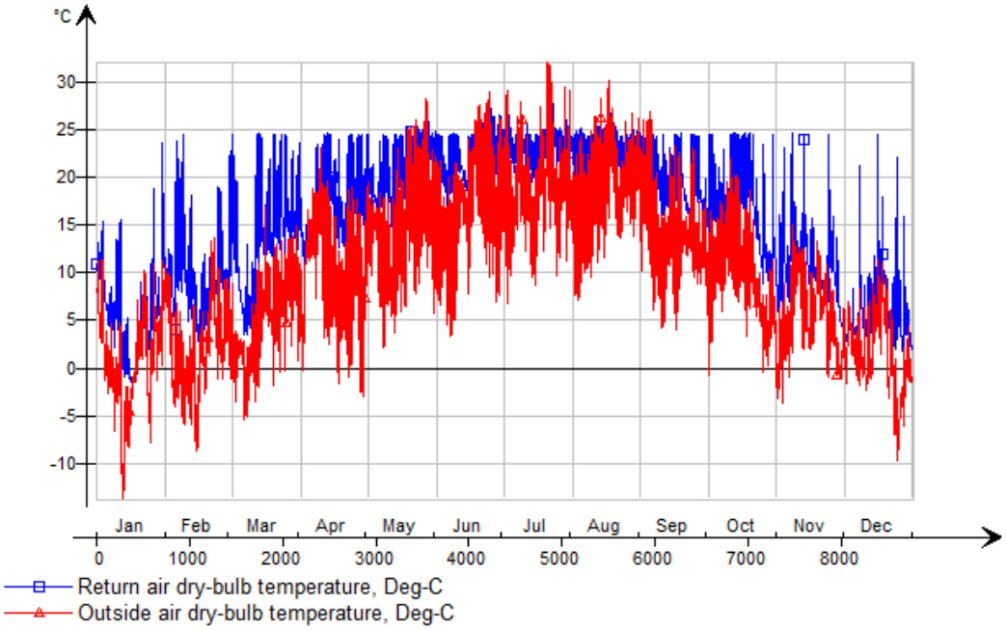


Figure 189: **Outside and indoor dry-bulb air temperature [°C]**

Simulations show how with a balanced passive system the indoor temperatures are not excessive, unless the outdoor temperature rises above 25°C. This is due to the presence of shading elements with overheating protection control and the good thermal envelope . See the PCM detailed chapter for further details on how the PCM passive cooling system will accommodate the peak summer cooling load. In the present simulation, it is not possible to model how the heat is dissipated to the outside via a separate system.

c). Appliances and HVAC systems selection criteria and description of the final design that minimizes energy consumption and optimizes comfort conditions.

The first selection criterion was the All-in-One Unit feature: for us it was extremely relevant to be able to store the HVAC system in the central technical module for mobility reasons, efficiency of the heat recovery, acoustic reason, isolation and aesthetics.

Furthermore, we required a low capacity field, an efficient COP value and overall performance factor and the minimization of the total system energy demand.

The separation of heating water and DHW seemed sensible for a number of reasons: low temperature savings, optimization of the performance factor and therefore energy savings.

In order to grant the maximum comfort and efficiency, a CO_2 level and air humidity regulation seemed imperative. Big transfer areas enable an efficient use of energy and hence lower the energy demand.

For the integrated HVAC system, we used a central ventilation heat recovery greater than 80% and a COP over

3,made possible with the use of exhaust air by the central air system.

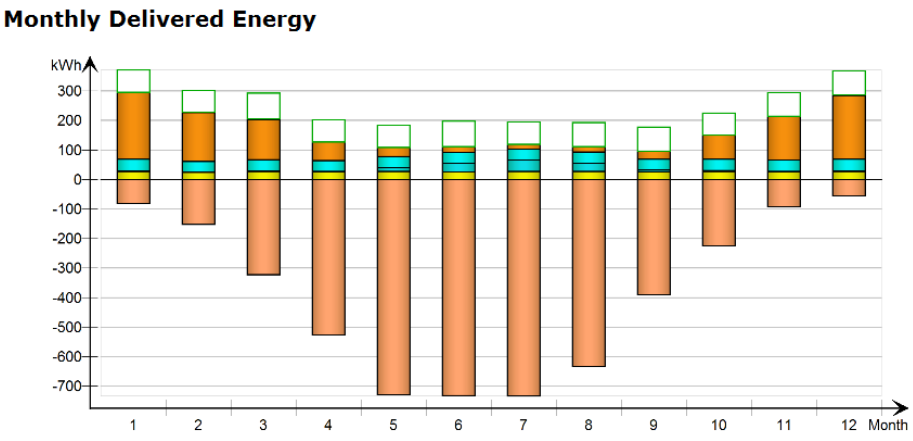
For a detailed description of the HVAC system, please refer to Section 5.3.7 and 5.3.8 of the Engineering and Construction Design Narrative

d) Predicted heating and cooling loads, appliances and HVAC energy demand.

	Energy Demand		Final Energy Demand		Costs		CO_2		Primary Energy Demand	
	kWh	kWh/m²	kWh	kWh/m²	€	€/m²	kg	kg/m²	kWh	kWh/m²
Lighting facility	317	5,8	317	5,8	83	1,5	187	3,4	825	15,1
Electric cooling	310	5,7	125	2,3	32	0,6	74	1,4	324	5,9
HVAC aux	453	8,3	453	8,3	118	2,2	267	4,9	1177	21,6
Electric heating	2804	51,4	1151	21,1	299	5,5	679	12,4	2994	54,8
Electric Backup Heating			6	0,1	1	0	3	0,1	14	0,3
Equipment, tenant	947	17,3	947	17,3	246	4,5	559	10,2	2463	45,1
Total energy demand	4831	88,5	2999	54,9	779	14,3	1769	32,4	7797	142,8
PV production	-4672	-85,5	-4672	-85,5			-2756	-50,5	-12146	-222,4
Energy balance			-1673	-30,6	779	14,3	-987	-18,1	-4349	-79,6

Figure 190: **Energy consumption, final energy consumption, costs of energy, CO_2 production, primary energy consumption**

The previous table shows how the Rooftop Building is a Plus Energy House, producing 36% of excess power by means of the PV modules surface. Such amount of electricity will be used to supply the battery, to feed the public electric network and to contribute to the E-Mobility.



	Delivered energy	
	kWh	kWh/m²
Lighting, facility	317	5.8
Electric cooling	125	2.3
HVAC aux	453	8.3
Electric heating	1151	21.1
Electric Backup Heating	6	0.1
Equipment, tenant	947	17.3
PV production	-4672	-85.5
Grand total	-1673	-30.6

Figure 191: **Energy Balance: monthly consumed and delivered energy [kWh]**

During the winter season the temperate climates are characterized by very high energy demand but little sunlight. For this reason, in spite of the positive energy balance, the building is transferred to the public power grid in winter. In summer and transition months the PV system covers the whole demand and the oversupply can be fed into the public grid or used for E-Mobility.

With regards to the economical aspect, according to the current price guide on the German electricity mix, the monthly utility costs for the building services do not exceed 100 € (without considering the gain due to the PV system). The main costs are the heating and electrical household appliances.

The following tables show energy demand, cost, CO_2 production and primary energy demand for each facility, along with the negative contribution of the PV system.

Month	Facility electric											
	Lighting, facility				Electric cooling				HVAC aux			
	(kWh)	Cost (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Cost (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Cost (€)	CO_2 (kg)	Prim. (kWh)
1	27.1	7.0	16.0	70.4	1.1	0.3	0.6	2.8	39.7	10.3	23.4	103.2
2	24.3	6.3	14.4	63.3	1.0	0.3	0.6	2.6	35.4	9.2	20.9	92.0
3	26.7	7.0	15.8	69.5	1.5	0.4	0.9	4.0	38.9	10.1	22.9	101.1
4	26.2	6.8	15.5	68.1	2.1	0.5	1.2	5.3	36.7	9.5	21.6	95.4
5	27.1	7.0	16.0	70.5	12.5	3.3	7.4	32.6	37.5	9.8	22.1	97.6
6	25.8	6.7	15.2	67.2	28.8	7.5	17.0	74.8	36.4	9.5	21.5	94.6
7	27.1	7.0	16.0	70.5	38.7	10.1	22.8	100.5	37.4	9.7	22.1	97.3
8	27.0	7.0	15.9	70.1	28.1	7.3	16.6	73.0	37.5	9.7	22.1	97.5
9	26.0	6.8	15.4	67.7	6.6	1.7	3.9	17.3	36.4	9.5	21.5	94.7
10	27.1	7.0	16.0	70.5	2.2	0.6	1.3	5.7	38.5	10.0	22.7	100.1
11	26.0	6.8	15.3	67.6	1.1	0.3	0.7	3.0	38.3	9.9	22.6	99.7
12	26.9	7.0	15.9	70.0	1.1	0.3	0.6	2.8	39.9	10.4	23.5	103.6
Total	317.4	82.5	187.3	825.3	124.7	32.4	73.6	324.3	452.6	117.7	267.0	1176.7

Figure 192: **Electricity demand [kWh], cost [€], CO2 production [kg] and correspondent primary energy consumption [kWh] for source of demand**

Month	Facility electric								Tenant electric			
	Electric heating				Electric Backup Heating				Equipment, tenant			
	(kWh)	Cost (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Cost (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Cost (€)	CO_2 (kg)	Prim. (kWh)
1	225.3	58.6	132.9	585.8	2.1	0.6	1.3	5.5	75.7	19.7	44.7	196.9
2	166.1	43.2	98.0	431.9	1.3	0.3	0.8	3.3	72.8	18.9	43.0	189.4
3	136.4	35.5	80.5	354.6	0.7	0.2	0.4	1.8	87.1	22.6	51.4	226.4
4	63.2	16.4	37.3	164.3	0.0	0.0	0.0	0.1	74.8	19.4	44.1	194.4
5	30.7	8.0	18.1	79.9	0.0	0.0	0.0	0.1	75.7	19.7	44.7	196.9
6	20.1	5.2	11.9	52.2	0.0	0.0	0.0	0.1	86.1	22.4	50.8	223.9
7	17.3	4.5	10.2	44.9	0.0	0.0	0.0	0.1	75.6	19.7	44.6	196.7
8	17.7	4.6	10.4	45.9	0.0	0.0	0.0	0.1	81.2	21.1	47.9	211.1
9	27.9	7.3	16.5	72.7	0.0	0.0	0.0	0.1	80.6	21.0	47.6	209.6
10	81.6	21.2	48.1	212.1	0.0	0.0	0.0	0.1	75.7	19.7	44.7	196.9
11	148.6	38.6	87.7	386.4	0.2	0.1	0.1	0.6	80.3	20.9	47.4	208.8
12	216.5	56.3	127.7	562.9	0.9	0.3	0.6	2.6	81.6	21.2	48.1	212.1
Total	1151.4	299.3	679.3	2993.5	5.5	1.4	3.3	14.4	947.3	246.3	558.9	2463.0

Electricity demand [kWh], cost [€], CO_2 production [kg] and correspondent primary energy consumption [kWh] for source of demand

Month	Produced electric			
	PV production			CHP electricity
	(kWh)	CO_2 (kg)	Prim. (kWh)	(kWh)
1	-81.4	-48.0	-211.6	0.0
2	-151.3	-89.3	-393.4	0.0
3	-321.6	-189.7	-836.2	0.0
4	-525.9	-310.3	-1367.3	0.0
5	-729.3	-430.3	-1896.2	0.0
6	-732.4	-432.1	-1904.2	0.0
7	-733.3	-432.6	-1906.6	0.0
8	-634.2	-374.2	-1648.9	0.0
9	-389.9	-230.0	-1013.7	0.0
10	-224.6	-132.5	-584.0	0.0
11	-91.6	-54.0	-238.2	0.0
12	-56.1	-33.1	-145.9	0.0
Total	-4671.6	-2756.3	-12146.2	0.0

Figure 193: **Electricity production through PV panels [kWh], saved CO_2 production [kg], primary energy savings [kWh]**

The CO_2 balance registers a monthly emission of about 200 kg during the winter months due to the energy demands of the building that require connection to the public grid. In the transition periods and in summer, however, a monthly emission amount of about 400 kg is prevented thanks to the photovoltaic panels. Other data tables can be found in the appendix.

The following graph shows the overall energy demand both for heating and cooling throughout the year in kWh.

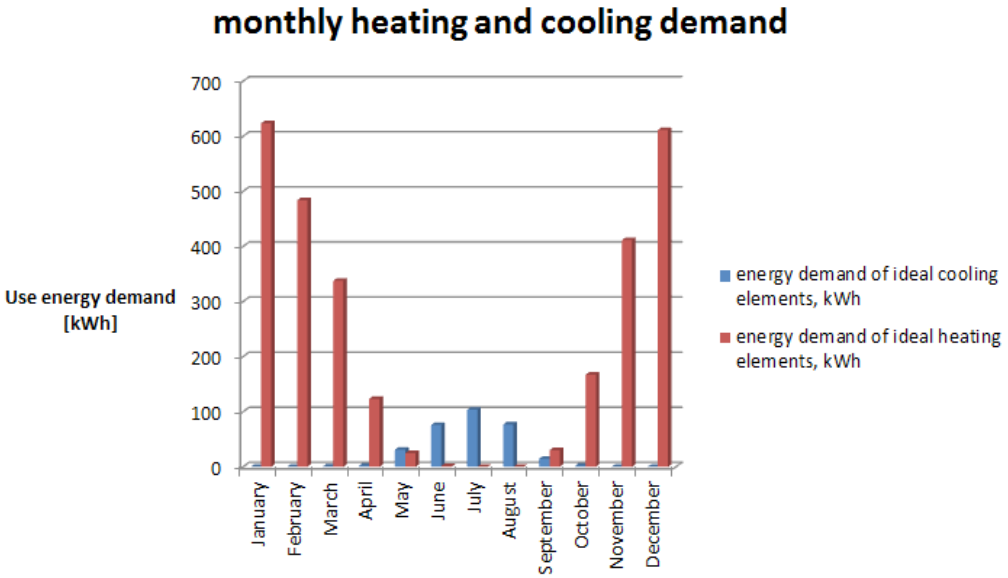


Figure 194: **Monthly Energy Demand for cooling and heating (ideal loads) [kWh]**

4. CONCLUSION

As a conclusive remark, this study gives a practical demonstration of the importance of simulation-based energy concept analysis. Through the optimization of the building and system design it was possible to reduce the overall energy need of the Rooftop Building by 44% in the intense optimization phase from June 2013 to end October 2013.

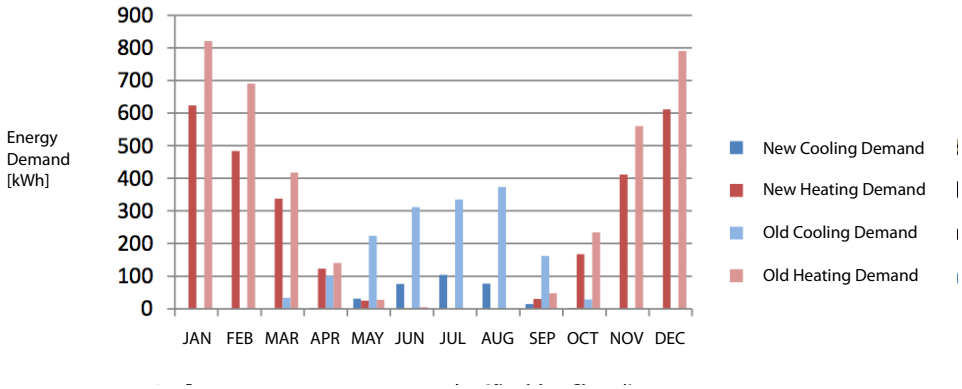


Figure 195: **Monthly Energy Demand for cooling and heating (ideal loads) resulting from the building and system design optimization (darker chart's columns represent the final need) [kWh]**

The Rooftop Building has a positive energy balance over the year: in fact, the PV system produces an exceeding 36% of power.

The simulations have shown the great potential for savings. However, given the complexity of the competition and the various range of requirements which need to be fulfiled, it was important to come to a compromise between form and function. In order to do so, the strong cooperation between architecture and engineering teams proved to be essential.

Building energy simulation is a fundamental preliminary design tool for innovative and energy-efficient buildings. BES played indeed a leading role in the development process of the building and system design.

SECTION III — ADAPTATIONS MADE BY THE TEAM IN THE HOUSE FOR THE PROTOTYPE IN VERSAILLES

Adaptations

Our house is placed on top of an existing building. Throughout the design process we aimed to make the distinction between the Rooftop House and the Altbau as clear as possible. Because our proposition is not an urban block structure but rather an interconnected grid of singular Rooftop Units, the prototype built in Versailles is nearly identical to the house in its local context: the footings would be different, the mock-up features (i.e. Treppenhaus and Brandwände, staircase and firewalls) already exist in Berlin. Apart from that the constructive design remains the same.

We are considering to not install the entire floor heating in Versailles, as this appears to be unnecessary, given that the competition takes place in summer.

On the western and eastern opaque walls of our housing unit we have devised a wall mounting system that is flexible enough to allow quick changes of surface materials for testing and easy adaption to climates. In Berlin we would install a wall heating system that connects to the low heat floor heating system. In Versailles we will use an innovative new organic fibre panel saturated with PCM to support our passive cooling system in the Versailles summer heat.

Simulation

In the following paragraph the results for the two weeks competition period in Versailles are presented. The set simulation period is between June 28th and July 11th. The correspondent climate is the one of Versailles, France. Also in this case, the simulations are entirely performed using the software IDA ICE.

Considering that the month of June has a lower number of days if compared with the month of July, the energy demand per month may be misconceived. In fact, both the production and consumption in the month of June appear to be much less than those of July.

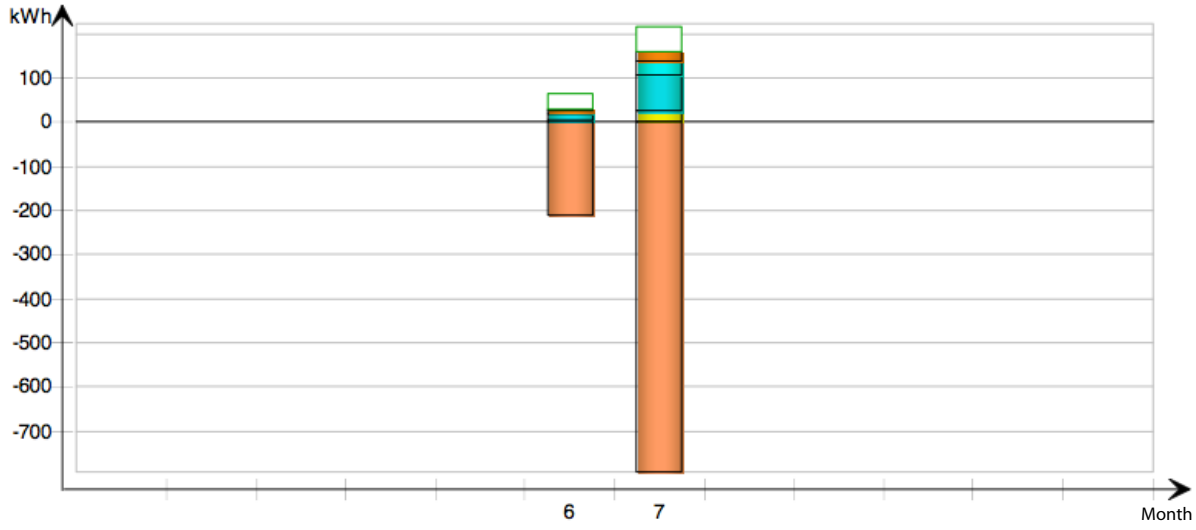


Figure 196: **Estimated energy production (negative values) and consumption (positive values) during the competition timeframe**

Month	Power - central											
	Lighting, facility				Electric cooling				HVAC aux			
	(kWh)	Energy Costs (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Energy Costs (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Energy Costs (€)	CO_2 (kg)	Prim. (kWh)
6	2.4	0.3	1.4	6.2	5.2	0.7	3.1	13.6	3.8	0.5	2.2	9.8
7	9.8	1.4	5.8	25.4	32.3	4.5	19.1	84.0	13.2	1.8	7.8	34.2
Total	12.2	1.7	7.2	31.7	37.5	5.3	22.1	97.6	16.9	2.4	9.9	44.1

Month	Power - central								Power - tenant			
	Electric heating				Electric Backup Heating				Equipment, tenant			
	(kWh)	Energy Costs (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Energy Costs (€)	CO_2 (kg)	Prim. (kWh)	(kWh)	Energy Costs (€)	CO_2 (kg)	Prim. (kWh)
6	2.4	0.3	1.4	6.3	0.0	0.0	0.0	0.0	14.3	2.0	8.4	37.2
7	8.6	1.2	5.1	22.3	0.0	0.0	0.0	0.0	22.1	3.1	13.0	57.4
Total	11.0	1.5	6.5	28.6	0.0	0.0	0.0	0.0	36.4	5.1	21.5	94.6

Month	Produced electric ***			
	PV production			CHP electricity
	(kWh)	CO_2 (kg)	Prim. (kWh)	(kWh)
6	-81.3	-48.0	-211.4	0.0
7	-304.8	-179.8	-792.5	0.0
Total	-386.1	-227.8	-1003.9	0.0

Figure 197: **Estimated energy demand, costs of energy, CO2 production and primary energy consumption per month over the competition period in Versailles, France**

		Energy Demand		Peak	Energy Costs		CO_2		Primary Energy	
		kWh	kWh/m²	kW	€	€/m²	kg	kg/m²	kWh	kWh/m²
	Lighting, facility	12	0.2	0.15	2	0.0	7	0.1	32	0.6
	Electric cooling	38	0.7	0.47	5	0.1	22	0.4	98	1.8
	HVAC aux	17	0.3	0.06	2	0.0	10	0.2	44	0.8
	Electric heating	11	0.2	0.03	2	0.0	6	0.1	29	0.5
	Electric Backup Heating	0	0.0	0.0	0	0.0	0	0.0	0	0.0
	Total Power from central	78	1.4		11	0.2	45	0.8	203	3.7
	Total	78	1.4		11	0.2	45	0.8	203	3.7
	Equipment, tenant	36	0.7	2.22	5	0.1	21	0.4	95	1.7
	Total Power, tenant	36	0.7		5	0.1	21	0.4	95	1.7
	PV production	-386	-7.1	0.0			-228	-4.2	-1004	-18.4
	CHP electricity	0	0.0	0.0						
	Total Produced Electricity	-386	-7.1		0	0.0	-228	-4.2	-1004	-18.4
	Total Value	-272	-5.0		16	0.3	-162	-3.0	-706	-12.9

Figure 198: **Estimated energy demand, peaks, costs of energy, CO2 production and primary energy consumption over the competition period in Versailles, France**

As expected, the energy demand for heating is zero during the competition period in Versailles. As a result, it seemed reasonable to postpone the installation of the underfloor heating system to when the house will be finally reassembled in Berlin. In fact, it would have been useless and very complicated to connect the pipes of the underfloor heating and then dissemble the house for transport.

Furthermore, it can be noted that the lion's share of the energy consumption in July is given by the active cooling followed by appliances and lighting (see Figure 196). However, it was not possible to take the self-constructed plant filter-bed into account in the simulation. The actual temperature from which the active cooling will be present is 27°C instead of 25°C. We are therefore to expect a decrease of the energy share for cooling in the hot season.

THERMAL ENVELOPE

The thermal envelope is a key component of the Rooftop House. It is not only designed to reduce the amount of energy used to keep the living conditions comfortable, even the amount of energy used to produce the material must be as low as possible.

Calculation of Thermal Transmittance

To classify the energy efficiency that is provided by the thermal envelope of the façade the thermal transmittance of the floor and roof (U-value) have to be considered. The lower the value of this factor the better. To calculate the thermal transmittance the following equation can be used [RECKNAGEL ET AL. 2011-12, S.400]:

considering:

- R_{si}- total thermal resistance inside, in m² K/W
- R_{se}- total thermal resistance outside, in m² K/W
- d- thickness of layer j, in m

$$U = \frac{1}{R_{si} + \sum_j \frac{d_j}{\lambda_j} + R_{se}}$$

- λ- thermal conductivity of layer j, in W/(mK)

As the vertical influence of inhomogene components have to be considered as well, the following calculation will be added for every component. The average thermal transmittance is defined as follows [UniDue 2014]:

$$U = \frac{1}{R_T}$$

considering the average thermal resistance

$$R_T = \frac{R'_T + R''_T}{2}$$

and the upper and lower thermal resistances:

$$R_T'' = R_{si} + \frac{d_1}{\bar{\lambda}_1} + \frac{d_2}{\bar{\lambda}_2} + \cdots + \frac{d_i}{\bar{\lambda}_i} + R_{se}$$

The average thermal conductivity is calculated, considering the area fraction *fi*, using

$$\bar{\lambda}_i = f_1 \cdot \lambda_1 + f_2 \cdot \lambda_2$$

and the thermal resistance per component zone using

$$R_{Ti} = R_{se} + \frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} \ldots + \frac{d_i}{\lambda_i} + R_{se}$$

This additional calculation results in a thermal transmittance value, which includes calm air layers, battens and other inhomogene structures inside the components.

Floor

Considering the material properties according to [PW-INTERNET 2013] the resulting thermal resistances for every layer of the floor construction can be given:

nr	material	thickness d	density ρ	thermal conductivity λ	thermal resistance
		mm	kg/m³	W/(mK)	m²K/W
1	floor boards, or corc, or acoustic insulation board (rubber)	16 3 17	500 140 600	0130 0,500 0,160	0,1231 0,0600 0,1063
2	dry screed panels	19	1300	0,400	0,0475
3	expanded polystyrene lay plate incl. underfloor heating pipes	25	938	0,035	0,7143
4	polyethylene film	1	1900	0,400	0,0031
5	roll corc	3	140	0,400	0,,667
6	OSB board	22	620	0,130	0,1692
7	cellulose insulation construction wood	240 240	65 460	0,040 0,130	6,0000 1,8462
8	fire protection plasterboard	12,5	1400	0,250	0,0262
9	wooden substructure	12	460	0,130	0,0923
				sum (insulation) floor boards	**7,2757**
				cork	**7,2126**
				acoustic insl. boards	**7,2589**
				sum (incl. wooden construction) floor boards	**6,7091**
				cork	**6,4332**
				acousic insl. boards	**6,5102**

Table 39: **material dimensions of the floor, incl. three types of floor boards (wood, corc, rubber)**

Therefore, considering the floor abutting on outer air instead of ground and including the thermal resistances for inside and outside:

R_{si}=0,13 m² K/W and R_{se}=0,04 m²K/W

the thermal transmittance of the floor at the insulation is:

U=0,134 W/(m²K) for floor boards,

U=0,135 W/(m²K) for cork plates and acoustic insl. boards

The calculates average thermal transmittance is:

U=0,149 W/(m²K) for floor boards,

U=0,150 W/(m²K) for cork plates and acoustic insl. boards

Roof

Considering the material properties according to [PW-INTERNET 2013] the resulting thermal resistances for every layer of the roof construction can be given:

nr	material	thickness d	density ρ	thermal conductivity λ	thermal resistance
		mm	kg/m³	W/(mK)	m²K/W
1	fire protection plasterboard	12,5	1400	0,250	0,0595
2	osb board	20	620	0,130	0,1538
3	cellulose insulation	240	50	0,038	6,3158
3	construction wood	240	450	0,130	1,8462
4	sellulose insulation	240	50	0,038	1,5789
4	purlins	240	450	0,130	0,4615
5	soft fibreboard	40	300	0,038	1,0526
6	trapezoidal purlins	40 to 100	345	0,500	0,3077 to 0,7692
6	ventilation		1,2	0,026	1,5385 to 3,8462
6	trapezoidal sheet	0,5	1050	0,130	0,000001042
				sum (insulation)	**8,7660**
				sum (incl. wooden construction)	**7,6972**

Table 40: **material dimensions of the roof**

Therefore, including the thermal resistances for inside and outside:

$$R_{si}=0,13\ m^2\ K/W \text{ and } R_{se}=0,04\ m^2K/W$$

the thermal transmittance of the roof at the insulation is:

$$U=0,112\ W/(m^2K)$$

and the average thermal transmittance is:

$$U=0,129\ W/(m^2K)$$

Solid Walls (East/West)

Considering the material properties according to [PW-INTERNET 2013] the resulting thermal resistances for every layer of the solid walls can be given:

nr	material	thickness d	density ρ	thermal conductivity λ	thermal resistance
		mm	kg/m³	W/(mK)	m²K/W
1	fire protection plasterboard	12,5	1400	0,250	0,0500
2	active pcm boards (incl. aluminum pipes)	25	110	0,039	0,0714
3	osb board	22	620	0,13	0,1692
4	cellulose insulation	280	65	0,040	5,5000
4	construction wood	280	460	0,130	1,6923
5	soft fibreboard	40	300	0,040	1,5789
6	ventilation layer	60	1,2	0,026	0,4615
6	lathing	30	520	0,13	0,2308
6	counter lathing	30	520	0,13	0,2308
7	weather boarding	20	460	0,13	0,1538
				sum (insulation)	**7,3696**
				sum (incl. wooden construction)	**5,1381**

Table 41: **material dimensions of the solid walls**

Therefore, considering:

$$R_{si}=0,13\ m^2\ K/W \text{ and } R_{se}=0,04\ m^2K/W$$

and neglecting the ventilation plus covering (because it has to be treated like being outside air; [WB-Buch, S. 161]), the thermal transmittance of the solid walls at the insulation is:

$$U=0,1175\ W/(m^2K)$$

and the average thermal transmittance is:

$$U=0,1840\ W/(m^2K)$$

Wall to Stairwell

The thermal resistance of the wall to the staircase can be calculated to:

nr	material	thickness d	density ρ	thermal conductivity λ	thermal resistance
		mm	kg/m³	W/(mK)	m²K/W
1	fire protection plasterboard	12,5	1400	0,250	0,050
2	soft fibreboard	20	140	0,042	0,526
3	cellulose insulation	280	65	0,040	7,000
3	construction wood	280	460	0,13	2,154
				sum (insulation)	**7,576**
				sum (incl. wooden construction)	**7,044**

Table 42: **material dimensions of the wall to the stairwell**

The calculated wall adjoints the existing wall of the staircase and on an unheated room. As the existing wall yet cannot be integrated in the calculation, considering

$$R_{si}=0,04\ m^2\ K/W \text{ and } R_{se}=0,04\ m^2K/W$$

the following U value can be calculated, at the insulation:

$$U=0,129\ W/(m^2K)$$

The average thermal transmittance is:

$$U=0,142\ W/(m^2K).$$

Glass Façade - Glazing

Summarizing the thermal resistance the results are [POMPE 2012, S.12; RECKNAGEL ET AL. 2011-12, S.188,190; WB-Buch, S. 163]:

nr	material	thickness	thermal conductivity	thermal resistance
		mm	W/(mK)	m²K/W
1	float glass	6	0,800	0,0075
2	argon	16	0,018	0,9029
3	float glass	4	0,800	0,0050
4	argon	16	0,018	0,9029
5	float glass	6	0,800	0,0075
6	air		0,260	0,1500
7	glass normal		0,800	0,0125
			sum (closed façade)	1,9884
			sum (open façade)	1,4286

Table 43: **material dimensions of the glazing**

Therefore, considering:

$$R_{si}=0,13\ m^2\ K/W \text{ and } R_{se}=0,04\ m^2K/W$$

the thermal transmittance of the glazing, in case of closed PV-Modules is:

$$U=0,4633\ W/(m^2K)$$

With open PV-Modules the given U-value of the glazing by the manufacturer is U=0,7 W/(m²K) and of the entire glass façade, incl. aluminum frame, U=1,1 W/(m²K).

TEMPERATURE SIMULATION

The following figures show the simulated temperatur profiles inside the layers of all construction components. Thereby, the profiles of the same component vary in the location of interest. For the simulation an exterior temperature of -10°C, an interior temperature of 20°C and an air humidity of 50% inside and 80% outside are assumpted. Figure 199 to Figure 203 show the temperature profiles inside the floor, roof, solid walls and of the wall to the staircase.

Temperature Inside Floor Layers

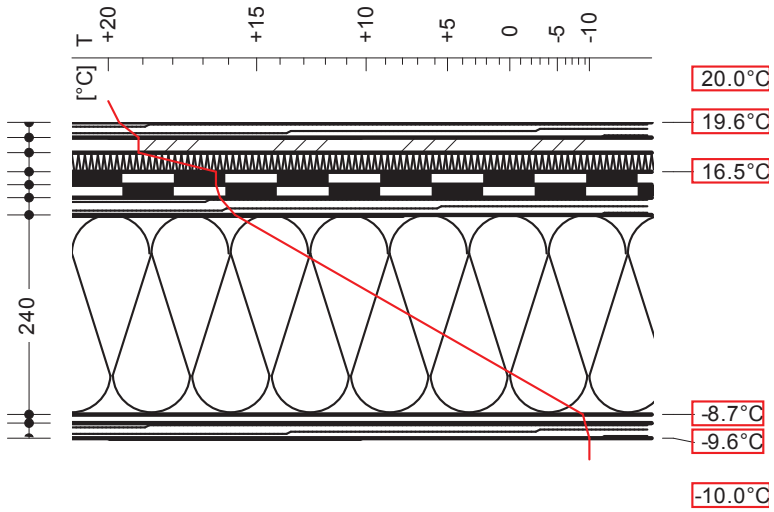


Figure 199: **temperature inside the layers of the floor at insulation**

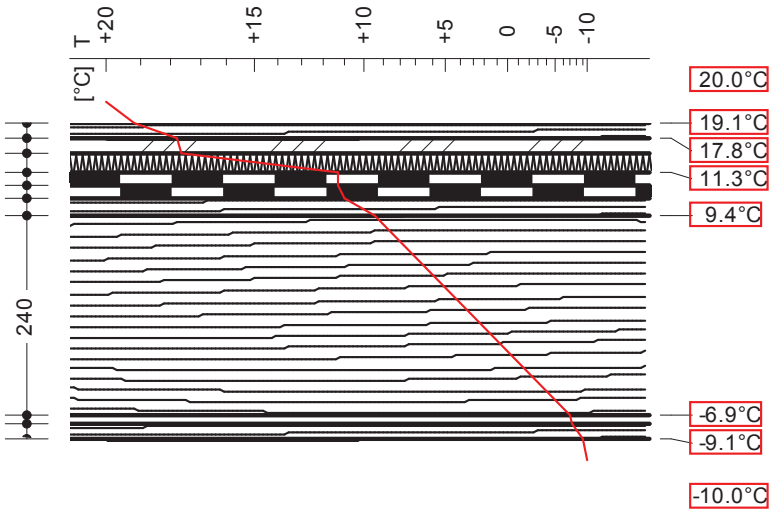


Figure 200: **temperature inside the layers of the floor at wooden beams**

Temperature Inside Roof Layers

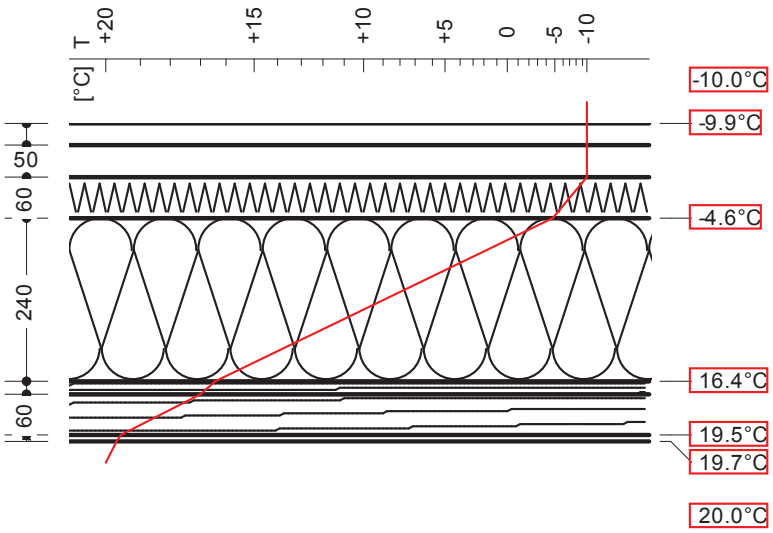


Figure 201: **temperature inside the layers of the roof at insulation**

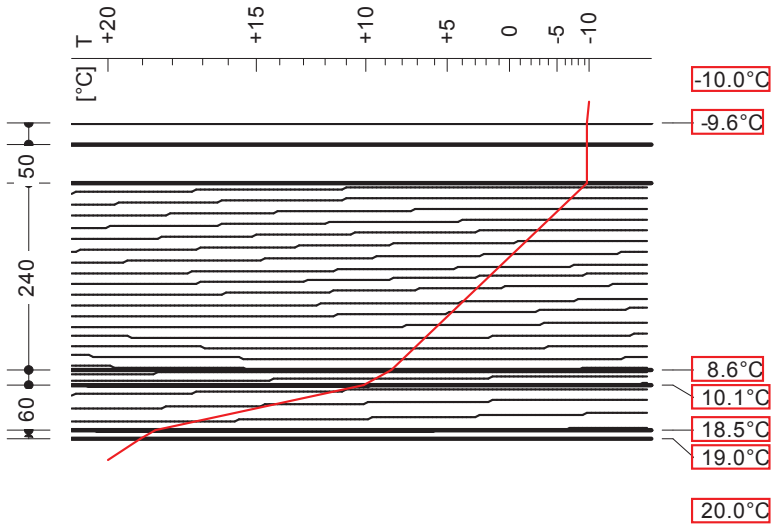


Figure 202: **temperature inside the layers of the roof at wooden beams**

As in the calculation of the thermal transmittance, the ventilated layers of the roof and the solid walls are not considered into the temperature profiles, because these can be assumed equal to the surrounding air.

Temperature Inside Layers of Solid Walls

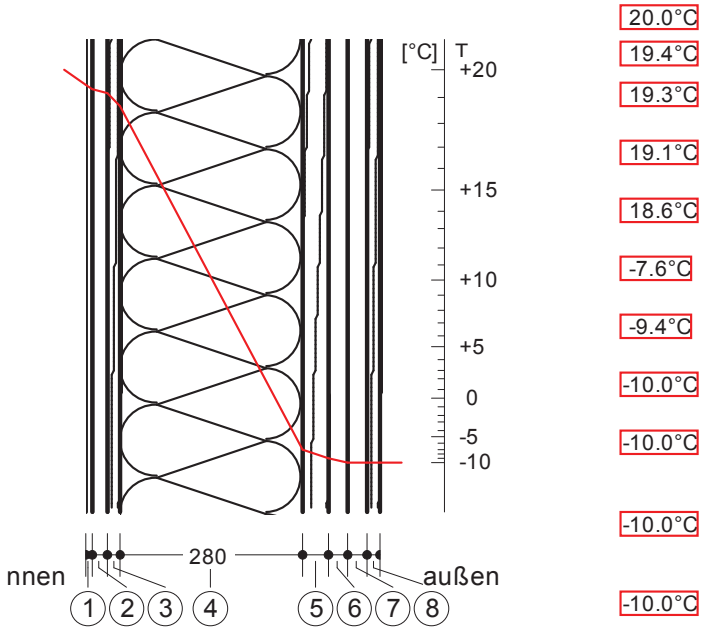


Figure 203: **temperature inside the layers of the solid walls at insulation**

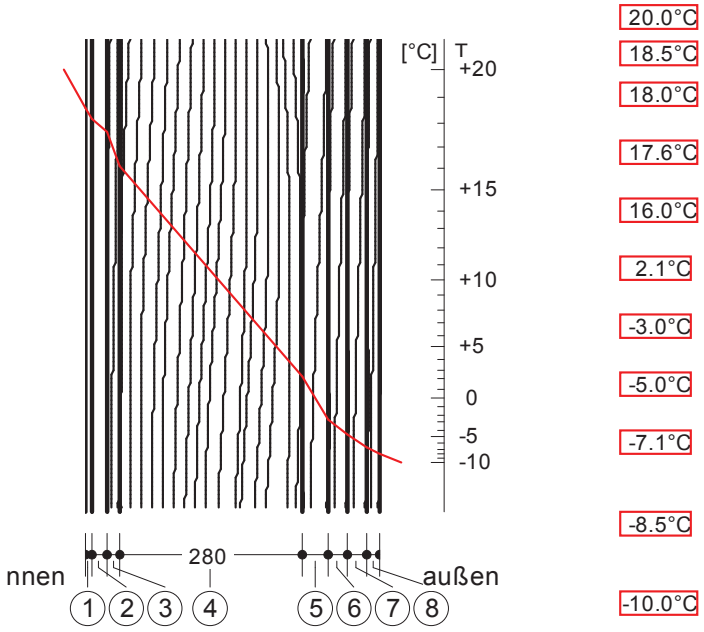


Figure 204: **temperature inside the layers of the solid walls at wooden beams**

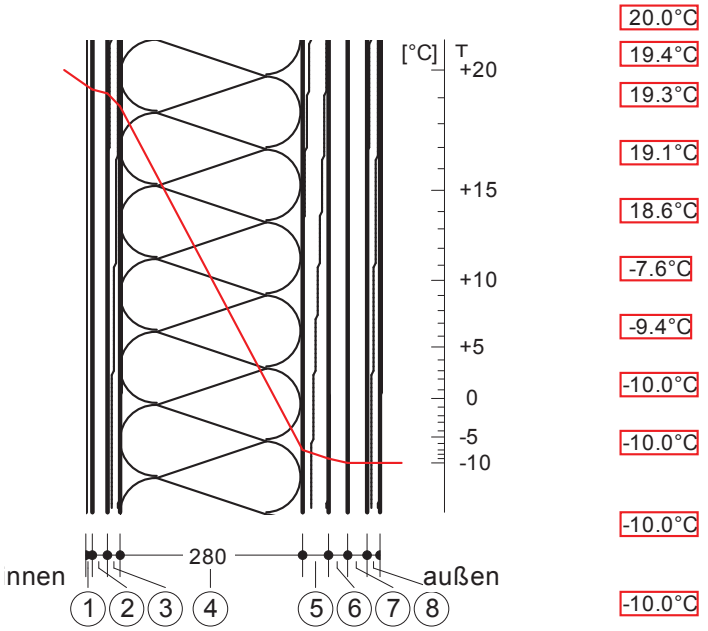


Figure 205: **temperature inside the layers of the wall to the staircase at insulation**

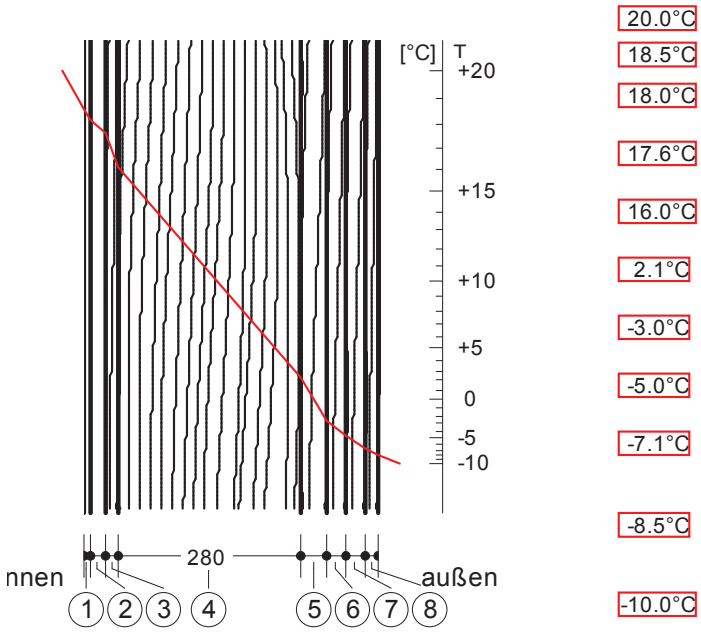


Figure 206: **temperature inside the layers of the wall to the staircase at wooden beams**

Conclusion

The temperature profiles, simulated according to DIN 4108 using static conditions of a worst case scenario, show, that the greatest amount of temperature loss is created inside the insulation layers. To draw conclusions to the creation of condensate further simulations are needed (see section humidity simulation).

HUMIDITY SIMULATION

In Germany two calculations are required by law. First is a static calculation assuming a worst case scenario according to DIN 4108-3. Second is a dynamic calculation accoding to DIN EN 15026.

The following figures show the simulated humidity profiles inside the layers of all construction components in accordance with DIN EN 15026. The exterior temperature of -10°C, the interior temperature of 20°C and the air humidity of 50% inside and 80% outside are assumed for the simulation of humidity.

Figure 207 to Figure 209 show the profiles of the three different floor layers. Figure 210 shows the profile of the solid walls, Figure 212 shows the profiles of the wall to the staircase and Figure 212 the profile of the roof.

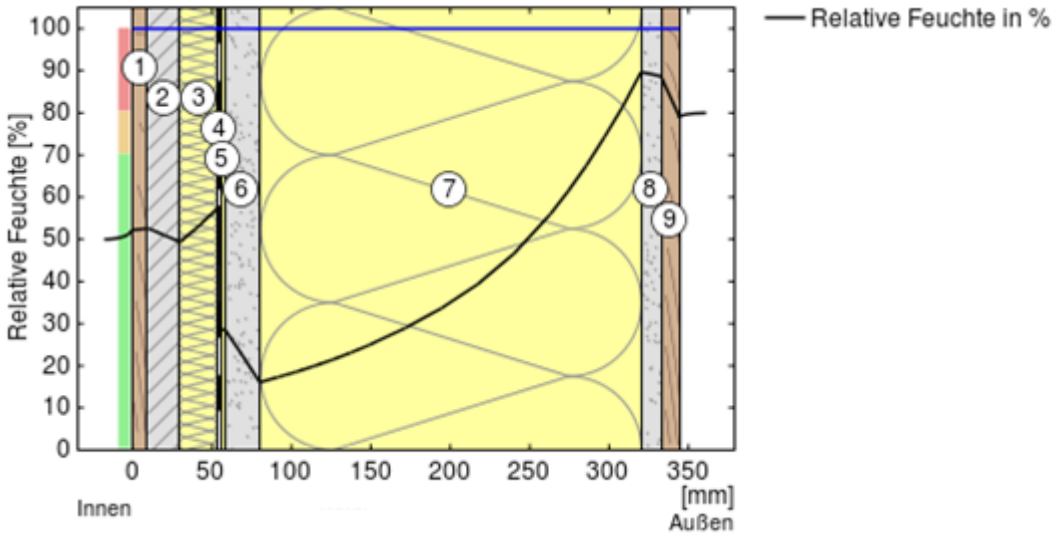


Figure 207: **humidity characteristics inside the layers of the floor with floor boards**

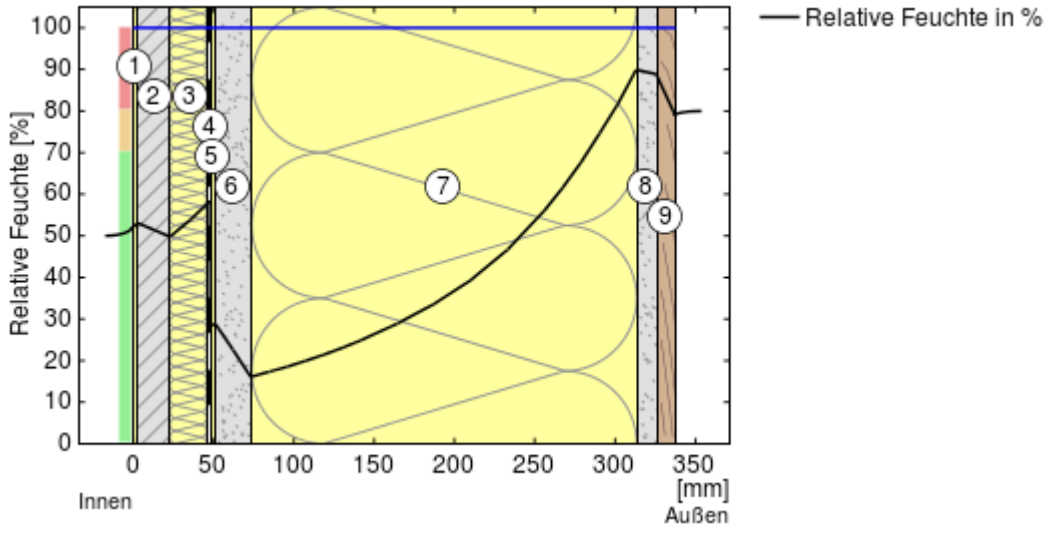


Figure 208: **humidity characteristics inside the layers of the floor with corcboards**

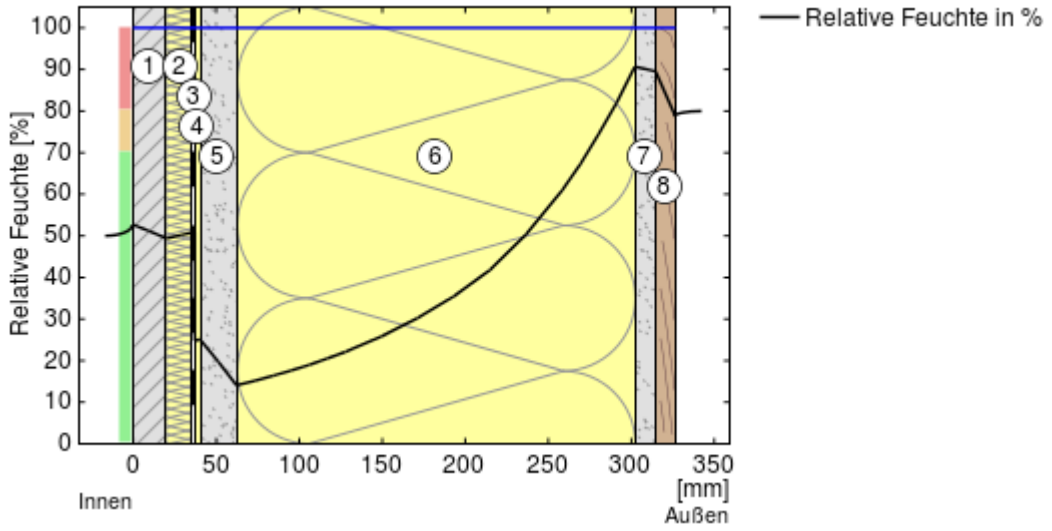


Figure 209: **humidity characteristics inside the layers of the floor with acoustic insulation board**

All types of the floor can be assessed to not create humidity inside the layers at the worst case scenario according to DIN 4108-3.

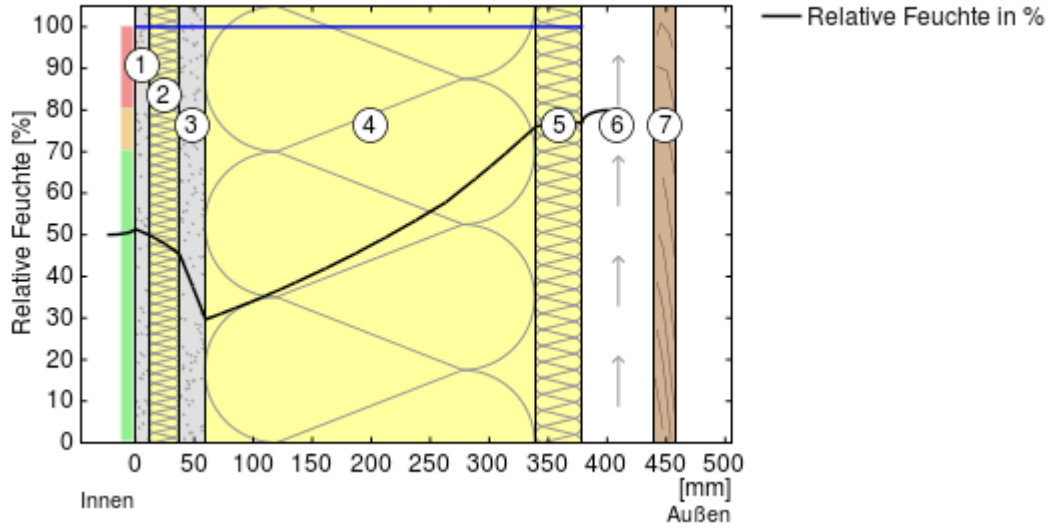


Figure 210: **humidity characteristics inside the layers of the solid walls**

As (see Figure 210)the above figure shows, no humidity is occuring inside the solid walls. Therefore, the ventilation layer fullfills its intended tasks.

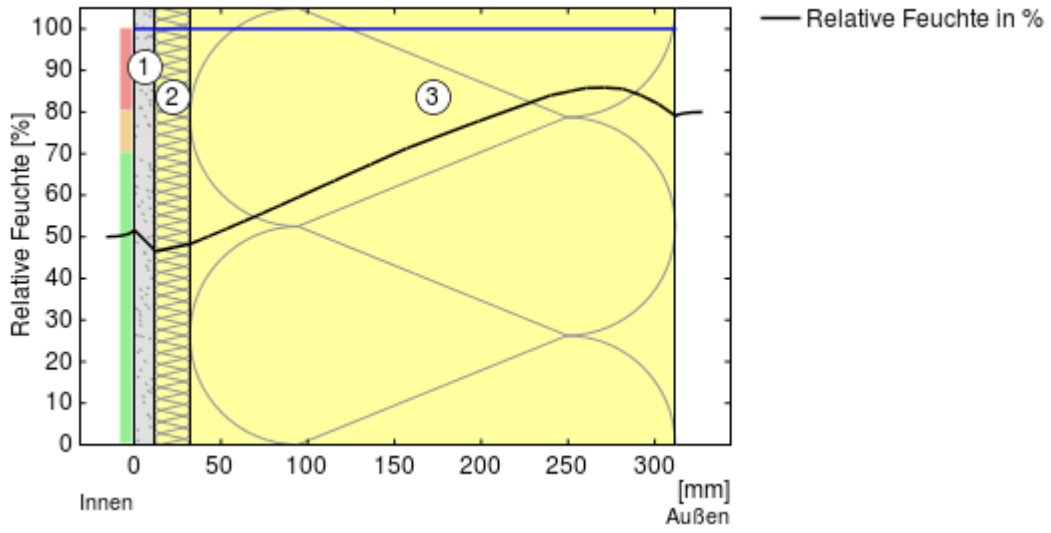


Figure 211: **humidity characteristics inside the layers of the wall to stairwell**

Above it can also be seen, that no condensation is inside any layer.

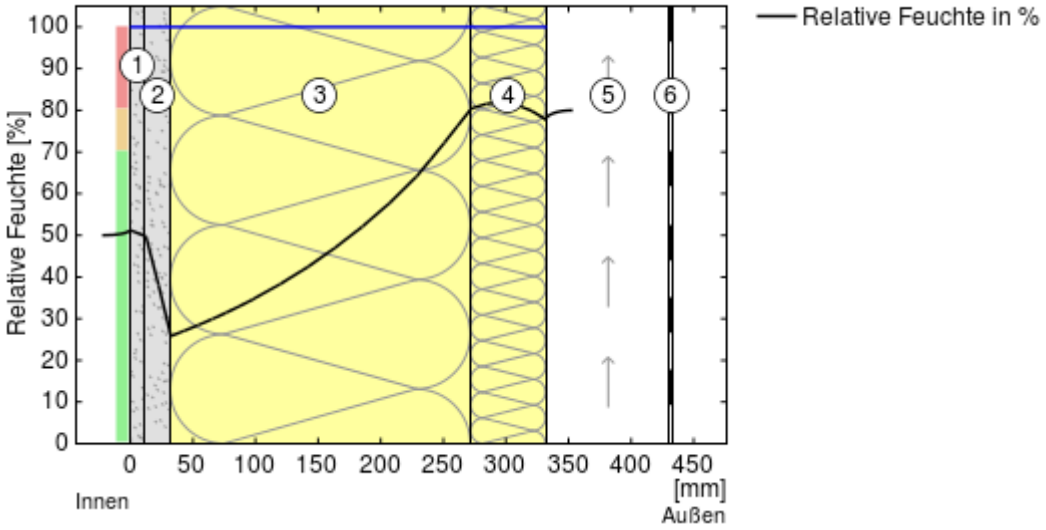


Figure 212: **humidity characteristics inside the layers of the roof**

Also inside the roof, no condensation is occuring. However, humidity transported via the ventilation layer needs three days to be transported again out of the upperst layers [u-wert.net].

All figures show, that under the assumed conditions in accordance with DIN 4108-3 the risk of condensation inside the buliding can be excluded. Because of this a mould formation should not be expected.

However, as consideration of these fixed conditions do not show the timely changes of the specific humidity of the components, additional factors have to be considered. Therefore, a simulation over a period of two years according to DIN EN 15026, considering changing weather conditions like temperature, ouside humid-

ity, rain and solar radiation, have to be made. The results are as follows:

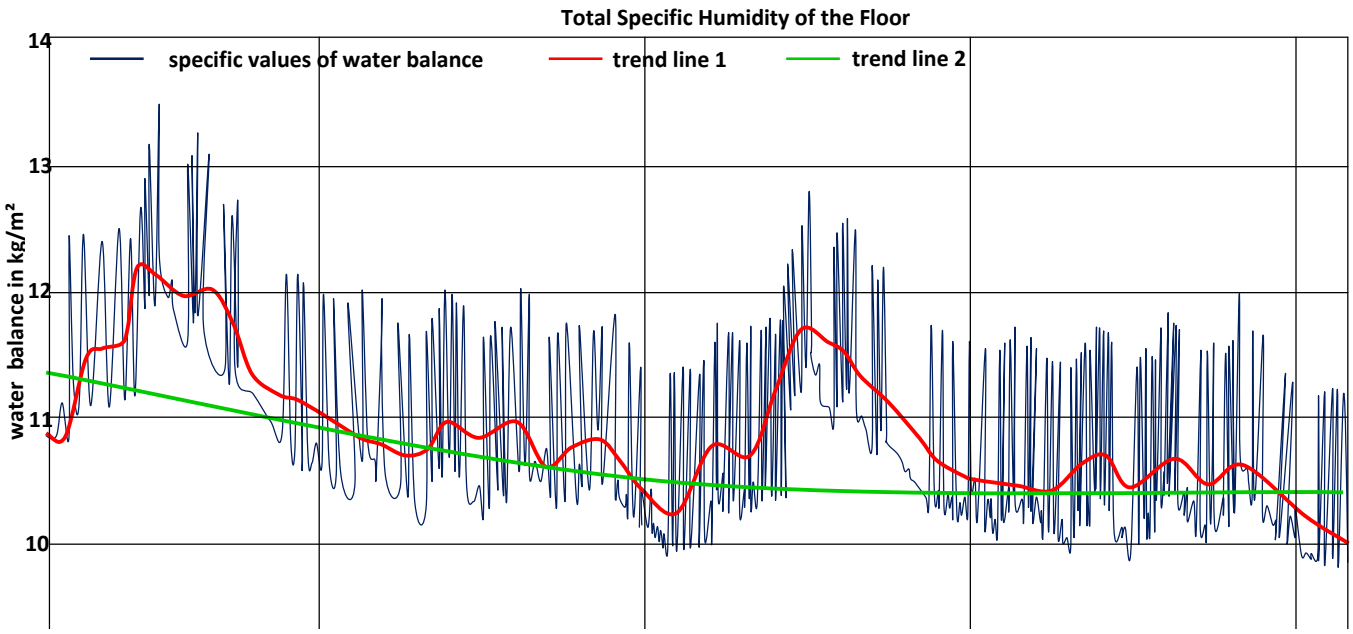


Figure 213: **total specific humidity of the floor, created using IBP WUFI 5.3 software**

Figure 213 shows that the floor components as planned will absorb and releases moisture in accordance with the humitiy changes in the sourrounding air. Summarizing, the trend lines 1 and 2 show, that the total specific humidity of the floor components will release more moisture than the amount absorbed. This leads to the conclusion, that all absorbed humidity can be released and no additional condensatiion is created inside the components.

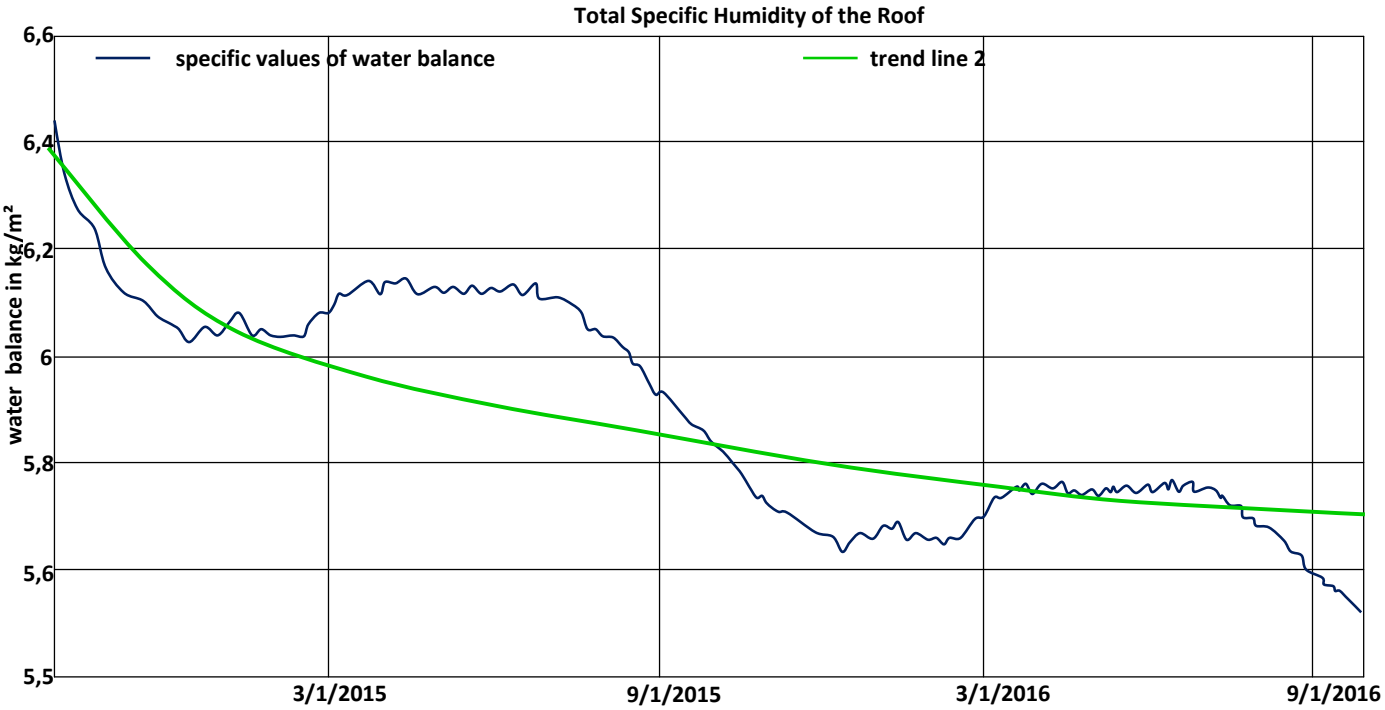


Figure 214: **total specific humidity of the roof, created using IBP WUFI 5.3 software**

Similar to the floor, the humidity absorbed into the roof can be released. This is shown in (see Figure 214) Figure 214 by the green trend line.

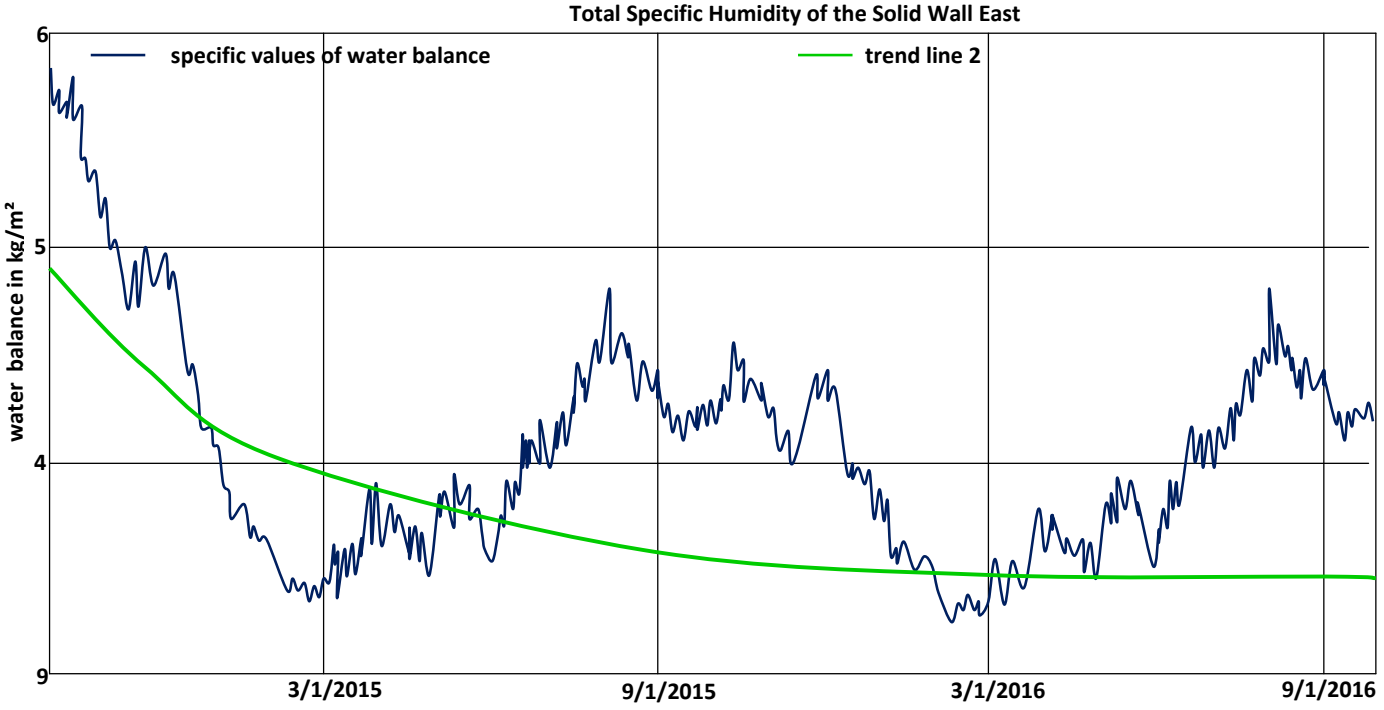


Figure 215: **total specific humidity of the solid wall on the east side, created using IBP WUFI 5.3 software**

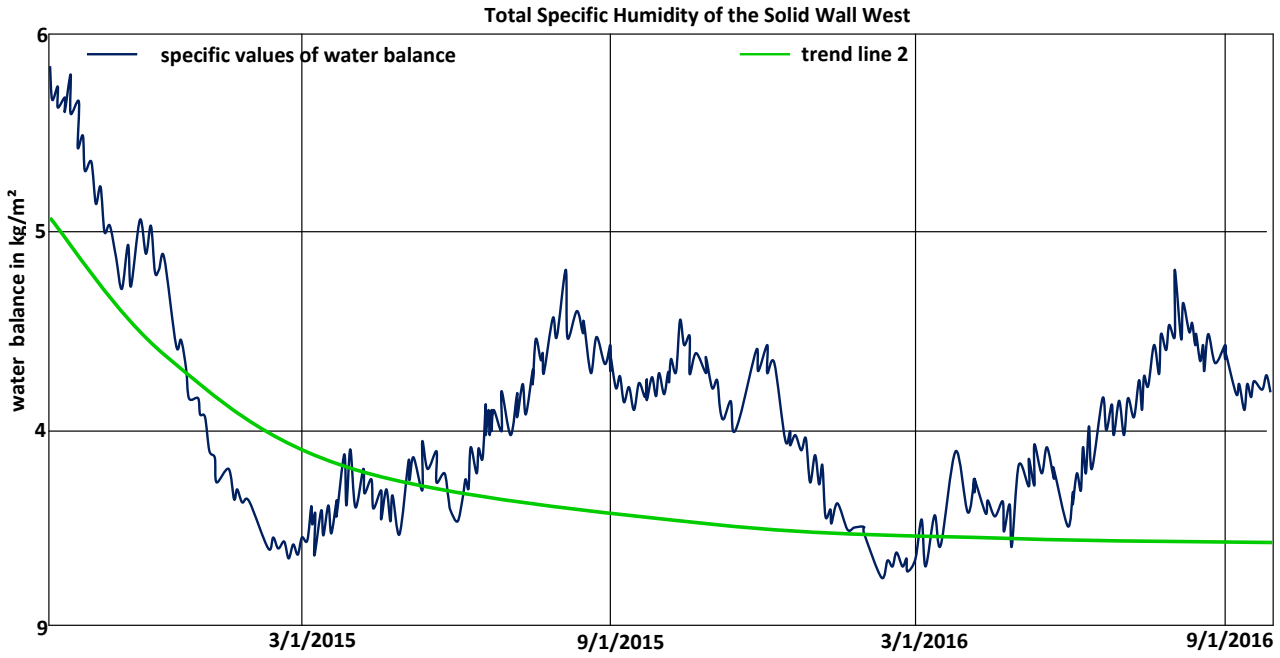


Figure 216: **total specific humidity of the solid wall on the west side, created using IBP WUFI 5.3 software**

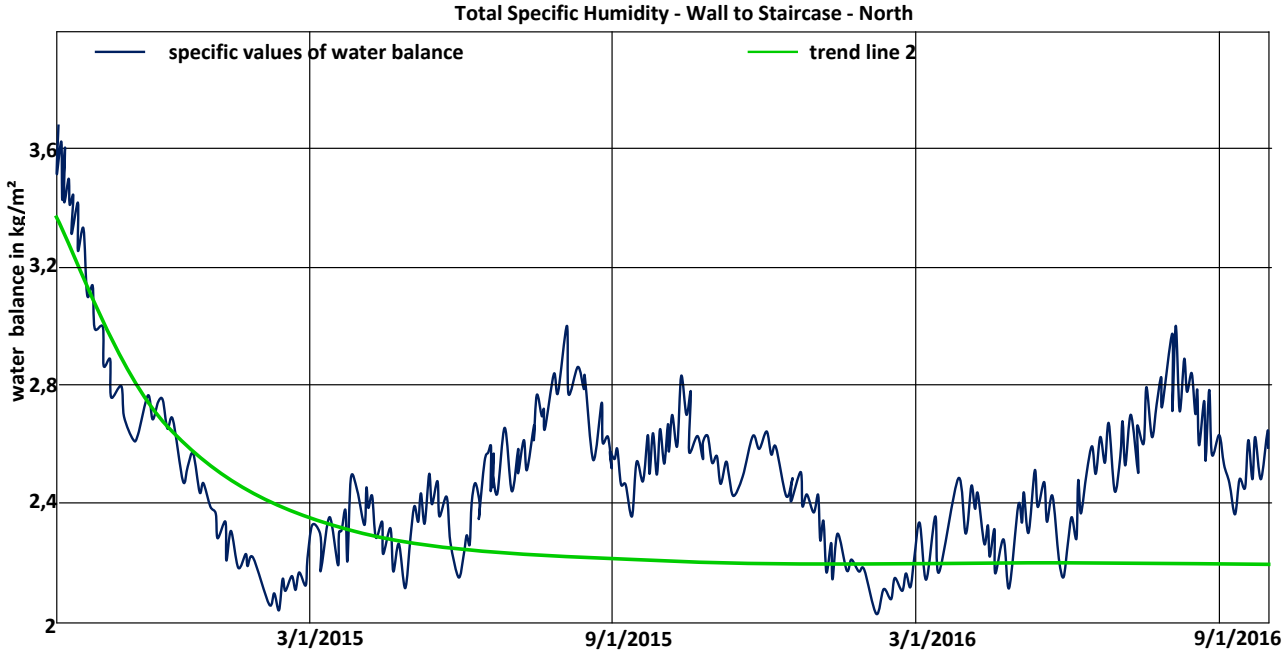


Figure 217: **total specific humidity of the solid wall on the west side, created using IBP WUFI 5.3 software**

Finally, the solid walls to the east and west side and the wall to the staircase also show no occurance of an appreciable amount of condensation. Also, there is a general trend of releasing more humidity than absorbing.

Heating Energy

If used as carrying structure, wood offers the advantage of being of a low thermal conductivity. The demand of insulating material can be decreased compared to steel or reinforced concrete constructions. [Rohstoff-Holz]

The wooden construction as well as the glass façade are designed to surpass German Passive House Standards. In concrete terms there are requirements especially for the thermal transmittance of components of the thermal envelope for new constructions. [EnEV2009, p.7]

component	EnEV 2014	house of Team Rooftop
	thermal transmittance U in W/(m²K)	thermal transmittance U in W/(m²K)
floor	0,35	0,134 or 0,135
roof	0,20	0,112
solid wall	0,28	0,145
wall to staircase	0,35	0,129
glazing	1,30	0,7 (glazing), 1,1 (total)

Table 44: **thermal transmittance of all components of the thermal envelope**

The maximum limit for the energy transmittance of windows is given by g=0,60 [EnEV200), p.33]. In comparison to that the g-value of the Rooftop Building is calculated with 0,26, so the requirements are easily reached.

Table 12 proves the fulfiled passive standards as also required to Rule 17 contest 13: Energy Efficiency of the Solar Decathlon, [sde2014-rules-v.2.1, p.42]. For a passive house u-values have to be less than 0,15 W/m2K to reach the demands of the thermal insulation of the building envelope, [Müller2007, p.15].

Meeting these standards minimizes the heating demand and creates optimal conditions for a self-sufficient building.

The use of large windows creates great comfort. Not only does the large amount of daylight reduce the lightening costs, the radiation energy is able to heat up the building additionally in winter.

COOLING ENERGY

The ventilation concept for roof and solid walls decreases the demand of an additional cooling. Flowing air streams inside the ventilation layers prevent the inner layers from heating up to high summer temperatures. The air streams transport most of the heat caused by sun radiation to the outside. The residual heat is stored inside the wood fibre insulation and is released, supported by the ventilation, during the night time before reaching the inside of the building.

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5.5. INNOVATION REPORT

Nowadays it seems difficult to innovate in a strictly regulated environment like the construction industry — yet is there a better place to rethink the world than the technology sector? There is no redundancy for failures and there is a dire need for new solutions that answer today's and not fifty-year-old questions. Whilst taking into account safety, regulation and reliability issues, we humbly look for new solutions or adaptions to existing ones.

5.5.1 INNOVATION IN ARCHITECTURE

Concept

We are looking for a smart, efficient and quick way to construct, deconstruct and reconstruct our house. Structural elements play a crucial role because without them the house simply would not stand. We have come up with a system that will allow us to meet the requirements above – A Penthouse as a solution to the city restoration and to create new living space. The old building from prewar times gets a new energy-efficient roof restoration and a new future oriented living space is created on the roof. The city gets a new roofscape design. A new layer of energy efficient houses on top of the old city, interacting with it, giving and receiving in a symbiotic relationship. The space on the roof top will be used by our building features to exploit the free energy contributions of the sun and of the outside air.



Figure 218: **rendering: exterior view from the inner courtyard**

Using the limitations of the surroundings to create a new living experience

The limitations of the competition, in acoordance with the existing walls and boundaries on the Berlin Altbau roof, have given rise to the idea of intelligent space division rather than to achieve a maximum thermally enveloped area. The simple, oblong shape of the Rooftop House clearly divides and defines the given space, creating graspable, controllable and clear spaces. The volume acts as a hub, a connector of exterior zones, and through its function zones it gives purpose to the different terraces. The smart connection of inside and outside and a new, innovative way of defining one's private space are prominent themes in the Rooftop House. By reducing the thermally controlled space and extending the perception of living space through the surrounding walls, the energy demands of the housing unit are reduced. Instead of adding large amounts of interior space, in the transition periods the resident can use the entire roofspace. He/she just needs to dress accordingly and can retreat to the comfort of the interior once weather conditions get too uncomfortable – a true interaction with nature.

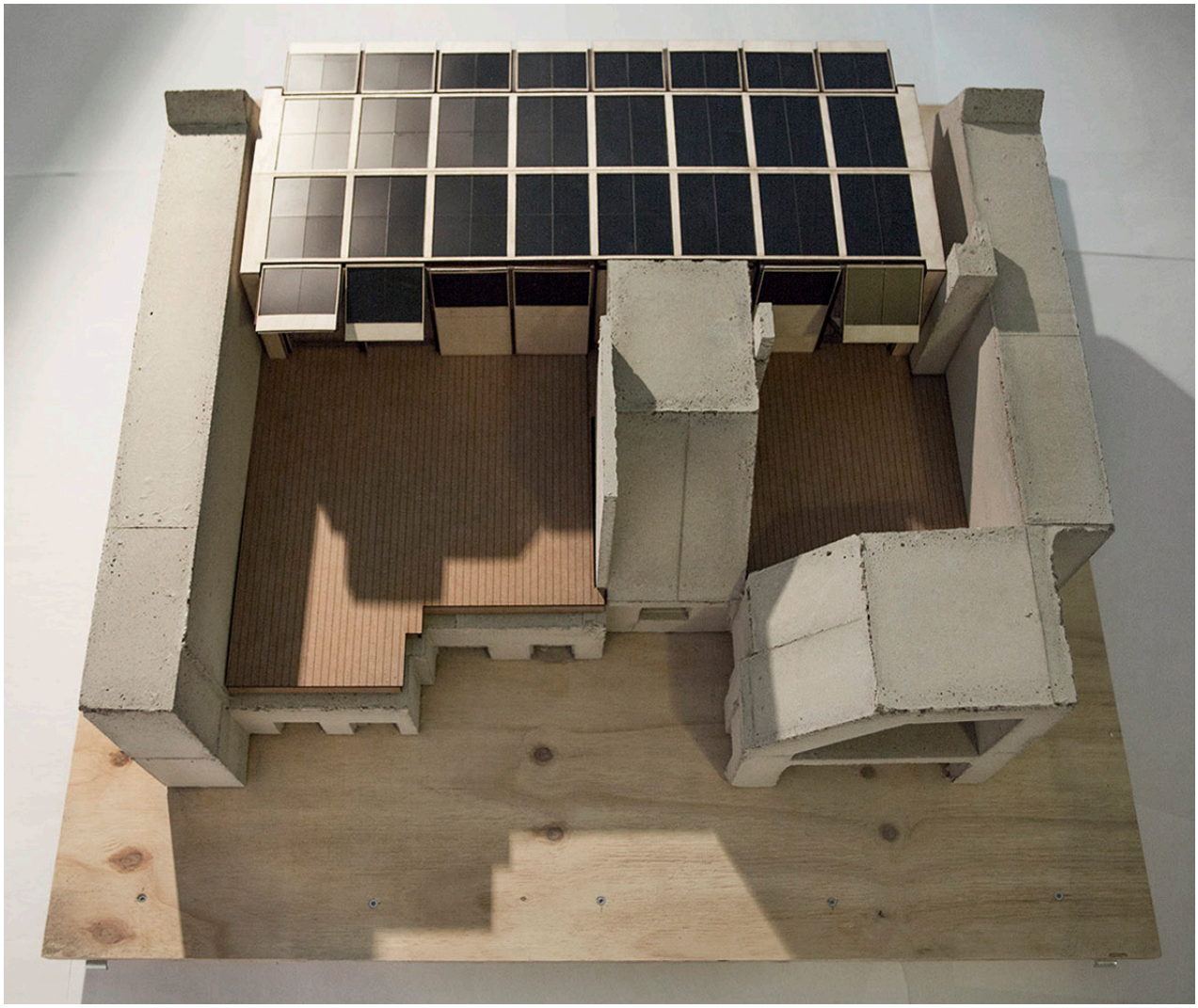


Figure 219: **Photo of model: terraces formed through placement of volume**

Altbau reimagined – the adaption of elements

> *"Die Berliner schätzen ihr Kastenfenster" – "the Berliner appreciates his box-type window"*

This statement is now more true than ever, as a wave of retro-enthusiam sweeps through the city along with hosts of young academics, seeking the nostalgic pre-reunification charm and Altbau living experience.

We, as native Berliners, seek not to render obsolete the elements that this experience is comprised of, but instead to borrow them, to merge them into new designs and innovative concepts.



Figure 220: **Berlin box-style window**



Figure 221: **typical Berlin floor board**

Our double layered façade is a reminder to the classical, Berlin-born idea of the "Kastenfenster": the box-type window, where an air gap between two window frames in the wall opening would significantly increase the insulation of the openings. Somebody familiar with the Berlin Altbau apartments will be quickly reminded of this mechanism as he or she opens the sliding door while the façade element folds up to extend the ceiling. In fact, the classical element has been adapted to serve more sophisticated energetic purposes than 100 years ago, but still it does its part in anchoring the Rooftop Unit's design to the city it was born in.

Another example of such an appropriation is the wooden floor. The boards are a homage to the classical Berlin Altbau floor finish. At the same time, they serve an energetic purpose – through their multilayered structure they distribute well and evenly the heat coming from the floor heating system below – and act as an architectural element. They connect inside and outside space, let the lines flow through the boundaries of house and terrace, throw the attention of the observer out over the skyline into the distance and generally provide a sense of direction and interdependency of spaces.

Spatial concept

True luxuries in a modern city are space, air and nature. Surely, these can be attained in public parks, of which Berlin has an abundance. But to experience these commodities in your own home, your private space, is almost impossible in this city where around the beginning of the last century 75 people lived in a single building (in Paris there were 38 residents per house at that time). The wide space on the roof, the air surrounding you, the feeling of freedom, a calm atmosphere creating time for relaxation: The Rooftop House provides all of that while keeping a style of minimalism, yet comfort. Minimalist luxury is what the Rooftop House is about. It lets you experience all the luxuries of space, but is ecological and energy-efficient at the same time. The Core Module has a high density of functions and it forces the inhabitants to deal with the limitations of space, while the free floating space around it is vast.

This minimalistic approach is an innovative statement. There can be no ecological and responsible lifestyle with a big swimming pool and other things - besides spacial freedom - that are generally perceived as luxury in our society. The Rooftop House is a home for a single person or for a couple of young to middle aged people looking for all the benefits of life in the city, while also being mindful of ecological values and their responsibility towards society and the planet. Basically, the Rooftop House is comprised of three layers. There is the Core Module in the middle, that unites all the important life functions of the house in its inside. On the inside of the Core Module is the bathroom, as well as the technical room and storage space as well as all appliances. It is connected to the living space by doors towards the long glass façades. On the eastern side of the module we also find the kitchen, hidden under a sliding panel. Then there is the outer hull with the glass walls and the folding façade. Between the Core Module and the hull there is the inside living space of the house. It is one single free floating space divided into distinguishable spaces only by the Core Module. This configuration creates a big living space to the east and a smaller private space to the west. On the right and left hand side of the module two hallways connect the rooms. Then there are the outside spaces. The roof of the house is divided by the Rooftop House's volume into several terraces, each one unique in its appearance and feeling. To the south side of the house, a long terrace, parallel to the building's façade, extends the interior living space like a large balcony.

On the northern side of the Rooftop House, two exterior spaces extend, each one very different from the other. Connected to the living space the larger, more open terrace with its roof garden reed bed invites to a relaxing summertime party or can be just a comfortable extension of the living space, halfway sheltered from the sun. Hidden from the curious visitor and aligned with the private space, a very sheltered, smaller terrace is formed, enclosed on all sides by solid brick walls of the adjacent buildings. Here one is undisturbed, at peace.

The outside and the inside of the house have the same wooden flooring, which extends the free floating space on the inside of the house to the outside. The wooden flooring is never cold and always comfortable to walk on. In the sun it does not get too hot so you can always sit and walk barefooted on it comfortably. The terraces provide space for parties and events like dinners and barbecues on the roof. The garden terrace is a relaxing oasis on the Rooftop in the middle of the city. Herbs and crops can be planted to be used for cooking. The mood of the interior is dominated by minimalistic clarity and purity, while also being comfortable and cozy. Outside and inside materials flow into one another, create holistic harmony and the breaking the barriers between in and out that is so central to our design.

The living room features low seating, which extends the space visually. There is an emphasis on the horizon-

tal line which gives the impression of wideness and openness of the room. There are horizontal accents such as low tables and seats. All furniture can be stacked and stored on the Core Module wall. Folding chairs are stored inside the module and can be taken out and used whenever needed. The kitchen is just around the corner on the side of the module.



Figure 222: **rendering: interior view**

The kitchen is very compact and practical. All the appliances fit snugly in the limited space. The entire kitchen can be hidden behind a moving panel. Once closed, the kitchen becomes invisible. There is, however, more than enough space for cooking. The herbs and vegetables grown in the garden in the small "backyard" can be used for cooking. Growing your own herbs gives you a closer connection to nature and the changing seasons. The glass façade behind the kitchen can be opened in summer to allow cooking events with your friends and a direct connection to the long terrace in front of the house. The cooking fumes are sucked away by the ventilation system and blown out through the roof. From the bedroom you have access to a number of closets and storage space in the module. The bedroom sports a king size bed that can be used by a single person or by a couple. This foldable bed is also low, creating openness. There is no TV in the bedroom, since the bedroom is supposed to be a relaxing environment without media distraction. The bathroom is the only habitable room inside the Core Module. It is small and minimalistic, providing all necessary comfort and high quality fixtures while being mindful of saving water. The cork surface is soft and a bit rough to the touch, contrasting the white ceramic fixtures. Warm light inside the bathroom creates a cozy feeling. The two southern doors of the bathroom can be opened even while bathing in the tub and allow you to enjoy your bath with a magnificent view over the Berlin Rooftops. Even in winter, the doors are airtight and insulate the inside of the house while allowing the cold winter air to flow into the bathroom where you lie in your steaming hot tub.

Functional concept

The Rooftop House is not only a house on top of a house. It uses existing space and infrastructure and serves to increase the urban density. With its minimalist exterior, it does not disturb the overall picture of the city.

The concept does not aim to radically change the city, instead it wants to make it better without changing its individual charm. The Rooftop House produces huge amounts of energy while using very little energy for itself, which makes it a surplus energy producing housing unit. It gives energy to the house it is built on and to the city. Of course it also is a flagship project sporting the newest technologies and ideas that will inspire architects and engineers to develop similar projects. On the scale of the house itself, nearly all the functional elements are centred in the Core Module in the middle of the House. It has all the technical elements, like the battery, the heart of the heating, cooling and ventilation system, as well as an interface that allows the inhabitant to control all the functions of the house, like the folding façade elements, the blinds and the lighting. Furthermore, the inhabitant can control the energy consumption and energy production of the house as well as getting information on the weather that will affect the houses functions. The Core Module also contains the kitchen, the bathroom as well as a lot of storage space. Around the module there is the free floating space that dominates the spatial concept.

Lighting

The folding façade elements provide shade when opened during daytime. There are hanging curtains that allow indirect lighting during the day. This creates a sheltered, diffuse atmosphere inside the house. In the sun radiation peaks around midday the house can close itself off against the sun on the southern side, the open northern façade and the cold, shaded spaces on the terraces together with the inside the house form a sheltered space. The combination of many shading elements guarantees optimal lighting. Sunlight can be used to save electricity, and the amount of sunlight that is allowed to enter the house can be regulated easily by the inhabitants. In the night and on cloudy days, there is artificial lighting. Hidden away inside the wood of the Core Module and the PCM ceiling are lamps creating a soft light. Apart from that, there are individual lamps and spots in the whole house where they are needed. The inhabitant has the possibility of regulating all the lights as he pleases, using the classical and time proven light switch installations on the Core Module, but he will receive a warning if the energy consumption is unnecessarily high.

New languages

The Rooftop House creates an image of a minimalistic and modest house. It is technologically advanced without having to stress this aspect. The interior of the house is comfortable without being unnecessarily luxurious. The materials used in the house are mainly natural materials like wood and cork. The wooden flooring is reminiscent of the removed attic of the house the Rooftop Unit is built on. Those materials have a warm and comfortable feeling to them and show a clear connection to nature. The surfaces are honest, they show what the material really is without covering it up. Also the cork in the bathroom is rather rough and shows its natural structure. All solid surfaces are warm to the touch. The influence of nature is stressed by the garden on the back of the house and the feeling of living on the roof, closer to the sky. The natural inside seemlessly flows into the more technically designed exterior of the house with the folding façade elements and the PV modules. The use of natural materials and recycled materials like the old wooden flooring are picked up by the façade elements through use of wood as a structural element. The strong presence of natural light due to the enormous glass façade invites another element of nature into the house. By using the gifts of nature in a good way, a lot of energy can be saved. The sun as an element of nature that is used

by technology brings together the entirety of the elements of the house. The house unites the old and the new; old materials and new technology. It shows that the old and the new can go well together, depend on each other and influence each other. New technological developments will be more easily accepted if they do not look and feel too strange. There is no need to change everything to live a sustainable life.



Figure 223: **rendering: exterior view from street-side**

Ventilation

A building equipped with central ventilation usually needs a lot of space to be reserved for pipes, ventilation openings and for the central ventilation unit. The innovation of our ventilation concept is the complete integration of the ventilation into the Core Module and the resulting minimization of the piping. By this integration, we were able to minimize the visible parts of the system to slots in the walls of the Core Module. In the living room and in the bedroom the slots will go along the wall creating a cosmetic effect. We want them to integrate into the room style. Therefore, we will just use 1200 mm of the slots as relevant ventilation parts. These slots will have a height of 15 mm and will be located 100 mm below the lowest point of the ceiling. In the bathroom is a similar system for the exhaust air. The fans are connected to CO_2 and humidity sensors, so there will always be a good air quality supported by the lowest possible power consumption. The electric power consumption of the fans will be under 60 W for the complete ventilation system, including a fan needed by the heat pump. In winter, heating energy is saved as there is a heat recovery factor of up to 90%. In summer there are additional windows that can be opened to relieve the fans. The three fans for the

bathroom, the kitchen and the technical room in our old concept were also replaced by the central fans. Concerning the data of CO_2 and humidity, the regulating system will adjust the air flow. Therefore, we expect reduced power consumption.

5.5.2 INNOVATION IN ENGINEERING AND CONSTRUCTION

"A pile of rocks ceases to be a rock pile when somebody contemplates it with the idea of a cathedral in mind."

Merci à Antoine de Saint-Exupery[1]

If you think we will break through the solar envelope now: sorry, you're in for a disappointment. We have smaller things in mind than a cathedral — and we don't want to travel to the desert on our own either. However, maybe building a house is the first step to building a cathedral. Why not start rethinking rusty strategies here? There are four areas of our house where we might have done just that.

MODULARITY & CONNECTIONS

Let us start with the engineering department that sometimes seems old-fashioned or at least conservative. Structural and constructive engineers have to make sure their work does not fail. Ever. Still, we try to put things together a little differently.

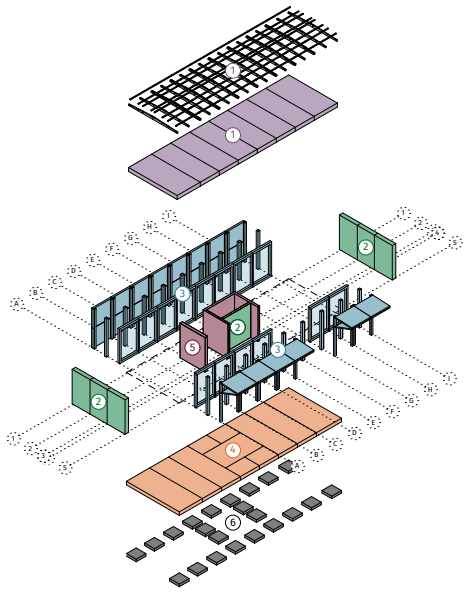


Figure 224: **The Core Module**

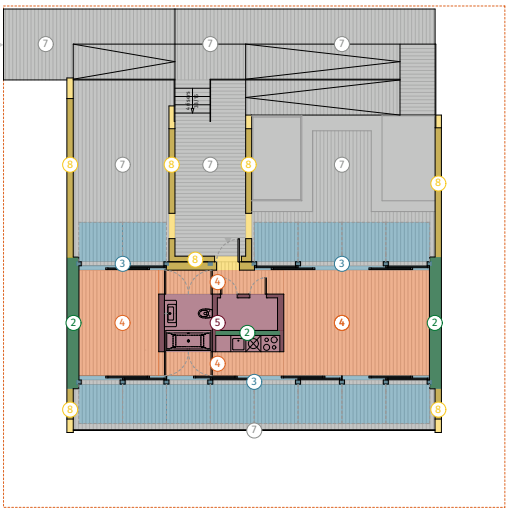


Figure 225: **The Core Module**

1 http://www.consilium.europa.eu/uedocs/NewsWord/en/ec/138963.doc (27.02.2014)



Figure 226: **The modular housing of the future? We don't think so.**



Figure 227: **The modular housing of the past: Plattenbau in East Germany.**

A huge challenge when building a house is that, unlike machinery, it cannot be simply be fabricated in a factory but is constructed where it will stand for most of its lifetime: the open, prey to the weather conditions. This results not only in deterioration during the lifecycle (as with all goods) but means that small weather changes during the construction phase can cause huge challenges for the engineers and builders.

We aim to avoid these challenges using a system of modular elements, as detailed in section 12, Construction Specifications. First example: the core module will be designed as an integral closed part that can be transported apart from others so that it would fit in any house similar to the Rooftop House. All basic living functions for its users are concentrated here: kitchen, technical appliances and building technology. Of course: to include all essential functions of a house in a module we would have to make the entire house a module. That indeed wouldn't be that innovative: moving truck-houses in the U.S., a past winner of the Solar Decathlon[2], ... The problem with this approach is that it results in an architecture close to those perfectly modular containers they use in shipping[3]. Our middle way wants to eliminate timely installations on site and still result in attractive housing that is unique, but flexible. No one wants to live in the same house as everyone else, or indeed if you want check out the Berliner Plattenbau[4], courtesy of the German Democratic Republic.

2 http://www.solar.arch.vt.edu/index2.html (27.02.2014)
3 http://4.bp.blogspot.com/_C-zXzp9Odak/TG1ui-iRhVI/AAAAAAAADME/00ZzJUbP6r4/s1600/shipping+container+Costa+Rica.jpg (27.02.2014). We admit there are some nice projects using shipping containers as housing, see for example http://bigboomblog.com/shipping-container-homes (27.02.2014). However that is not exactly modular architecture with pipes connecting in all the right places and a light and sustainable thermal envelope, but industrial products reused and refurbished in an interesting way.
4 http://upload.wikimedia.org/wikipedia/commons/7/7f/Plattenbau_WBS_70_in_Chemnitz.jpg (27.02.2014) We would be happy to build our Rooftop House on top of a DDR Plattenbau or Paris Banlieue Maison à panneaux or London precast concrete slabs.



Figure 228: **steel Top-UV or 'Schwalbenschwanz'-Connection**



Figure 229: **Wooden terrace connections, wooden Schwalbenschwanz.**

We have adapted space- and time-saving connection methods that decrease the need for material and waste. One perfect example for this is the connection of our terrace modules. Wood constructions often perfectly hide the many tons of steel used inside to connect them. Our ancestors had better ideas, borne out of necessity: using wooden connections (see Figure 229)[5]. Unfortunately we cannot revert to this method everywhere and still have to use steel connections to build more critical parts of our house. They can be innovative, too — particularly with regard to the construction process. To quickly assemble our roof modules each pillar is prefitted with a the negative part of a 'Schwalbenschwanz' into which the positive part fixed on the roof module fits perfectly (see Figure 228)[6].

We try taking this principle down to every piece of our project. Decisive parts of our furniture are being designed with fair designers ***Burkhardt Leitner constructiv*** who have rich experience in smart and flexible frame systems. We use them for our movable furniture (see Figure 230). **You take an aluminium rod and stick its magnetic side into knot: all done, no screws. And disassembly is just as easy. Other furniture is modular by nature, we can sleep inside or outside and the table seats two to ten people. Why this also makes for a nice interior concept is detailed in** Section 5.2.1.

5 http://www.selbst.de/sites/default/files/imagecache/gallery_618x377/pictures/step_by_step_bauanleitung/esstisch-sitzbank-eckbank-bauen-03.jpg (27.02.2014)
6 https://webshop.schachermayer.com/cat/pictures/derivates/4/103/365/DV004-ppic_pitzl_holzverbinder_hvp_600.jpg (27.02.2014)



Figure 230: **Furniture concept by Burkhardt Leitner.**

The main advantage of building most parts before you arrive at the construction site is the immense time you save. Not only is there even more time for construction workers to enjoy a coffee, risk arising from sudden weather changes decreases and, consequently, financial risk is reduced. You can develop solutions for problems that invariably arise during construction while building your prototype inside a hall, secure from weather influences. Once you have found a good solution you can essentially copy and paste it.

Naturally some of the charm of the building industry comes from the fact that we build a prototype nearly each time a building is required. That is nice, yet imagine the possibilities of an architecture that is ***not standardised*** but allows for similar underlying reproduceable construction methods that can be adapted where and when needed. An example that illustrates quite well what we mean is a project called Wikihouse.[7] They offer a platform where you upload a construction set and make it available open-source. Everyone is free to tinker with your design. It is not the most profitable solution, but a great way to share your prototype with many more people and make a Rooftop House accessible to pretty much everyone. We'll talk to the judiciary departments of our universities.

7 wikihouse.org (30.10.2013)

FAÇADE

It seems to be an occurring feature of innovative ideas that they have a long unpredictable tail of problems. Mistakes are inevitable, and indeed necessary. At this stage we can present what seems a very innovative idea; the innovative product is being built after nights of calculations flying right into the trash and discussions with faculty, the financial department and our contractor; it will be presented dans la Cité du Soleil.

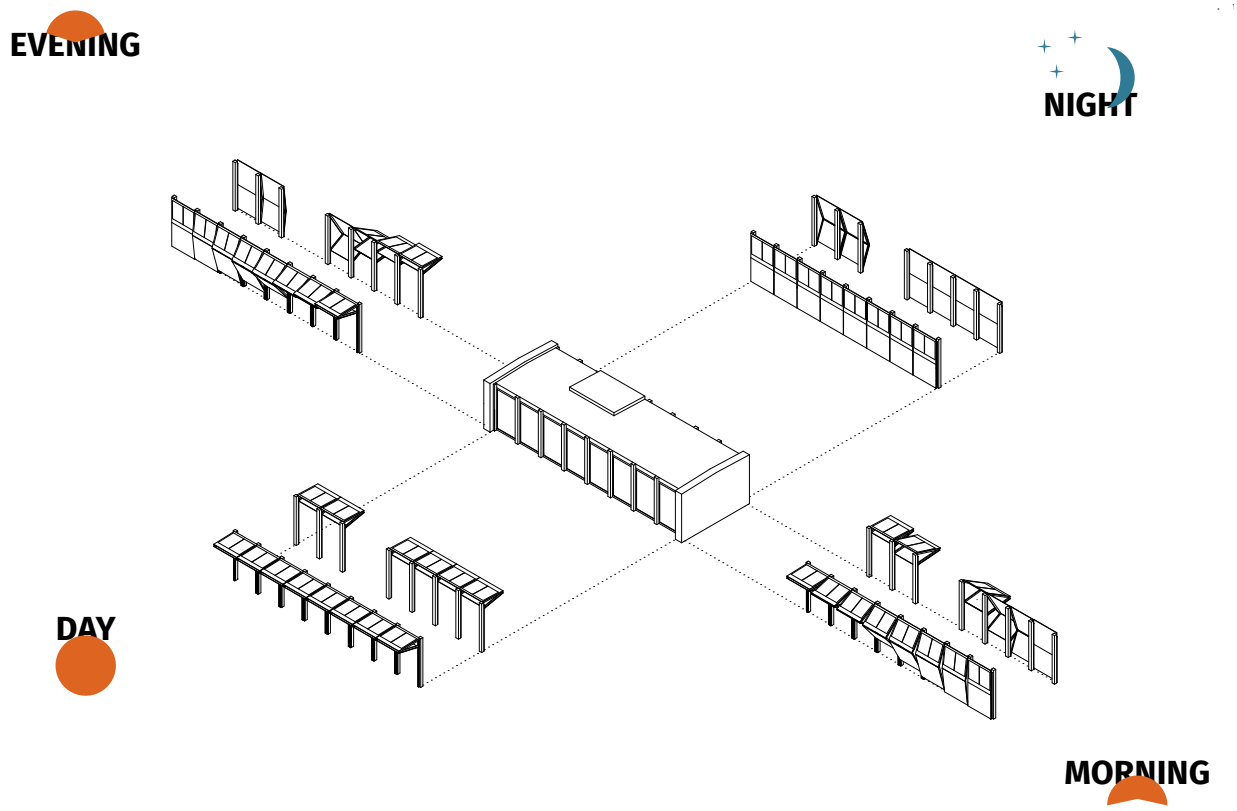


Figure 231: **Façade adaptability during day and night**

One thing that struck us with buildings is that they are so static. Most of them never move away from their one selected spot and while there often is no incentive to because the view is so nice, after some time cars and trains seem more interesting. So... Movement. Dynamics. Why is this so appealing to the human mind? Our natural environment is not sitting in an office 9 to 5, keeping our feet quiet, eyes moving across this very screen or paper. We want to walk, breath fresh air, be on the move. And we usually do that during the day with the sun shining. At night we retreat to our houses and relax. Our entire biorhythmus depends on the sun. Abundant fossil energy sources have somewhat distracted us from nature, which might be the reason for diverse physiological and psychologic illnesses.

We think part of the widely proclaimed re-orientation towards sustainable forms of life must be ***living during the day and sleeping at night***. The sun is the guide for our house. The PV-fitted façade follows the sun's rhythm:

- opening up slowly at dawn, naturally waking the Rooftopians

- moving ever higher up with the sun
- wide open during peak day hours, shading the area below
- setting with the sun during dawn
- sleeping through the dark hours and acting as additional insulation layer

In summer it would open up like a cabriolet, in winter it would mimic a bear in its sleep. This façade scenario, while most energy efficient, will probably be incompatible with human wishes. Therefore we connect the façade to our overall monitoring and regulation system „Regulation and Interaction“.

Construction of the façade is modular, each of the fourteen modules being 1.75m wide and 3m high. They can be installed right on the pillars, upon which the PV panels are installed (the glass is too sensible for pre-installation). After that the electrical parts will be connected to the house grid over the roof where the other PV panel have already been installed.

REGULATION AND INTERACTION

Any intelligent system is only as intelligent as its input. And only as efficient as its user wants it to be. Complex systems are not automatically intelligent. These are the main leitmotifs we try to follow designing our regulation system.

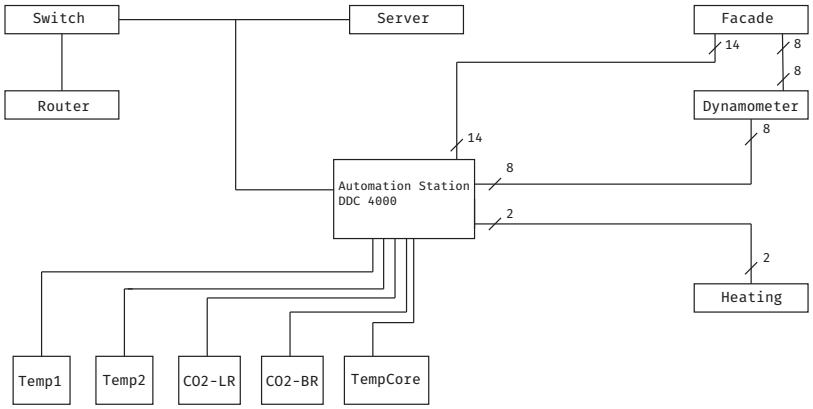


Figure 232: **Sketch of the regulation system.**

First, a server unit in the technical room controls the building regulation using weather data. It receives this data from online weather reports. We also use parallel data input from sensors located in the house and on the outer hull. The systems in the technical room deliver their data on humidity, water temperature, etc.

The main goals of this system are:

- Regulating opening and closing of the façade according to weather patterns (in case of a storm or snow warning the façade will stay down)
- Storing energy for cloudy days by charging battery and buffer tank
- Regulating the PCM cooling system
- Close and sensible interaction with users over a command centre and mobile app

WATER CIRCULATION

As you may have noticed we have two long glass façades. (That is not exactly the smartest way to build an energy-efficient house, but a much more human one than what your usually see.) Of course we use highest standard glass insulation — we still have to offset our lack of thermal mass in the thermal envelope. We attempt to do this using Phase Change Material in a suspended ceiling. The PCM is incorporated in adobe-aluminium-modules fabricated by Lehmorange[8], making it easy to recycle as opposed to other compound products. In order to effectively discharge the passive PCM we need a cold water circle. Where would that water come from?

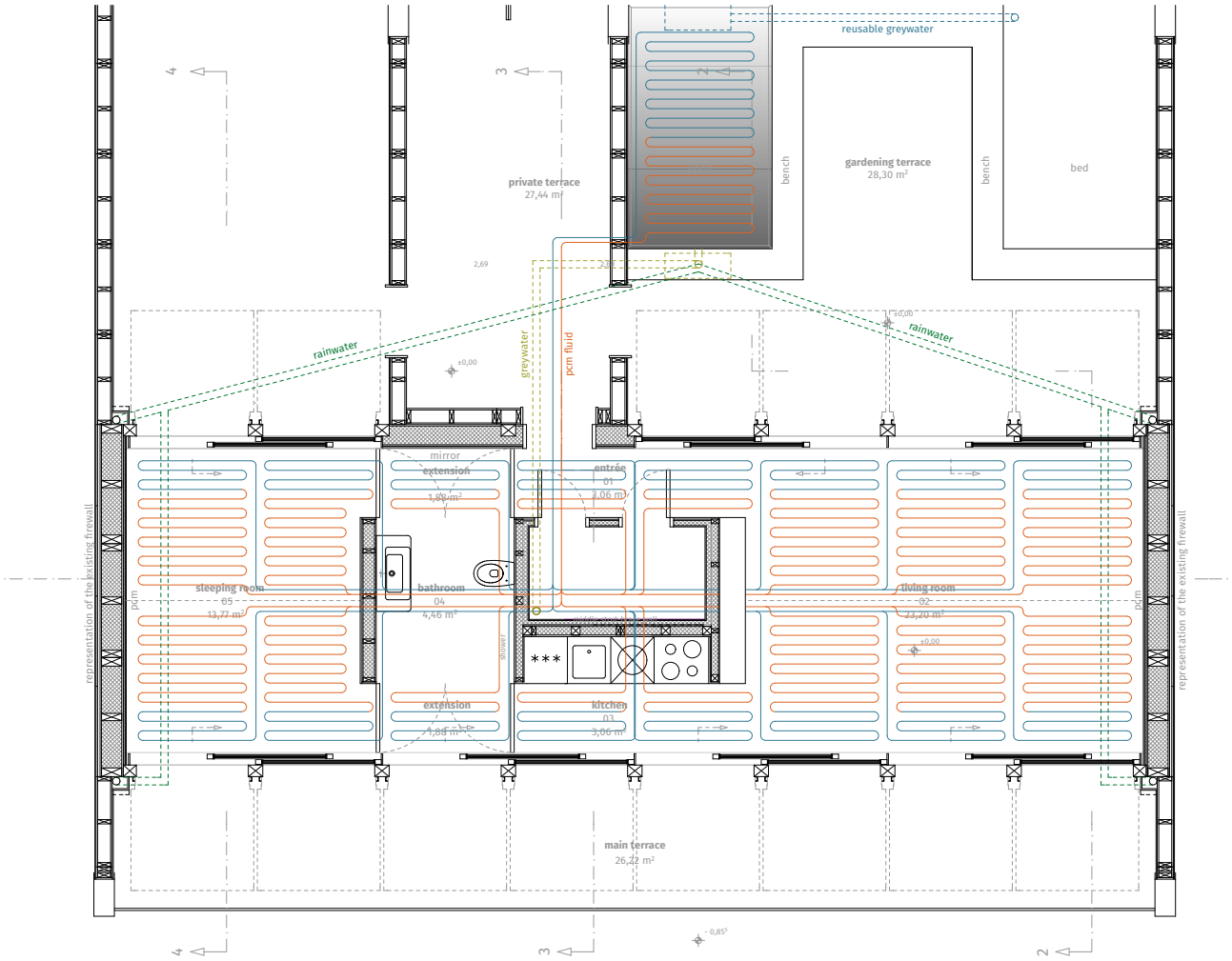


Figure 233: **Integrated water cycle.**

8 lehmorange.de (21.02.2014)

Scene change to the sanitary team. According to the SDE Building code[9] greywater may not be reused other than for vegetation watering purposes. It would be nice to have green elements on our Rooftop (and red ones, tomatoes are very tasty.). The greywater cycle in old Berlin buildings is usually just connected to what we call blackwater (drain/waste/vent). Hundred years ago no one cared. Thus, if our house would be connected to an existing Altbau, the now necessary and sensible differentiation between grey- and blackwater would be pointless. Except if you took the greywater and put it to different use. Our northeastern terrace is perfectly apt for gardening, so we placed a flow reed bed and a vegetation bed. The greywater coming from the bathroom sink, the bathtub and the washing machine flows into the first, some nice flowers spring up and the water is purified in the process. If there is more water we use it to make more green (and red) flowers spring up in the separate bed. That you can lie down in the summer heat on the wooden bench in between is a plus.

This way we create a water circulation without any need of energy for the cleansing process. We avoid using potable water for irrigation, too. The pipes we use are made up of metal and polyester layers, complementing each other and resulting in low thickness, low expansion during temperature differences, good insulation, and low weight at high stability which means less material.[10]

Of course the water for the PCM modules shouldn't necessarily go through the heat pump if there is a more passive solution to cool it down. What better way to do that than let it circulate through the greywater reef bed? This way we create a cooling circulation for the ceiling with little energy effort — only one pump is necessary. Throughout the Berlin winter we do not need any cooling cycle, which is why we have a valve outside to empty the water into a bucket for next spring. This way it will not freeze and we can use simple H_2O without chemical additions.

9 Rule 8.5, 9.2, 51.8

10 http://www.made-in-china.com/showroom/koberao/product-detailqenmVpZrHdhJ/China-Multilayer-Pipes-RS-2001-.html (27.10.2013)

5.5.3 INNOVATION IN ENERGY EFFICIENCY

Today we are surrounded by a great number of ground-breaking technologies and pioneering materials. It seems like the whole world is bursting with innovation; scientists and developers are continually proposing new, energy-efficient answers to contemporary problems and constraints.

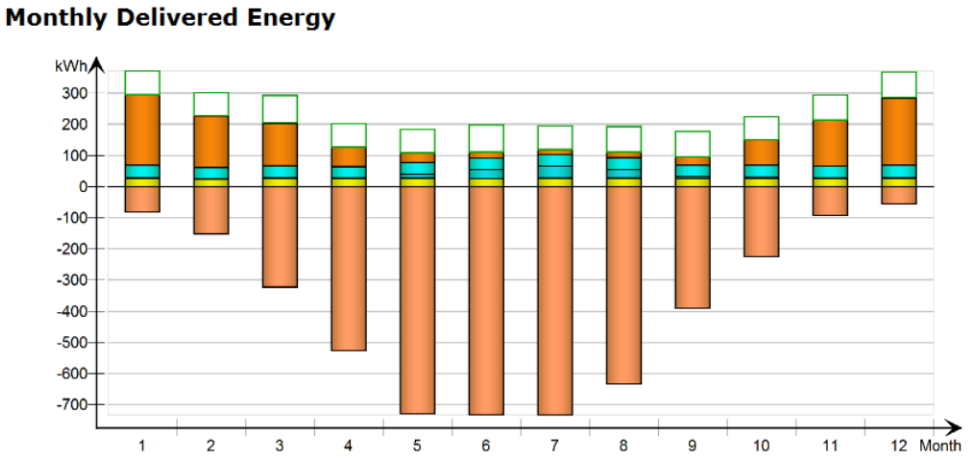
Innovation in energy efficiency means, first of all, a new way of conceiving a building.

In the case of Rooftop the building is considered as a whole since the very first steps of the design process; this results in an extraordinary integration and consequentiality regarding the solutions.

Before introducing every single aspect of innovation in energy efficiency separately, it is necessary to make an important consideration. This consideration comes from the very nature of Rooftop: a house on top of another house. Besides the social importance of such a choice in a city like Berlin, this solution implies a tight energy bond with the “hosting” building. The Rooftop is a “good” parasite: a net energy producer rather than a net energy consumer. The exceeding energy produced at the roof and at the innovative folding façades (1673 kWh, or a surplus of about 36% the total energy consumption) will be fed to the hosting building or directly to the electricity net. Therefore, the nature of the building itself is very innovative.

Although the Rooftop Building could appear at a first sight as a glass window, it is actually much more than that. Glass is widely used in construction for its large capability of establishing a strong connection with the outdoor, which grants high levels of visual comfort and pleasant living. Moreover, it allows the full exploitation of natural light. All these characteristics were extremely important for us. We wanted to maintain a horizontal visual connection with the fascinating, ever changing, cityscape of Berlin and yet we wanted our inhabitants to experience great comfort. On the other hand, the constraints of using glass façades are equally known. Typically, glass façades make it much harder to control the indoor thermal environment, they involve higher use of air-conditioning and large thermal losses at night-time. We needed a compromise between high living standards and high energy performance. This is how we came up with the concept of Rooftop. In a city with a cold climate such as Berlin, winter heat gains need to be exploited as much as possible. Thus, glass façades are a valid solution. Our folding PV façades allow a better control over indoor climate as they work as screens for direct solar radiation during the summer but they let heat gains in during the cold season due to the lower trajectory of the sun. The issue of night thermal losses through transparent components was solved once more thanks to the folding façade. In fact, the folding elements work as insulation during the night, when the heat stored indoor during a winter day would tend to leave the building due to the temperature difference. An air gap between the folding façade and the glass façade contributes to such insulation.

Overall, our solution allows the Rooftop Building to become over a year a net energy producer rather than a net energy consumer, as shown in the following graph.



	Delivered energy	
	kWh	kWh/m²
Lighting, facility	317	5.8
Electric cooling	125	2.3
HVAC aux	453	8.3
Electric heating	1151	21.1
Electric Backup Heating	6	0.1
Equipment, tenant	947	17.3
PV production	-4672	-85.5
Grand total	-1673	-30.6

Figure 234: **The monthly energy balance**

ENERGY SAVINGS

Our final solution is a result of many months of optimization. The energy performance achieved with such solution has dramatically improved if compared to the first design. Innovation happens within tradition. Before optimizing the detailed energy system, some basic choices were taken which resulted in remarkable savings. The orientation to be adopted in Versailles, the number of glass façades and the optimization of the glass façades shading using our special folding system were among the most important choices.



Figure 235: **The three designs: three glass façades (left hand-side), PV modules with lamellas (centre), final solution: two glass façades and no lamellas (right hand-side)**

An optimized shading control on the South façade resulted in a cooling demand reduction of about 70%. A increase of energy demand for heating (3%) was given by the reduction of heat gains through the transparent components.

As far as it concerns the energy system, we developed two main concepts. The initial concept employed a decentralised heat pump, required a domestic hot water temperature of 55 °C and a sole underfloor heating system with a input temperature of 45 °C. The thermal levels were reduced in the second energy model, which included two separate buffer tanks: one for space heating at a maximum temperature of 35 °C and an other one for DHW at 45 °C. A supplementary wall heating can be included for particularly rigid climates. This solution would grant a larger heating exchange surface and it would allow the water temperature to be maintained at 35 °C. Also the coefficient of performance of the heat pump is different among the two solutions: the decentralised heat pump has a COP of 2.6, while the centralised heat pump as a COP of 3.1. This

number increases to 3.3 due to the use of the heating stored in exhaust air and the consequent higher input temperature of the heat. The only energy demand which appears to grow in the second solution is the one related to the ventilation (see Figure 237).

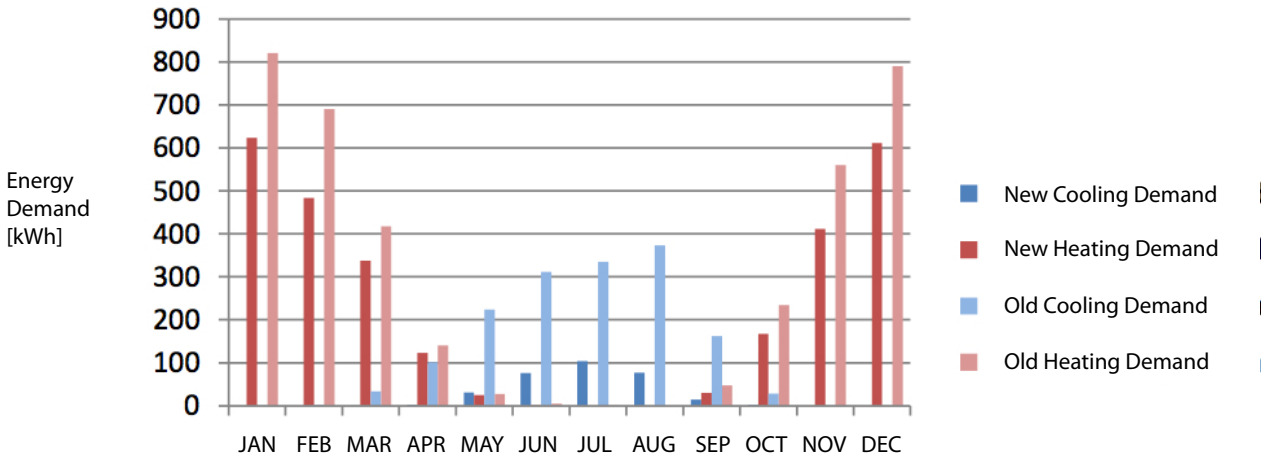


Figure 236: **Monthly energy requirements [kWh] for heating and cooling of adopted solution compared with first design.**

(see Figure 237) also shows how, through the simulation-based energy concept analysis and optimization of the building and system design, the total energy requirements of the building were reduced by 44%.

Over the year, the energy balance is positive with about 36% of energy excess supplied by the PV modules. The simulations showed a great potential for savings. However, as there are several weighting factors for such a competition, the final energy concept was developed in agreement with the architecture team and the whole engineering team.

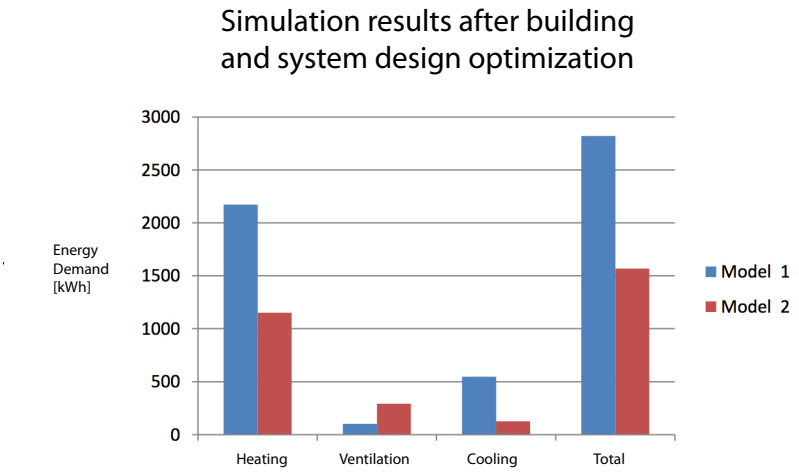


Figure 237: **Yearly energy requirements [kWh] for heating, ventilation, cooling and overall of adopted solution (Modell 2) compared with first design (Modell 1).**

INNOVATIVE CONSTRUCTION: MORE THAN JUST A THERMAL ENVELOPE

The thermal envelope is critical for efficient building technology. This enables one of the core ideas of the Rooftop Building: equipping it with a compact and highly integrated block of technology that takes care of meeting the comfort criteria of the users.

The most innovative components of Rooftop are surely our special façades. Thanks to their design, technology and building skin become one: form becomes function and esthetics is fully imbedded in functionality (or the other way around!). The way the roof and façades are planned gives the PV solar modules two further purposes besides just producing electricity. In fact, they act both as shading surfaces for the interior in presence of solar radiation and they take an active role in the insulation during the night time. When direct solar gains through transparent components are excessive, the modules can act as proper shutters. As such phenomenon will occur during the highest solar radiation times, the electricity production is not drastically compromised. Moreover, this innovative solution allows us to extend the actual PV modules surface and to enhance the electricity production in a useful way. This is particularly important because, being the Rooftop a sort of parasite of existing buildings, the PV inclination cannot be optimized. An horizontal configuration allows the needed flexibility and makes the PV system independent from the building orientation. Two thermal solar collectors are also integrated on the roof. The choice of competitive vacuum solar collectors from augusta solar allows a great outcome (100% of domestic hot water demand in a typical summer day) for a low surface (the total area of the collectors is 3.2 m^2). The building can be arranged in different layouts and typically a transformation occurs between daytime and nighttime in order to react to the different temperature levels.

In this way, the building skin becomes a sort of active medium between indoor and outdoor, and it is fully subdued to external conditions and to the needs of its users. The inhabitants of Rooftop, in fact, can take an active role in determining their comfort level by adjusting the folding façade. This solution allows the needed flexibility to operate the building under different climate constraints or in a logic of climate change just making a few simple adaptations.

INNOVATIVE HVAC SYSTEM: HEATING, COOLING AND VENTILATION ALL AT ONCE

Great focus was put in maximizing the utilization of “free” sources of energy; due to the peculiar position of our building on top of existing buildings, the structure is extremely subjected to outdoor conditions. This characteristic allows to exploit solar energy, wind cooling energy and the thermal energy present in outdoor fresh air in a very efficient way.

An air-water heat pump seemed at once the most fitting choice to benefit from the outdoor air thermal energy at a minimum electricity expense. The real innovation, however, comes from the decision to integrate heating, cooling and ventilation in the reversible heat pump device LWZ 304 from Stiebel Eltron. The big advantage of a reversible heat pump consists in the possibility to operate the same compact system for heating (space heating and DHW production), cooling (PCM innovative cooling system while maintaining the DHW production) and ventilation with pre-heating by exhaust air. All functions are integrated and centralised in one compact system. The benefits of having one module go from easy transportation to maintenance to the reduction of energy losses on the system circuit. The incorporation of all basic functions in one core is a

very efficient, innovative solution.

The concept of a building as a whole implies thinking of its internal functioning processes as closed-loop systems rather than linear systems: energy wastes of some processes become important sources for other processes. In the case of Rooftop, for instance, the exhaust air (output) works as a heating source (input) for the incoming fresh air intake. This solution allows the heat pump to work closer to its optimum, as it reduces temperature differences between the fluids.

Another example of synergy between technologies is given by the self-designed constructed wetland. Thanks to this design, the graywaters coming from wash hand basins, showers and baths are biologically filtered and they support the PCM innovative cooling system.

The PCM are used for cooling and recharged primarily by natural ventilation and by the filtered water coming form the constructed wetland. In case of need, active cooling from the heat pump will increase the recharge-rate and ensure a good degree of efficiency.

The heat pump itself is supported by solar thermal collectors, which are planned to cover the total amount of domestic hot water demand during the summer months. The PV panels sustain the heat pump's compressor electricity need.

The innovative aspect of such cycles is evident: instead of thinking of a single solution to a single problem, issues are solved with a number of integrated methods which allow a great resource efficiency. Elements are added to the original scheme in order to extend the system boundaries and connect with resource flows in adjoining systems.

While integration and synergy are normally the way to promote efficiency, in some occasions separation can be very helpful. This is the case of the two buffer tanks that are included in the heating system: one for domestic hot water and the other for underfloor heating. Due to the different thermal levels of the tanks mixing the two flows would result in an energy inefficiency.

Focus: summer heat reduction

Part of the Rooftop House design concept is the implementation as a lightweight building. This means that the building is lacking a large thermal mass, traditionally a measure to reduce the indoor temperature increase due to the solar heating of outer components.

Two design elements replace the function of the thermal mass of the thermal envelope: the innovative PCM system and the wood fibre insulation.

To avoid an overheating of the building in the summer a cooling system is inevitable. A conventional air conditioning system is out of question due to the high energy consumption. This is how we came up with our PCM system.

As Michael Pawlyn states in his book Biomimicry in Architecture[1],

> *[...] fossil fuels should be used for making high-performance materials, not for*

1 Michael Pawlyn, Biomimicry in Architecture, RIBA Publishing, 2011

burning.

The use of PCM materials allows dynamic process to take place in our building: the heat is effectively absorbed when the indoor air temperature is warm thanks to the melting of PCM. This is possible because the breaking and reforming of bonds between molecules as the material changes phase require a considerable amount of energy.

The PCM system is therefore able to cool down the building during peaks without using our self-produced energy. During most of the cooling season a single pump, which only works during the night, is the only mechanically working element in the system. At the same time we combine the grey water treatment with the cooling circuit, by using the reed bed as a heat exchanger for the cooling fluid. This way not only completely different systems interact and have a positive impact on each other, but also the materials and energy needed to operate a separate heat exchanger for the cooling circuit are saved.

The wood fibre insulation, as described more detailed in Section 5.6.2, is used to prevent summer midday heat from entering the indoor space before being cooled down by night air.

The use of renewable materials that combine high heat capacity, density and heat flow resistance, prevents summer day temperature amplitudes to cause a heating-up of the building before the colder night air cools down the thermal envelope.

Humidity regulation

Humans are very sensitive to humidity levels. The walls and the roof of the Rooftop House are constructed with wood fibre boards placed inside of the vapor barrier. As the wood fibre is able to store and release large amounts of water, the humidity inside the living area is kept in comfortable regions; the high amplitudes of the humidity curve are smoothed. This layer does not only increase comfort by regulating humidity in a natural way; it serves several more duties. Heat bridges are avoided as the boards thermal transmittance is low, noise levels from outside are decreased and the layer can nonetheless be used as installation level.

Thermal insulation

Our thermal envelope easily matches the ambitious modern requirements for energy saving buildings like the German Passive House Standard. With integrating wooden carrying structure and insulation for roof, floor, solid walls and high insulated glazing, energy losses to colder surroundings through the thermal envelope are almost negligible. This cuts down the requirements on space and energy consumption of the heating system again.

PV AND ENERGY MANAGEMENT

Gaining maximum power

To exploit the full potential of our PV installation we will use power optimizers from Solar Edge with integrated MPP-Tracking, which reduce the open circuit voltage to 1 V and maximize the energy gain. The 50 modules will be divided in groups of four and connected to one power optimizer per group to use the full potential of the optimizers. Only the last optimizer will be connected to just two modules to reach the maximum of a 5000 KWp PV installation. Therefore, we will have 13 optimizers wired in series connected to the input of the Solar Edge inverter with a power output of 5000 W (rule 7.3 d). The power optimizers are also able to monitor the group of modules and communicate with the inverter. In such a way, we will have a detailed overview of the behavior of the modules, power analysis and reports of possible system failures. In this system if one group has a limited energy outcome (e.g. in case of shadow or a broken module) it will not affect the rest of the system.

Intelligent energy management

The inverter output will be connected to the main grid and through a separate connection to a combined battery charger/inverter of the Xtender series from Studer Innotec. This separate connection is controlled by an external contactor, which can switch between the utility and the back-up grid. This cabling solution is called Solsafe S-Box and is also a component from the Studer Innotec system. This ensures an automatic anti islanding protection in case of a main grid failure. The Xtender again also has a connection to the main grid, to our battery bank existing of the two SB12V160E-ZC Super B batteries in series and to the domestic grid. With two energy meters one after the inverter from Solar Edge and one after the main grid this way of wiring secures an intelligent electricity supply from the main grid and the battery bank with a detailed overview of energy consumption and production.

Efficient energy saving

The use of Lithium Ion batteries is an already proven way to store electricity in an efficient way for domestic use. This type of battery makes a great storing system over a daily period because of the high efficiency of up to 98%. With a high energy density about 250–730Wh/L ; 0.90–2.23 MJ/L, this battery type has a relatively small size and therefore a great potential for private use. Also in an e-mobility solution this type of battery is right now the most promising technology, which is also a reason why we chose the e-bikes explained in the e-mobility concept.

Thinking further

Related to the orientation of the house there is a huge potential given by the moving façade elements. In an East-West Orientation those elements are ideal to track the suns radiation through simply following the suns pathway from sunrise to sunset. This construction makes it possible to catch the most efficient angle for irradiation, independent from the changing solar altitude over one year. This idea is also realizable with just a few alterations in case of a north south orientation.

In this position the north façade could move from a horizontal state up to an angular degree of 30 ° above the roof. The mobility of the south façade would stay the same from a horizontal point down to a vertical position.

In our case we decided not to move the north façade above the horizontal point in order to achieve a symmetrical house design which improves the overall aesthetics of the building.

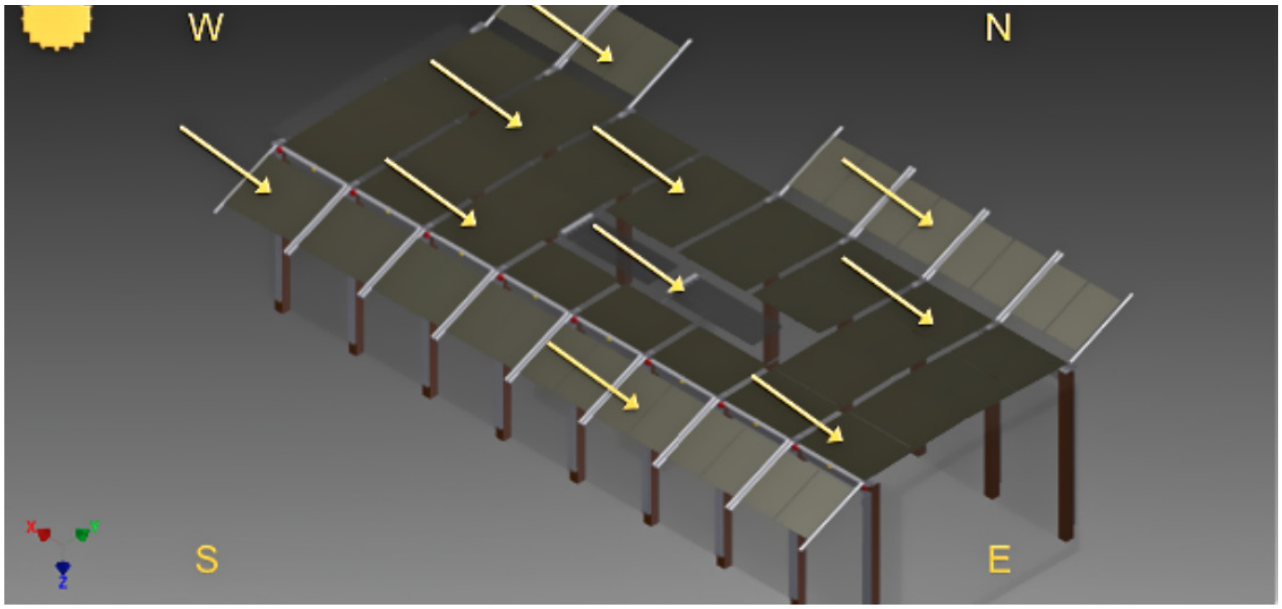


Figure 238: **Possible concept for façades in North-South orientation**

TALKING NUMBERS: THE ECONOMICAL ASPECT

The costs of every single component of the energy strategy are listed in detail in the project financial summary section of this deliverable in the figure construction costs of the house.

The overall cost for our energy solution is 58.927 EUR with 16.823 EUR for cooling, 3.374 EUR for ventilation and 38.730 EUR for heating and solar thermal. The overall cost for PV/ electricity is 26.142 EUR.

Gains through surplus of electricity production

The PV system can produce around 9.364 kWh/a. The electricity demand of the house over the year is 3479 kWh/a. This means that we have a surplus of around 5885 kWh/a which can be sold to the inhabitants of the host building or the government, which provides the energy-feed in rate of 11,23 cent/ kWh. This results

in an annual gain of 660,89 EUR.

Savings in heating costs in comparison to average house

The energy systems consisting of and optimized symbioses of heating, cooling and ventilation has a significant effect on the heating costs of the house. We all are aware that the building sector is responsible for about 30 % of the CO2 emission in developed countries through the great costs of heating for inefficient houses. We therefore have spent a lot of research in optimizing the energy system of our house and make it as economical as possible.

The overall heating energy demand is about 3000 kWh/a. The cooling demand is about 600 kWh/a. This means about 54 kWh/a for heating and 11 kWh/a for cooling with a living space of 55 square metres. This is significantly smaller than the average which is about 160 kWh/(m²*a).

We can assume saving in heating costs of (160 kWh/m²*a- 65 kWh/m²*a)*26 Cent/kWh *55 m² = 1358,50 EUR/a. We will assume an energy price rise of 4 % per year.

The costs for the whole energy system are 85.000 EUR. We will assume that economy of scale will drive down the cost of the energy system by 40 % in a scenario of several units being built on Rooftops of Berlin. With 660,89 EUR gains through energy surplus and 1358,50 EUR/a gain through cost reduction with a 4 % increase per year the Pay Back Time would than be 19 years.

Benefits for the inhabitant of the Rooftop Unit and the host building

The inhabitant of the Rooftop Unit is ecologically aware and takes pride in only consuming green energy. He saves a lot of money in heating costs and lives in a unique apartment, that contributes to the energy supply of the city and the inhabitants of the host building.

Further details on the benefits for and the relationship between the inhabitants of the host building and the Rooftop Unit can be found in the affordability section of the UDTA report of this deliverable. In particular in the Market Viability section: Contracual relationship between Rooftop inhabitant and host building, the collective housing building concept and the affordability section.

5.5.4 INNOVATION IN COMMUNICATION AND SOCIAL AWARENESS

We kept asking ourselves: What defines us? What makes our communication extraordinary? We only have a chance to be recognized and to transmit our messages to a big number of people if we stand out of the broad mass. Therefore we were always trying hard to think out of the box and not to do what everybody does. That is also the reason why this innovation report is kept short, simple and to the point.

First of all, it was important to us to have a strong base for our communication. The Rooftop Fundamentals Responsibility, Connectivity and Adaptability perfectly embody – in an abstract way – our values and principles. Although they are just being used indirectly, we can always draw on them when explaining our project to others.

We deliberately did not use classic criteria to characterize our target groups. We are confident that it is much more helpful to provide the right information when we distinguish people by their engagement and interest levels. Also, we do not want to primarily communicate our house or us taking part in the Solar Decathlon, we are using the whole project – combining house, team and competition into one – to carry our messages: we are communicating through the project to raise social awareness.

A bunch of innovative actions accompany the development of the project since the beginning. If you just take a look at our daily Facebook-facts or the “Connect the dots”-posters, you will see new kinds of information carriers. Taking part in the energy transition demonstration shows that our engagement goes beyond the competition: we really want to change something and stand up for our value of responsibility towards nature. When we heard that a Children Science Slam would be organized within the scope of the “Long night of science”, we immediately knew that we had to take this chance to get in touch with kids and explain our ideas to them in an entertaining way. Guess what, our slamming team member Arno even wore a helmet and brought wood wool to make the house graspable for the kids. Additionally, we designed a Partner's Lounge specially dedicated to all those who supported through the years, devoting to them their own personal space.

With our cotton bags, pencils and yardsticks, we created unique giveaways that are actually useful, do not produce any needless waste and definitely make a difference to conventional dissemination material.

Furthermore, we are sure that you will rarely find a website like ours. If you either look at the concept of our house with all the technical details, the context or the story of our team, all the information is displayed in a way not seen elsewhere. With the clear design and all those amazing graphics and icons (did you see that chameleon?), even the complicated things are easy to understand and that is exactly what we are aiming for: Giving everybody a clear picture of our project, not just an accumulation of random details. Please take a look!

We are awesome. And orange. A little green behind the ears, as Germans say (and which means to make jokes often and hoax around). That said, we feel devoted to our incredible architects and engineers who have spent so much time making the Rooftop House become real. So, really, we just want to make an already amazing project even more amazing without falling into the schemes of conventional marketing and communication. Stay orange, and green!

5.5.5 INNOVATION IN URBAN DESIGN, TRANSPORTATION AND AFFORDABILITY

URBAN DESIGN

The concept and ideas characterizing the Rooftop Building is in many ways innovative and a new type of addressing the need for more living space in a growing city. The use of our Rooftop Unit allows the city to increase its density without sacrificing green lands. This innovative approach to an inner-centre creation of new living space allows more people to take advantage of existing public transportation systems that are perfectly equipped within the inner city Figure 239.

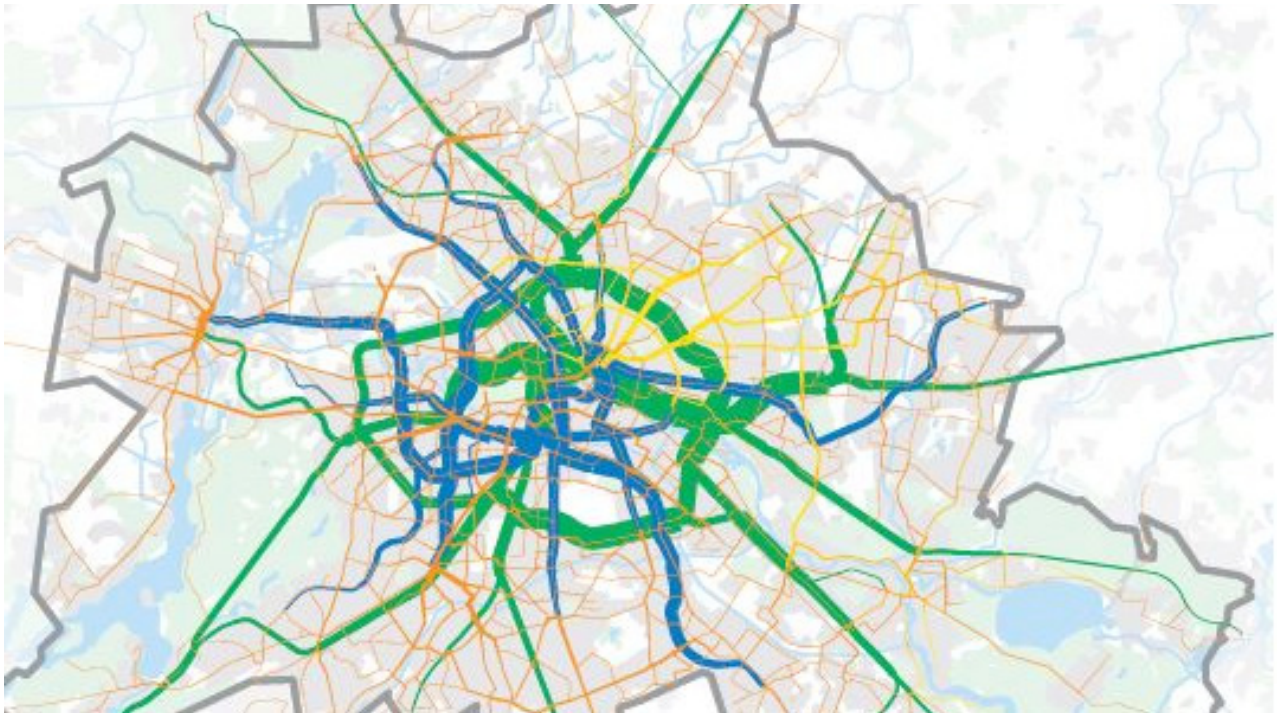


Figure 239: **Capacity of Berlin's public transportation system**

By attaching the Rooftop Units to existing buildings, we are not only saving valuable space in the city centre, we are also contributing to a harmonic interaction of modern and old architecture within the city. Taken our five main principles into account that are outlined in our Urban Design Strategy (see section 5.1.1) we strengthen the city's existing identity by adding more living space in the very centre of the cities where people can live, work and spend their leisure time as they were used to. The symbiosis of old host buildings and our Rooftop House enables not only the direct inhabitant of our unit to profit from these innovations; this Rooftop concept is also profitable for the indirectly involved people living in the flats of the host building since this is refurbished and increased in value by adding the Rooftop Unit.

MOBILITY

Additional to the advantage of a well-equipped public transportation system within the city, the Rooftop comes with another innovative approach in strengthening the inhabitant's individual mobility. For this, we use the peak power generated by our photovoltaic systems to charge bicycle batteries of the Copenhagen Wheel that are easy to attach to any existing bike. Like illustrated in the Mobility Concept, we therefore accommodate the steadily increasing number of ways that are done by bicycles by adding a very convenient and innovative solution for the inhabitants of the whole building.

As illustrated in Figure 240 this idea fits perfectly to a scenario research done by Berlin's urban development department in 2009. In a scenario for 2025 they predicted an increase in the usage of bicycles (green) by 23% up to 15.7% of total traffic. In the same way, the public transportation system (yellow) will keep its strong position and will increase its share of total traffic slightly to 33.6%. In contrast, individual car-oriented traffic (rose) and traffic on foot (blue-green) will decrease.
The costs for one Copenhagen wheel are at about 799 $ at the moment.

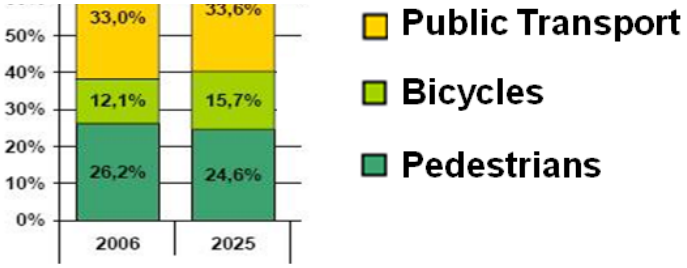


Figure 240: **Choice of transport scenario 2025**

That is much cheaper than an average e-bike at about 1.500 – 2.000 €. Furthermore the Copenhage wheel and its app allow the user to create maps of urban data including air pollution levels, ambient temperature and noise levels that can help the city create energy friendly infrastructure solutions. You can also share your data through social media and help your friends plan healthier bike routs and warn them about traffic congestions - Interconnection between inhabitants.

AFFORDABILITY

We based our affordability strategy on two innovative columns. The first is the contracting solution between Team Rooftop and the base house owner. The second innovation is based on an idea which can be described as the atomization of the real estate market through crowd investments. Both elements help us to be able to rent the Rooftop Unit for less money than the rent index would suggest. You can find a detailed description of the contracting solution and the crowd investment in the affordability section of this paper.

Crowd investment and crowdsourcing for the future of real estate

Through our model we enable average citizens to participate in projects, that were previously oly available to large institutional buyers. This democratizes investments and also makes projects viable that otehrwise would not be possible hence accelerating the cities transformation toward environmental sustainability.



Figure 241: **Crowdinvestment in Real Estate**

ECONOMIC VIABILITY

The cost of the energetic refurbishment of the a German "Altbau" include insulation of the top storey ceiling, the façade, the cellar ceiling, replacement of windows and establishment of a central heating and water heating unit. It is most cost effective over time to refurbish the building to a KfW 100/85 or 70 standard, which means that it will consume the same xx % amount of energy as a new-build house has to according to the EnEV (Energy Saving Ordinance for New Buildings).

The dena (German Energy Agency) calculated that refurbishments to 100/85 and 70 are economically viable and result in rents plus maintanence cost remaining at the same level as they were before.

The following table shows the cost for refurbishment and savings in energy consumption and heating after refurbishment with different types of KfW- energy standards:

Refurbishment Costs and Savings in consumption

KfW- Efficiency Housing Type	100	85	70	55 (Passive house)
total costs in €/sqm of living space	275	310	355	420
savings for heating oil per year in €/ sqm of living space with price of 0,65€/l	9,04	10,07	11,11	11,89
savings in energy per year in €/sqm of living space with price of 20 cents /Kilowatt/hour	27,8	31	34,2	36,6
years for amortisation of costs	8	8	8	9

Refurbishment Costs ans Savings in energy and heating oil

The analysis of the Germany Energy Agency thus show, that a energetic refurbishment is economically viable and it is possible to have rent plus maintenance costs stay at a constant level up until KfW- Efficiency Housing Type KfW 70.[1] Through the production of solar energy by the Rooftop Unit and savings in energy and heating costs it is thus possible to guarantee a dividend of 2 % annually over a long period of time for the investors as shown in the Affordability Strategy of this deliverable.

1 http://www.energiesparen-im-haushalt.de/energie/bauen-und-modernisieren/modernisierung-haus/modernisierung-kosten-haus.html

Innovation in Sustainability

The Rooftop Building is not only built to operate in a sustainable way related to production of electricity and energy consumption because of the choice of materials, it also has some elements to offer which are improving a sustainable livestyle in an unusual way.

Sustainability through reapplicable concept

For example the main elements of the energy production concept, besides the intake surface on the roof are the 14 foldable façade elements. Since the Rooftop Building is constructed in a high altitude on the roof of an host building, even within a dense city structure the problem of shadowing the solar modules is avoided. In this optimal position, and with the added space for modules in a vertical position through the opened façade elements the orientation of the building becomes a minor factor in the yearly overall energy budget of the house. This way a much larger building stock can be explored throughout the Berlin pre-war tenement housing landscape.

Sustainability in Space

An innovative way to use our measurable area limits through the competition is the redefinition of living space in a larger incorporated living experience concept. Therefore we restrict the thermally controlled area to a minimum, with all necessary housing functions and incorporate the terraces into the spacial design. This way the living experience extends far beyond the reaches of our hvac system. Also, the thermally controlled space is optimized for maximum useable area, with the core module as a very space efficient way to incorporate all major technical functions.

Sustainability in water

Another part is the local purification of the emerging grey water. Through the use of a constructed wetland the water will not just vanish in the drain but can be cleaned so far that it is usable again for irrigation (in Versailles) and for toilet flushing (Berlin concept), for which purpose it will be collected in a container. This will lower the water consumption, and the cleaning process as such takes plce in a very simple, sustainable reed bed.

5.6. SUSTAINABILITY REPORT

It presents the current design in energy savings at this stage of development. The different applications are described in the related sections according to rule 24 ongoing for the sustainability report. Not only the design for a more efficient handling during the use phase, referring to savings of direct energy like electricity and heat is part of the following articles, but also the use of the chosen materials to reduce the impact of grey energy.

General Concept of the Project and Sustainability

In 1998 the committee of enquiry of the German government formulated the general orientation "Protection of the humankind and the environment – ambitions and basic conditions of a sustainable development" [BMVBS 2013a]. According to this adjustment sustainability can be subclassified into three equitable dimensions: ecological, economic as well as social and cultural dimensions [SCHARP et al. 2002, S.9]. Figure 242 illustrates this definition of sustainability.

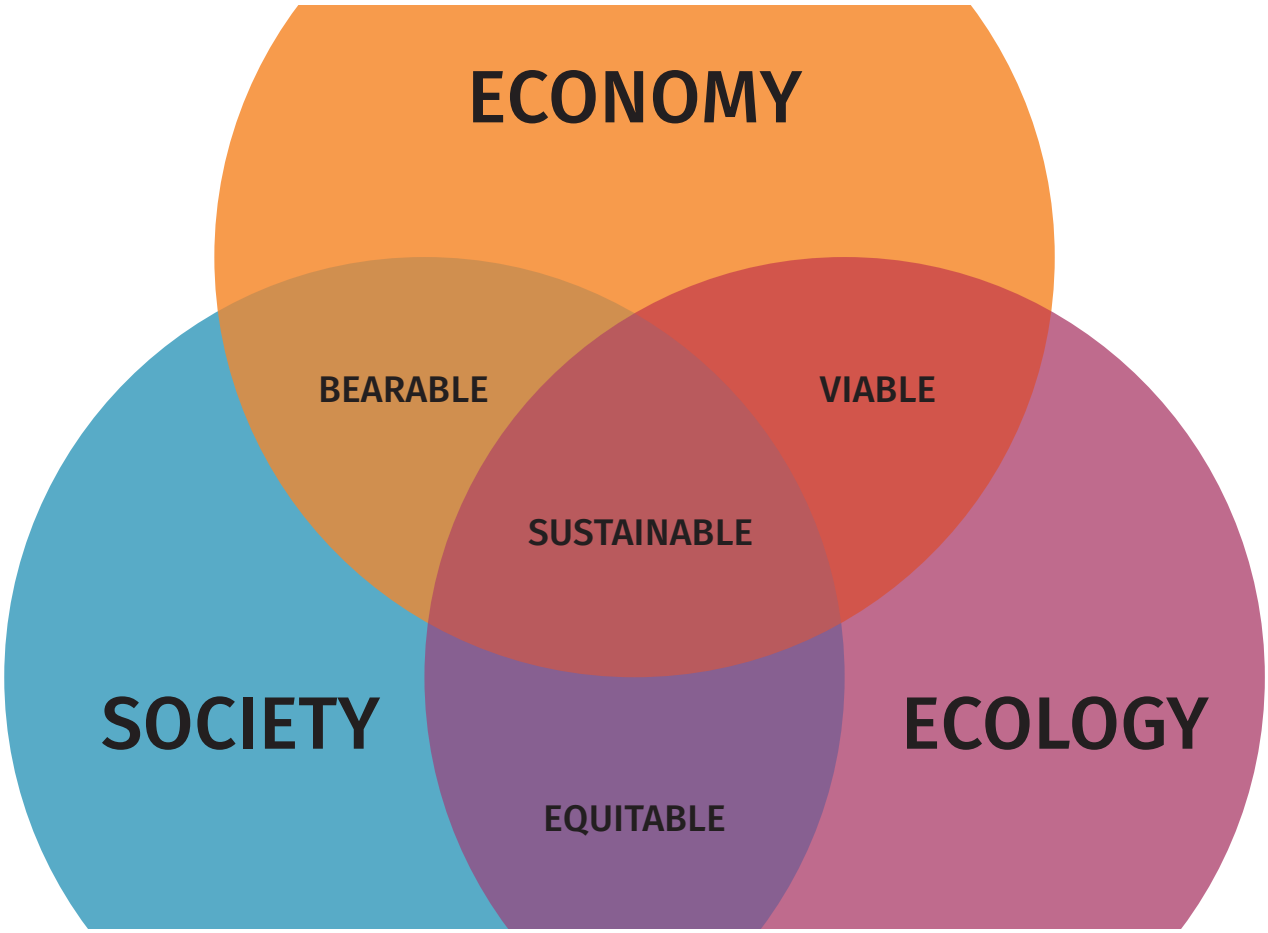


Figure 242: **Definition of Sustainability, according to [Ebac 2013]**

The building sector — construction, maintenance and use — accounts for **40% of energy, 40% of resources and 25% of produced waste in Germany. Thus, developing and applying measures in favour of sustainability for the building and construction industry promises to protect both the environment and financial resources.**

The Rooftop House is constructed as a highly energy-efficient building that meets ecological requirements. Naturally the economical and social qualities are equally important.

Economic, Social and Cultural Aspects

The main ecological aim is the reduction of costs across the entire life cycle. In detail this means preserving and enhancing the estate value of existing buildings. Social and cultural quality contains the design and security of a building as well as the impact on the users heath and comfort. [BMVBS 2013b]

Building in big cities as Berlin is difficult because of increasing urban density. The growing population and limited developed areas demand for an effective use of space. Instead of demolishing the green lungs of the city or closing the war wounds characteristic for German cities, we aim to provide living space somewhere else: on top of an existing turn-of-the-century building ('Altbau'). The Rooftop House tries to address the economic challenge of providing an affordable unit through a crowd-funding concept embracing the existing inhabitants of the Altbau, please refer to „Affordability“ on page 67 for a detailed explanation.

In a nutshell the economic benefits are two-fold. First, by using existing housing units, parks and green spaces we preserve the city and reduce capital costs. Second, the investment for the landowner/owner collective pays off in time by producing energy, thereby lowering the operational costs for the inhabitants. In addition, the old house may be refurnished — depending on how far funds go.

Building equipment and appliances of the existing building will be used for the Rooftop House which additionally cuts investment costs. It can be connected to the installed electric grid, including tubes and cables, to the drinking water supply and to the sewage system. Since Berlin's sewage system was built for a much higher density of population, before the second world war, this systems still has plenty of unused capacity and a connection of more than a Rooftop Houses would be possible. Operational costs are cut due to the low energy demand of the building. Electrical and thermal energy generation from PV and solar thermal modules respectively reduce the exterior demands of the building. Rooftops also provide the best location for solar systems, making solar installations on top of existing buildings far more sensible than on pristine countryside.

In order to keep impacts on the environment to a minimum, we are looking for a sustainable construction — a quick and responsible assembly that

- is carefully prepared, leaving no neighbour out in the cold
- reduces acoustic and visual intrusions
- keeps waste production in check through maximum prefabrication, in particular the core module that ships pre-assembled.

Since the Rooftop Building is developed as an exemplary housing unit for use in a big city, in which a high density of old building structures and therefore host buildings for the project idea is existent, it is important to consider the sustainability of this building at an urban scale.

The Rooftop Building is meant to sustainably densify the city, without many of the negative aspects of gentrification.

With the provided renewable energy on the host building a new, though only half-visible way of communal life appears: the energy can be used to support the host building and people beneath it, especially in summer. As part of a smart grid (which Berlin plans to implement) Rooftop Units would become part of a decentralised energy production and distribution method, making the city less dependent on fossil power

plants — if a sustainable energy storage system is developed in time: batteries such as those in the Rooftop Unit could be part of the solution, but will not be enough.

Looking for a crowd-funding solution to refurbish the host building (see section 5.1.3) seems like a sensible approach in the era of angel investors.

Ecological Aspects

Meeting high ecological standards comprises lowering the demand of resources and media. In detail this means lowering the demand of primary energy, the ozone depletion and generating potential, the potential in acidification and the eutrophication potential during the whole life cycle of the building. [BMVBS 2012e]

Consequently, the efficient use of materials for the new construction of the Rooftop House is of primary concern. Simultaneously the percentage of renewable materials has to be as high as possible. Therefore, the most commonly used material for the building is wood which is one of the most sustainable building materials. To increase the positive properties by analysing the materials life cycle, the wood used for the flooring will be reused material from the old roof that would be taken off to be replaced by the Rooftop House. All wooden and most of the other materials are reusable and recyclable.

The Rooftop House is highly efficient insulated. This lowers demand of heating and cooling energy. Additionally, the superfluous generated electrical and thermal energy from the PV and solar thermal modules can be fed to the grid of the existing building below or to the public grid.

To sum up, instead of irresponsible building the Rooftop House sustains a completely new construction. The Rooftop concept preserves old building structures while improving the energy footprint and integrating itself subtly into the cityscape.

5.6.1 SUSTAINABILITY IN URBAN DESIGN, TRANSPORTATION AND AFFORDABILITY

Historical Introduction and Analysis

Sustainability commands the appreciation of past efforts. The concept of an ideological tabula rasa is not possible in a post-modern society. Practical reasoning and a sober work approach towards the existent structures is the utmost priority of present planwork in the public sector.

Especially the public transport system has been subject to many financial and urban design efforts and deserves a closer look. The public opinion on it has not always been as supportive as in current times. A close competition between personal profit and the common good have shaken the development of the transport system, this was further influenced by a destabilising spiral of privatisation.

Up until well into the 19th century Frederician horse carriages dominated the surprisingly broad, cobbled streets of Berlin that had been developed during the 17th century. Whilst in 1850 easily matching American cities in growth, the state of the Prussian capital was embarrassingly and hopelessly underdeveloped. As early as 1830 New York, despite the fact that it only accommodated a fifth of the population of Berlin, had built rails for its hackney carriages. This concept was a genius invention that had enabled mining for centuries. For inner town transportation it bore the tremendous advantage that not the entire width of the street had to be cobbled, furthermore it structured and concentrated the carriages to designated paths.

Any aspiration to bring these advantages to the increasingly densifying city centre of Berlin, were simply rejected by the unyielding reactionary Prussian government bureaucracy. The government of Berlin had been robbed of its right to build streets by the state government as far back as the 15th century. Instead, the approach seemed to be: „Don´t build anything, don't let anybody else build anything." After a grotesque struggle between city representatives and three separate government authorities, the Berlin-Charlottenburg tram line, that did not even enter the city centre but simply crossed the Tiergarten, was finally realized in 1865.



Figure 243: **early "Tram" public transport system**

Only in 1867 Berlin eventually regained its right to build, and used this opportunity to expand the tramway network. In 1930 the city had the most extensive network in the world. However, this was at a time when in most developed countries, were focusing on the advancement of the fast transit system. In Germany, the Prussian government knew to delay this in order to protect the very strong postal lobby of the time.

In effect, this resulted in a series of suburban train connections, that came to a sudden stop at the city's boundary, whilst in places such as London, the trains penetrated the heart of the city. Several investors had pleaded to the Prussian government to connect the railheads, but were only acknowledged when the military advantage of this concept became apparent. A rushed, cheap connection was built, which was never operated for public transport services, however the increased freight traffic proved to idea worthy of further development. A look towards Paris inspired the design of a circle line, which was to run around the entire city and connect all suburban lines. What may have been a sensible approach for the French capital, simple did not suit urban development of Berlin at the time. It was only in the 20th century and after the expansion of Berlin beyond the boundaries of the circle line, that it began to play a significant role in the public transport system.

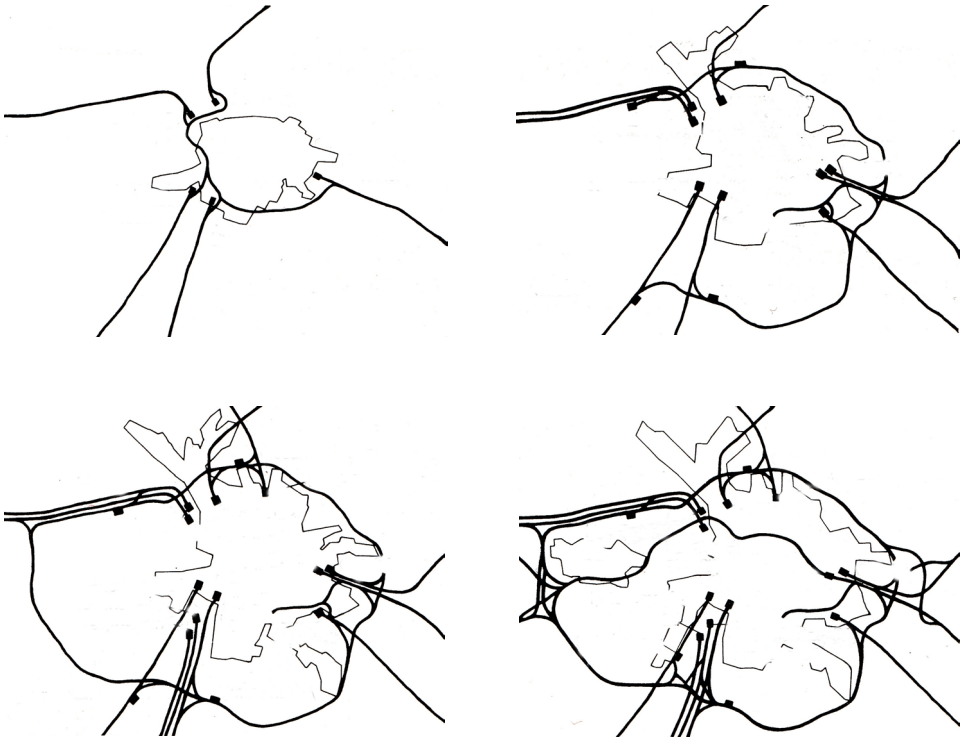


Figure 244: **expansion of the railway system 1851, 1871, 1877, 1882**

The needs of the 19th century were more accurately met by cross city routes, which connected the radially approaching rapid transit trains and made the entire city centre accessible. Furthermore these would be considerable less space hogging, replacing a large number of railheads with a concept that can be understood as a prolonged main station, stretching across the entire city. Leading urban planners demanded this to be realized by advancing the expected betterment of adjacent lots before private speculation kicked in. After decades of back and forth the opposite became true when the citytrain ran from east to west in 1882: it lacked clear

direction and winded its way through the city, aiming to avoid privately owned land plots and yet connecting new main-line railways. Partially the line was financed by renting out the underlying archways. Yet, agitated by frenetic applause it did not fail to propel Berlin into the centre of international infrastructural interests.

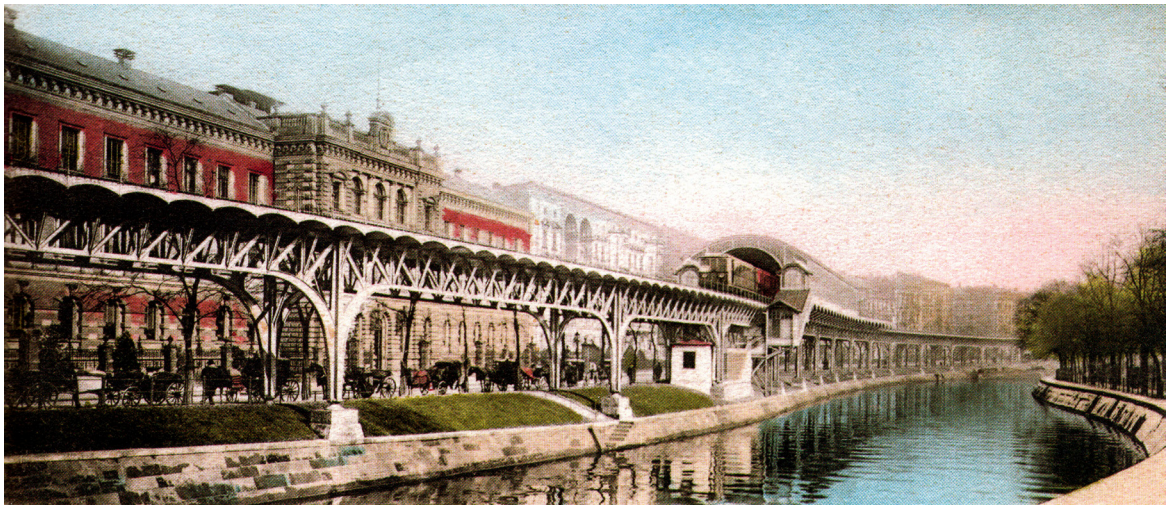






Figure 245: **railway station "Möckernbrücke" around 1905, recoloured**
Figure 246: **left: extensive and strenueous building underground line building process**
Figure 247: **right: entrance to Friedrichstraße metro station**

Since the early 1890s the expansion of faster transport means than the tramways became evermore important. In 1853 London had introduced the first underground train line, the considerable success of this prompted further projects in the English capital. The high installation costs, slim profit margins and problems due to smoke development did not shy away the English, however for these reasons the city of New York decided to invest instead into elevated railways. In 1967 one of these connected the north and the south end of Manhattan via a series of avenues. The incredible racket the train made was an agony to close-by residents, yet the city developed rapidly along its cheap transport line. Striving towards this American model the company Siemens & Halske took on the Prussian bureaucracy and once again decades of struggles began, in 1902 Berlin's first elevated train began its maiden voyage. And once again, the technological advancement did not receive the anticipated response by the residents of Berlin. The Berliners found the trainway's metal framework visually disappointing.

From then on it was decided to invest into the Markian ground, so that instead of expanding a potential elevated rapid transit train network, underground tunnels were dug.

The end of the first world war and the revolution in 1918 turned Berlin's urban development inside out: finally the magistrate was able to vote democratically and legitimately, thus freeing itself of the backward orientated Prussian military state. Capable officials were now in charge of the development of the traffic planning. The autobus- and tramway companies, as well as high- and underground train lines were now under charge of a united, city-owned company, whilst the S-Bahn and long-distance transport were subject of state control.

During the 1920s the investment focus was on electrifying the system, the 30s were dedicated to building a second diametrical line. It ran mostly underground along the north-south axis of the city and meant that Berlin now had an extensive public transport network: Radial train lines towards the suburbs connected to the city's circle line, and whilst Berlin's centre was well accessible via the east-west-line and the north-south connection.

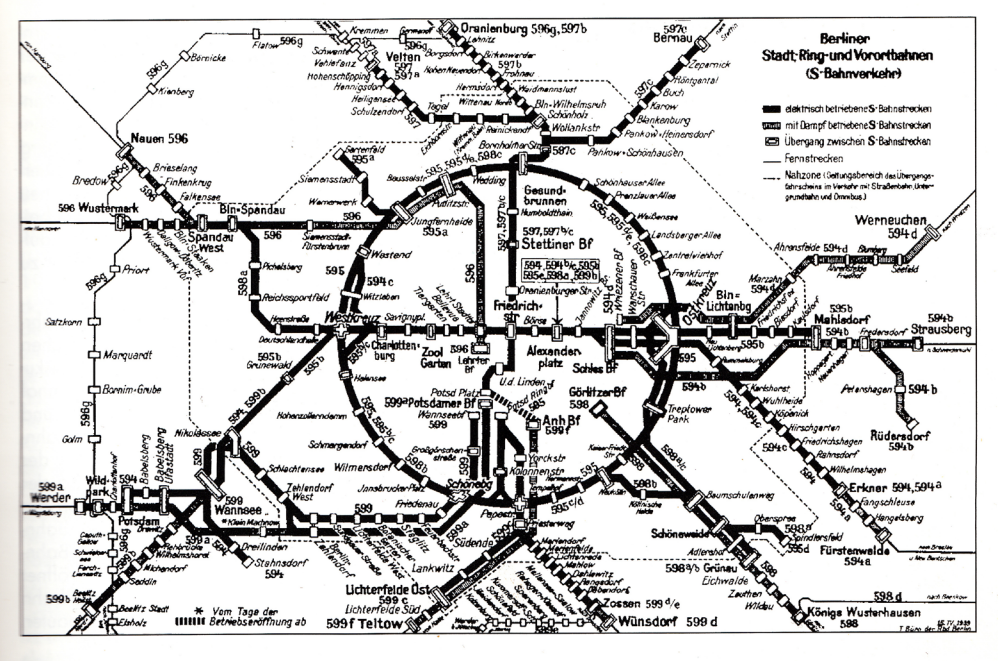


Figure 248: **Plan of Berlin railway network 1939**

Compared to the Cold War and the division of the capital, the Second World War only marginally effected the transport system. Naturally, during the division of the city train connections running from the Russian sector into any other sectors were interrupted, however this was not the end of grotesque developments. The city's public transport company BVG was also divided into the western and the eastern BVG, whilst the GDR was in charge of the Reichsbahn and thus Berlin's entire S-Bahn system. In consequence, the west of Berlin was not able to control its own S-Bahn system. The GDR officials however let various repairs and investments flow into the eastern part of the S-Bahn network. The western government had to watch its train lines rot away and concentrated instead on the development of an extensive underground train network. Some lines even running parallel to existent but mal-maintained S-Bahn lines. As part of the Marshall plan and due to large subvention sums from the FRG the west of Berlin was able to invest considerable amounts into its infrastructure. The tram lines were considered out of date and abolished, giving way to utopian road construction plans. Inspired by the financial liquidity and the spirit of the time, planners developed a concept of inner city

motorways. Due to public protests, only two thirds of a motorway encircling the city were realized. It was also due to public protests and lack of request, that the western S-Bahn system was closed down.

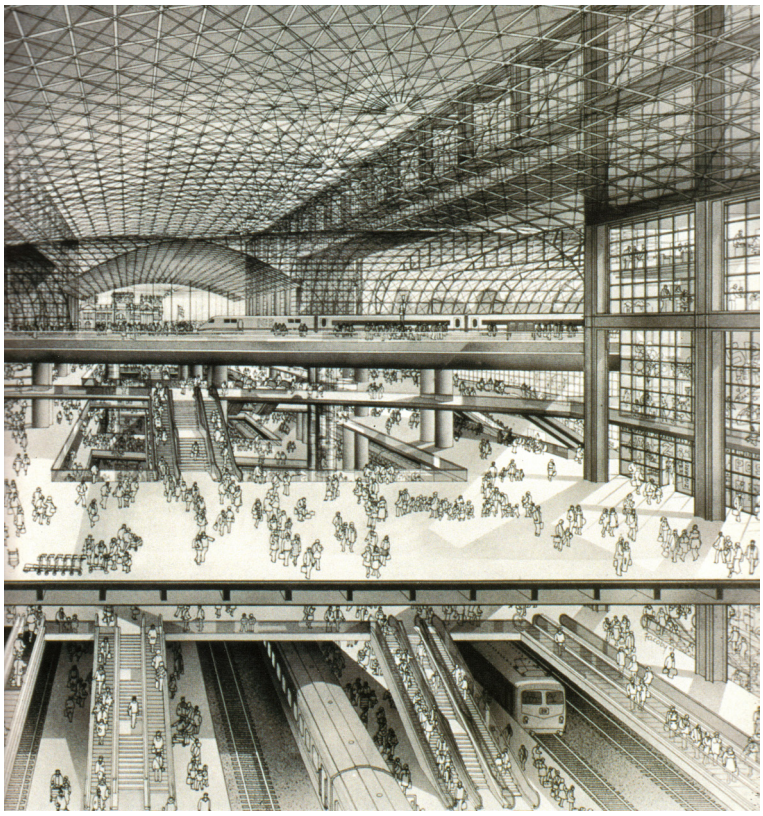


Figure 249: **Drawing of the Berlin main station of GMP Architekten for the competition entry**

The eastern part of the city however further developed its S-Bahn and Tram network, consequently the city's halves grew evermore apart. That was until the 9th of November 1989. The urge to reconnect the city halves, the euphoria of Germany's reunion and the belief that soon the capital would count 5 million inhabitants led to a wave of enthusiastic, but contradictory plans. Everything was to be realized: new motorways in the east. New S-bahn networks and tram lines in the west. New underground lines in the east. No Trams anywhere. No S-Bahn anywhere. A new main station. The possibilities seemed endless, however soon the realisation followed, that they were in fact not. It became clear, that even simple invasions into the existing structures were costly and tedious operations.

It was decided to reanimate the circle line and invest into a new main station, one new underground line towards the east, and two tram lines towards the west. With tight funds the city is still working towards this goal. Yet through effective management of the existing structures, and an increase in trains, the capacity of the public transport system has significantly increased compared to pre-war times.

After a long struggle, many backs and forths Berlin finally has an effective, extensive and reliable local public transport system. In order to make the most of the costs and efforts invested into it, a denisification along the existing routes and in the heart of the city is the only appropriate way forward.

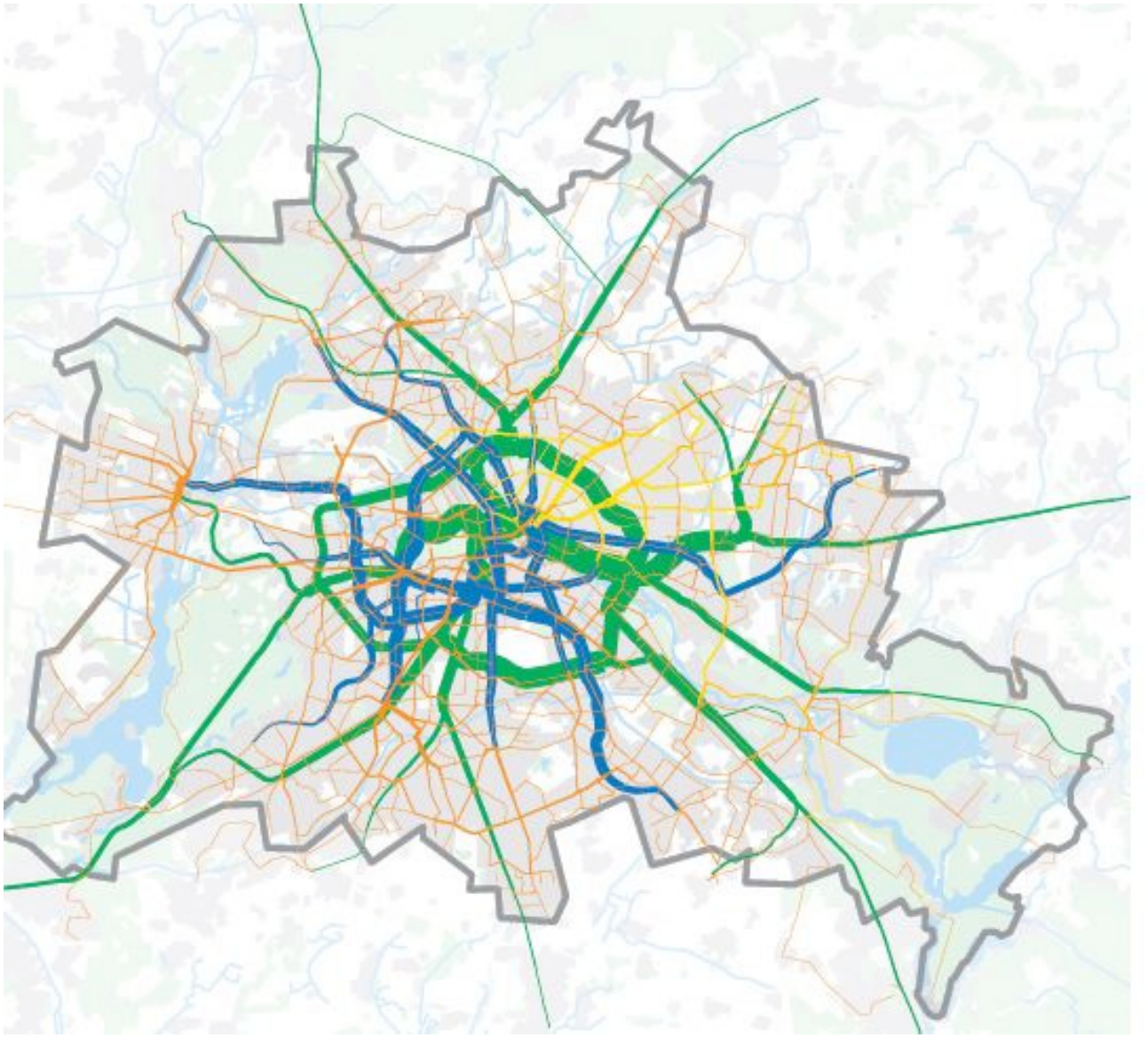
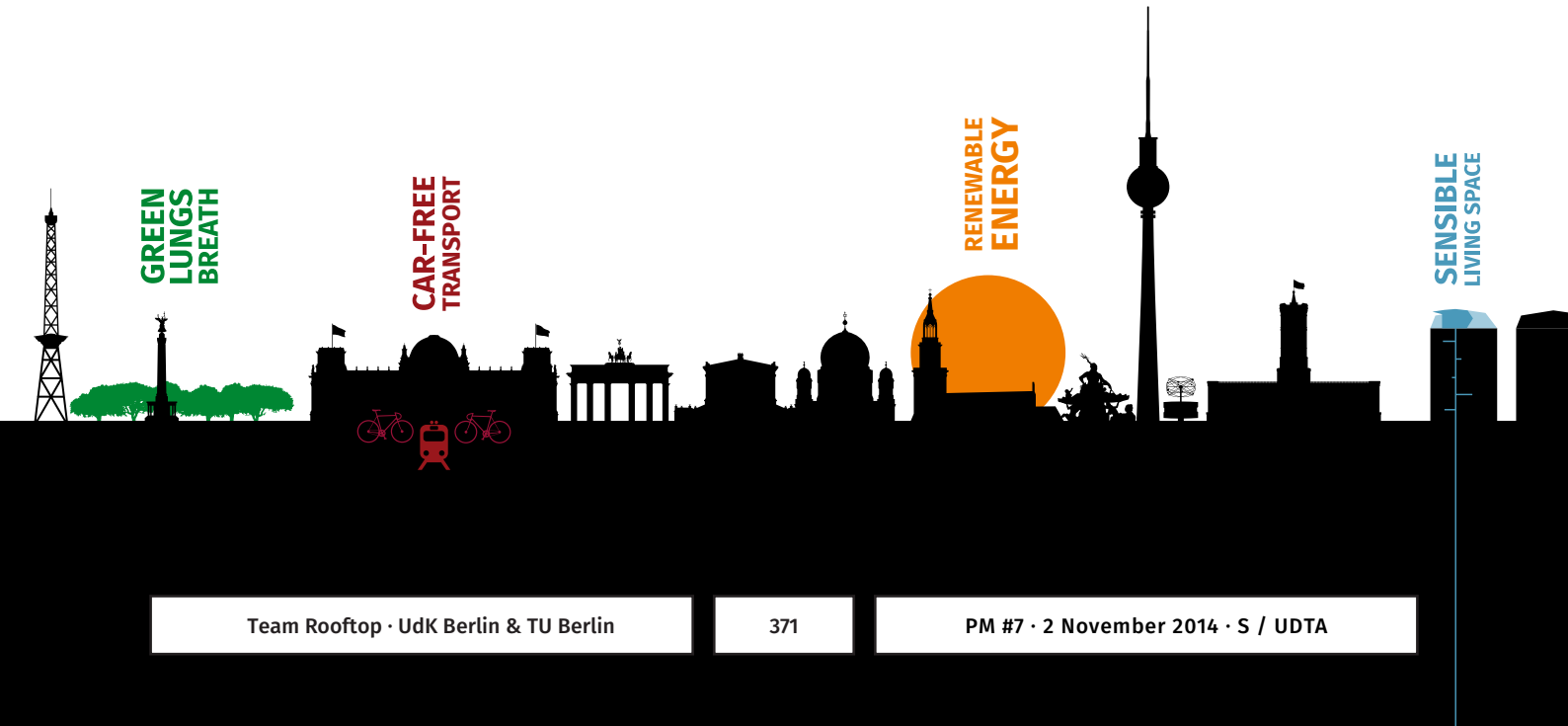


Figure 250: **Contemporary capacity of Berlin's public transportation system**

TRANSPORTATION AND ROOFTOP

The Rooftop Unit contributes to a sustainably developing city in several ways. This is illustrated below. The first and most obvious quality is the advantage that our Rooftop Unit allows the city to increase its density without sacrificing green lands. Furthermore, by adding the Rooftop Units to existing buildings, no buildings need to be demolished but they are renovated and transferred into state of the art energetic buildings. This allows landlords of the existing buildings to lighten annual maintenance costs by creating a new income source by adding the Rooftop Unit that generates power from photovoltaic systems.



MOBILITY

By focusing on the inner city densification instead of sacrificing the valuable green parts our inhabitants can use the existent public transport system whose heavy investments can be better redeemed. The mobility strategy is extended by using electric bicycles that allow individual mobility as well as free movements outside contributing to a sustainable and healthy lifestyle of the Rooftop House and host building's inhabitants.

As already outlined in the Mobility Strategy in Chapter 5.1.4 the e-bikes provided by Copenhagen Wheel offer adoptable solutions to the specific needs of the various inhabitants in the host and Rooftop Units. By replacing an average of 50 percent of the current car usage in Berlin by cycling with the e-Bikes, the overall traffic generated by cars drops from 32 to 16 percent in 2020 after the establishment of Rooftop Units all across the city. One single Rooftop Unit and its host building can save an incredible amount of more than 170,000 Euros in costs that would incurr for the car usage within 12.4 years (which is the average lifetime of a car before it gets replaced). Additional to the monetary savings of the dropped car usage there is a reduction of CO2 emissions of 8.875 tons. This is generated by just 25 people resp. households dropping their car usage by 50 percent. This number approves the great potential of Rooftop's mobility strategy since the overall drop in car usage in Berlin's population by 50 percent would mean an incredible reduction in CO2 emissions. One person saves 1.78 kg of CO2 emissions per year by reducing car usage by 50 percent. Therefore, the whole population of Berlin would save 623,356 tons of CO2 in only one year. This equals 12.5 percent of the current CO2 emissions caused by traffic.



Figure 251: **Saved CO2 Emissions**

Furthermore, the sensing unit of the Copenhagen Wheel captures information about your surrounding while you drive such as air pollution, ambient temperature and noise level. This information can be shared through an online platform. You also have the possibility to share the information with your city. By gathering data

from several units over a period of time maps of urban data can be created as shown in Figure 252. These maps can be used to plan healthier bike routes and support professionals in combating air pollution and prevent traffic congestions. A course analysis of the fine-grained data can help to understand the impact of transportation on the city infrastructure and help study such phenomenas as heat islands. Thus, this crowd-funding can help the city structure and implement environmental friendly transportation policies.

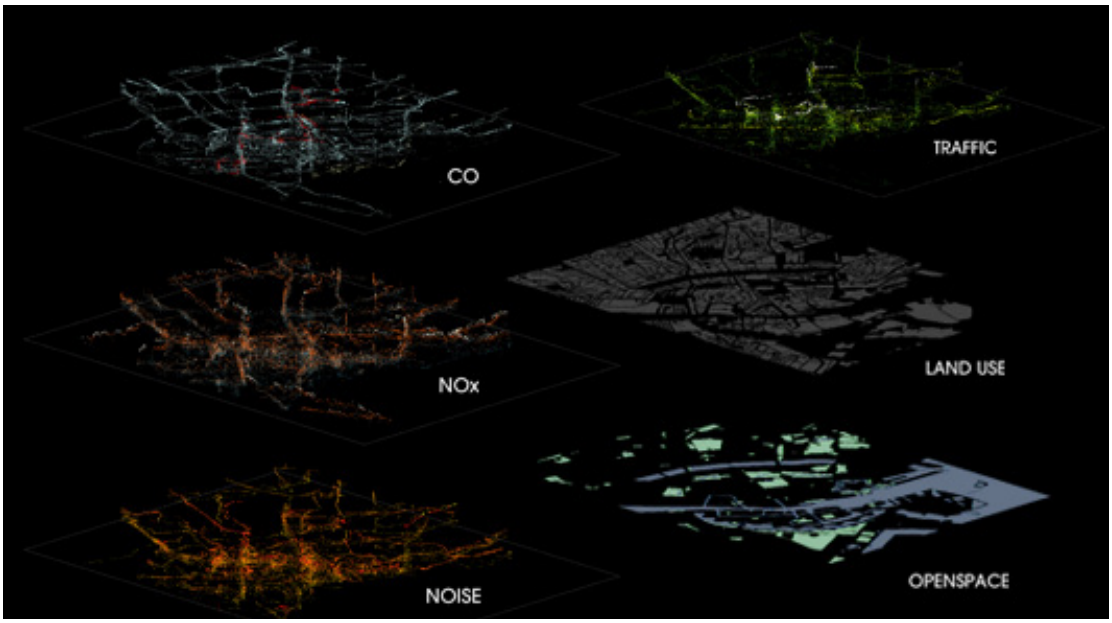


Figure 252: **Urban data gathered by Copenhagen Wheels (source: senseable.mit.edu)**

An example of how the app showing you the current pollutions levels of NOx in your city is shown here:

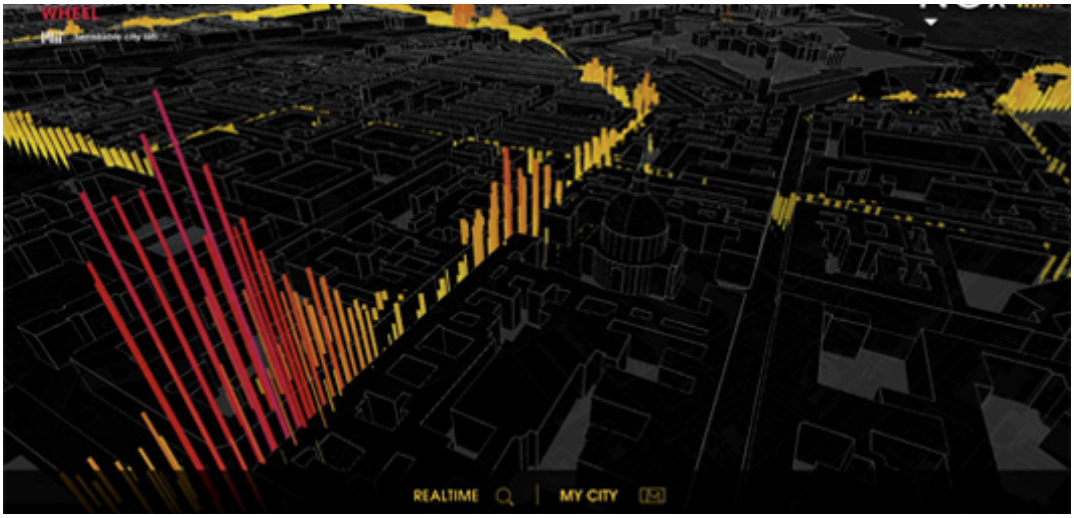


Figure 253: **Application data about NOx (souce::senseable.mit.edu)**

AFFORDABILITY STRATEGY

Another sustainable factor in our Rooftop concept is the innovative business model making the Rooftop Unit affordable to a majority of people. This concept does not concentrate on fast money streams to build dozens of skyscrapers with luxury flats but focuses on a private funding and a socially fair development. Hence, the rent for the Rooftop House will always be fixed below the rent index for the specific area to not contribute to overall rising rents. It therefore increases solidarity within the communities and demonstrates a sustainable and socially fair investment in new living space. Our affordability strategy includes a contracting solution between Team Rooftop and the base house owner, where the Rooftop Unit is built on. The base house owner allows Team Rooftop to put a Rooftop Unit onto the existing house. By allowing this, Team Rooftop pays for the renovation of the roof structure as well as the base house leading to higher energy efficiency of the base house.

With our crowd investment business idea we are also able to rent the house for less money than the rent index for the specific area would suggest. Therefore we countervail the rising rents of capitals in Europe, especially in Berlin, which lead to gentrification. This enhances the social sustainability of our project.

5.6.2 BIOCLIMATIC STRATEGIES

Berlin is located in the temperate zone at the transition from maritime to continental climate. The average annual temperature is 9.5 °C and the mean annual rainfall 591 mm. The warmest months are July and August with an average temperature of 19.1 °C and 18.2 °C. January is the coldest month with an average temperature of 0.6 °C. Most precipitation falls in August with an average of 64 mm, the fewest in April with an average of 33 mm (averages from 1981 to 2010 by the German Weather Service).

With respect to the wind speed and wind direction, mostly Northwest and Southwest winds are observed in Berlin. Especially in winter wind speeds are high and a lot of maritime, well mixed and clean sea air is brought to the city. Southeast and East winds are characteristics for high-pressure weather conditions from continental air masses, which can lead to very hot or very cold days, depending on the season. The latter weather conditions characterized smog situations until the 1980s, because the pollutants produced in the city (especially stoves and car exhaust) could not evaporate due to the low exchange weather. The sharp decline of coal-burning stoves and the advent of exhaust filters and catalysts in cars have significantly mitigated this problem for the last 20 years.

The small differences in roof height within the city lead to a quite homogeneous urban climate. However, significant differences in temperature can be measured due to the density of buildings in the city and the district centres compared to large urban open spaces, and in particular to the vast agricultural areas in the surrounding regions. Especially in summer nights temperature differences of up to 10 K are measured. In this regard, Berlin benefits from its large green spaces; more than 40 percent of the urban areas are green stock. The great number of smaller open spaces, but in particular the larger urban green areas such as the Tiergarten, the Grunewald and the former Tempelhof airport, which climatologists refer to as "cold islands”.

The following bioclimatic strategies have been devised based on the local climate in Berlin and are considered as appropriate passive design strategies to ensure thermal comfort inside the Rooftop Building using as little as possible energy during the entire life cycle of the respective components.

PASSIVE DESIGN STRATEGIES

To get a quick impression of the holistic bioclimatic concept, this chapter starts with an overview of the applied strategies. The respective components are described in a more detailed way in the course of this chapter and also in the chapter Engineering and Construction Design Narrative on page 111.

Our special façade design allows reaching a u-value nearly as low as a wall during the winter months. In fact, when the shading devices are closed, an air gap is generated between the glass façade and the shading devices. If properly dimensioned an air gap acts as a great insulator; it should not be too large in order to prevent heat transfer by convection, nor too small so that conductive heat transfer can be efficient. The façade was first planned to act according to the following regulation: open during the day and closed during the night. This has changed, the concept has been analysed in detail and different operating scenarios have been designed for optimal use of solar gains and shading. During the winter, when the façade is set to the open position, the overhang allows the direct solar radiation to enter the indoor space; on the contrary, in summer time the overhang shades the glass façade due to the higher solar trajectory. A temperature

sensor located in the room regulates the closing of the shading devices when the room air temperature reaches 24 °C to prevent overheating. This baseline temperature was chosen according to thermal comfort standards set by ASHRAE, where 24°C represents the lower limit of a range of summer acceptable operative temperatures. As the temperature will continue to rise due to the thermal mass of the building, it seems reasonable to set the shading devices' regulation on the lowest temperature of the acceptable range. The roof has a passive ventilation system below the photovoltaic collectors, in order to raise their efficiency and protect the room from excessive heat. In cooling mode, the PCM ceiling stores the heat during the day time and transfers the heat using water pipes to the vegetal filter bed during the night time. A central ventilation system recovers the exhaust heat and pre-heats the incoming fresh air up to 90%; the remaining heat will be used to increase the air heat pump efficiency. The central exhaust air contains the exhaust air from the bathroom, the kitchen and additional air from the electric equipment heat like the battery to cool it and use the heat for the heat pump evaporator.

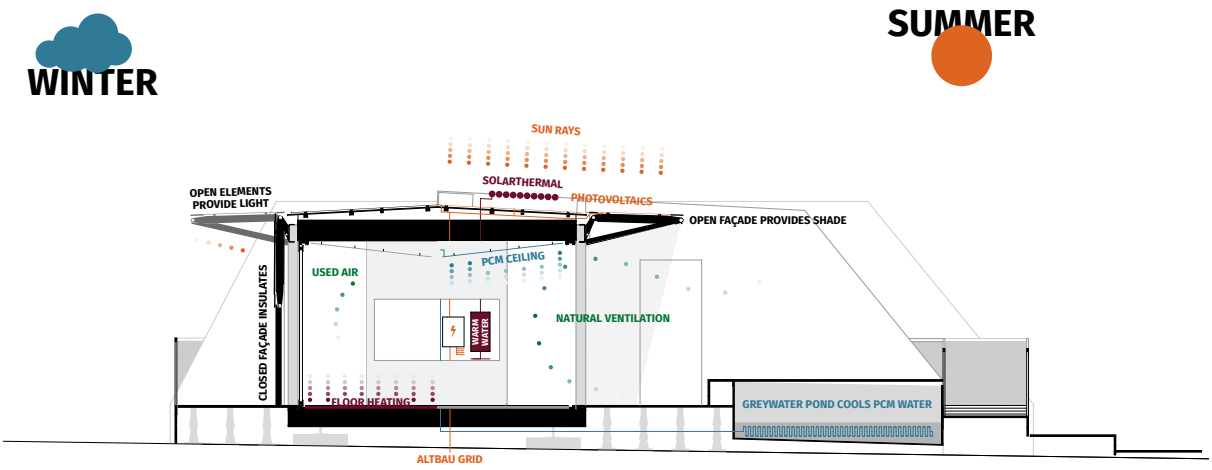


Figure 254: **Bioclimatic Scheme**

Project Envelope

During the design process we kept in mind the fact that we wish to build a sustainable building. To achieve this goal our principles were:

- using as less material as possible
- using as much materials produced close to the site as possible
- using working processes as sustainable as possible.

This is the reason why we ordered the construction wood from local manufacturers and work closely with a local craftsmans' professional school. Also, this is the reason why we choose local wood for our terrace instead of the bangkirai type that might be found on many Berlin Rooftops.

Among common construction materials wood is a good insulator, especially if compared to metals such as steel. It is important for our insulation strategy to use wooden pillars as this is an additional positive factor and keeps the house close to the environment. Even though our façade uses metal materials to move up and down offsets this in terms of energy production. The system is also designed to last a long time, maybe even improve with age, like good wood (or wine) is supposed to.

As a rule of thumb, the built environment should modify the natural environment to approach optimum conditions of livability. The shelter should filter, absorb or repel environmental elements according to their contributions to human comfort. A strong importance to the way a building interacts to its surroundings should be given from the very first stage of design, especially when designing a sustainable house. Due to its location on top of existing buildings, Rooftop has a very profound interaction to the surrounding climate and it is designed in order to exploit this aspect as much as possible. The unit is largely exposed to solar radiation as it typically has low to no neighbouring shading surfaces. Moreover, it is greatly exposed to winds due to its height and to the few obstacles to the wind airflow. These aspects were at the basis of the Rooftop design.

The simple, compact shape of our design grants a low area/volume (A/V) ratio, which is suitable for cold climates such as the one of Berlin, and minimizes thermal bridges and undesired thermal losses.

Glazing

The glass façade provides a great impact on the thermal performance of the Rooftop House.

Typical for glass façades is the great part to the thermal heat loss of buildings created by transmission. The chosen system provides a collective thermal transmittance of 1,1 W/(m²K) and a total energy transmittance (solar transmission coefficient) of 0,34 W/(m²K). Thereby, in winter, the heat loss is tempered as usual for passive house standard. For more technical details see section *5.3.2 Description: Properties & Advantages of Layers - Glass Façade*.

In summer, when the sun normally heats up glazed façades, the shading created by the folding façade avoids a great part of heating-up the house. Therefore, the costs and energy consumption for cooling are kept low.

Additionally, the great glass area on top of a high building presents a great view, which creates high comfort for the inhabitants. Seven of the façade elements are movable so that the living area, especially at warm

days, can be extended and the house therefore be opened to the environment, which also increases the comfort.

Daylight

Berlin is an overall very flat city with only very few high peaks. Most building heights still syntonize to the old Prussian eaves height of about 20 meters. This was due to the limited length of fire fighters ladders at the time. For this reason, shading through neighbouring buildings is not a problem in Berlin. Even the low winter sun is not cut off by neighbouring houses, as the streets' widths respond to increasing house heights. Due to the two huge glass façades at the north and south side, the whole interior rooms are flooded by the light. Even if we have to close the façade at the south side to protect the house from overheating, the north side still can stay opened cause of very low irradiation intensity at the north side, so that it will not contribute a lot to the heating by the sun. Through the opened north façade, there is always sufficient brightness in the house from sunrise to sunset. But most of the time also the façade elements of the south side will be open because the façade will shade off the glass façade against direct sunlight at high standing sun in mid summer.

By choosing light, wooden flooring for the terrace, the sunshine is unobtrusively reflected into the interior enlightening it in a comfortable manner. As the ceiling of the house held in a light, natural clay surface, light is allowed to reach deeply into the interior spaces. In wintertime the façade elements will mostly be opened in order to maximize solar gains, closing mainly in the cold night hours. The sun does not only bring light, but also warmth to the house. So as an result we will not have to switch on additional light sources during the day. Just in the hours of darkness we have to run the artificial lighting. However, if both bathroom doors are closed, also the bathroom light has to be switched on at daylight hours. This slightly use of artificial lights reduces the energy need of the building, which influences the ecological friendliness.

Space Planning

As the interior space planning is an open space we chose not to develop a strict zoning scheme with interior division walls. However, the bedroom is located in the eastern side in order to benefit from morning sun, while the living room on the western side maximizes natural lighting usage during daytime. The relatively small dimensions of the interior with the central positioning of the technical room and bathroom make it reasonable to have a unique space. In fact, the open space solution allows an efficient controlling of indoor conditions and the privacy is granted by the nature itself of Rooftop: a two people living space. The technical room in the middle makes ti possible to reach all living zones in a very efficient way and it simplifies the heating and cooling circles.

Furthermore, the doors next to the bathtub perfectly fit the profile of the glass façade: this allows to extend the surface of the bathroom by simply "opening a door". The bathroom hence extends to take some of the hallway space and directly connects to the terrace. The advantages of such choice do not only concern the enjoyment of taking a bath as part of the Berlin skyline. In fact, such a solution also allows natural light to enter the bathroom space, and it permits the benefits of natural solar gains. Moreover, this solution allows to further divide the internal planning. The bathroom separation helps to acoustically and spacially divide the bedroom from the living room, granting more privacy for the inhabitants.

Passive Heating Strategies

The Rooftop project utilizes the sun as its power source in three different ways: PV solar cell equipment generates current from the incident sunlight, a heat pump uses the exterior air as source for producing hot water and solar thermal collectors support the heat pump cycle.

Two long glass façades facing South (equator) and North maximize direct solar heat gains through the building envelope during the cold months and grant a vast amount of natural lighting. The radiant floor is characterized through a good thermal mass, which helps enhancing energy storage and releases it during the cold hours. At the same time, the presence of such big glass surfaces could originate great heat losses during the night time and this is the reason why the folding façade was engineered. Furthermore, the glazing surfaces are designed to allow as little thermal losses as possible during the night. Acting as a miniature power plant and as important insulation during the winter, this façade becomes a screen to direct solar radiation during the summer months, when it also contributes to enlarging the living space by providing pleasant shaded terraces.

Passive Cooling Strategies

To gain a fundamental understanding of the operation of PCM, it is necessary to explain the concept of latent heat closer and distinguish it from sensible heat. Illustrative, this is explained using the example of water. The energy required to melt of 1 kg of ice, approximately corresponds to the energy which has to be applied during the heating of 1 kg of water from 1 ° C to 80 ° C (Mehling, Schossig and Kalz 2009).

While water is a latent heat storage at 0 °C, the heating of water from 1 °C to 80 °C is a sensible process. This term comes from the fact that the sensitive storage of heat can be felt due to the temperature increase. Latent heat storage means the storage of heat during a phase change, in this case from solid to liquid, wherein the temperature remains constant, even though a large amount of energy is supplied to the system. This image (see Figure 255) shows the processes of sensible and latent heat storage are shown. While during sensible heat storage, the temperature increase is related proportionally to the amount of stored energy, the latent heat storage is characterized by an isothermal region. This indicates the process of melting of the material, while the heat is still stored, even though the temperature remains constant.

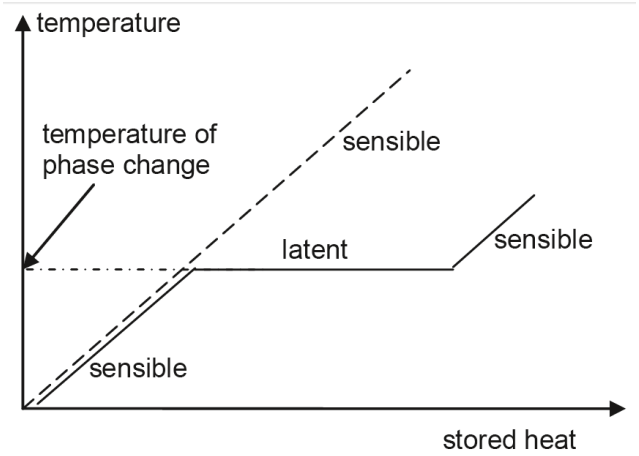


Figure 255: **Heat storage as latent heat for the case of solid-liquid phase change (Mehling and Cabeza 2008)**

In building technology this physical principle is used to compensate temperature fluctuations in spaces and to store energy from for example solar thermal systems. In order to create a pleasant indoor climate, materials are needed that do not have a melting point at 0 °C as water, but at 20 to 30 °C. This is the case with salt hydrates, paraffins and fatty acids, whereby paraffins have been commercially available as PCM integrated into building materials for well over 10 years (Mehling, Schossig and Kalz 2009).

In buildings with heavy mass the heat storage capacity of the components in most cases is sufficient to prevent overheating in summer and a fast cool down in winter. However, lightweight buildings' thermal mass must be introduced into the building in addition to prevent this. In Figure 256 different materials are compared in relation to their thermal storage mass. It shows the link the thermal storage capacity regarding lightweight buildings (components made of for example wood or plaster) and heavy building masses (components made of for example brick or concrete). At the same time the advantages of PCM are highlighted as mass storage in lightweight buildings. With thin materials, the thermal mass of the building can be increased significantly without having to deviate from a consistent lightweight construction.

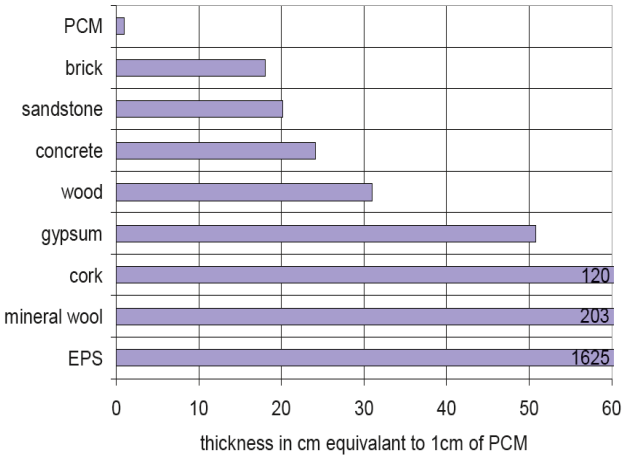


Figure 256: **Necessary layer thickness of different building materials to store as much heat as a 1 cm thick layer of PCM (Mehling and Cabeza 2008)**

The entire cooling system is based on a PCM-ceiling is described in the chapter Engineering and Construction Design Narrative, which shows that both active and passive control of the system is possible. This is made possible by using a control system for the discharge of the PCM ceiling, which checks during daytime the "charge level" of the PCM, which means that, based on measurement calculations are performed that indicate the degree to which the PCM is liquefied within the ceiling panels. Once a certain degree of liquefaction has been reached, the heat pump is activated and provides cooling water to discharge the PCM. This must be done before the PCM is fully liquefied, since it would lead to a significant increase of the indoor temperature, because of the inertia of the PCM ceiling, before the effect of the cooling fluid could be notice.

As the ceiling is designed in a way that under normal circumstances it is able to absorb the entire cooling load during the day, in general it must be unloaded only during nighttime. For this purpose, the water temperature is checked using temperature sensors in the constructed wetland. In case the temperature exceeds 18.4 °C after 23.00h, the cooling circuit is passed through the heat pump, which cools the cooling fluid to the desired temperature.

Using this scheme, we have our cooling system designed in a way that under normal conditions it functions as a passive system, only requiring a pump with a capacity of about 4 W as active component.

Thermal Energy Storage

The Rooftop project utilizes two buffer tanks to optimise the domestic hot water production and the heating/cooling cycles supported by the heat pump and the solar thermal collectors.

A domestic hot water (DHW) cylinder with 235 l capacity and a maximum temperature of 45 °C is integrated in the front of LWZ 304/404 SOL heat pump from Stiebel Eltron. An improved thermal insulation reduces heat losses to a minimum.

Furthermore, a 200 l buffer cylinder (SBP 200 E cool from Stiebel Eltron) is coupled with the heating and cooling system for a number of reasons we will explain hereunder. An advantage of such cylinder is given by the possibility to operate the tank both in heating mode in winter and in cooling mode in summer. As a result, the SBP E cool entirely exploits the whole performance range of a heat pump-based system, in winter and summer alike. The maximum temperature in heating mode is 35 °C. As expected, this value is lower than the temperature of the domestic hot water vessel. In fact, a great benefit of under floor heating system is given by the possibility to operate at relatively low temperatures. Also in this case, a highly effective insulation guarantees very low heat losses.

The primary heating water in both buffer tanks is not mixed in order to achieve the benefits of natural stratification or thermal layering. In fact, stratification allows the water to sort itself according to the principles of gravity (hotter water rises, colder water descends) almost flow-less into the corresponding thermal zones, resulting in a fast process with very low energy losses and no surplus energy use. By doing so mixing effects are minimized, the efficiency of the heating system is improved and hot water can be directly extracted at the required thermal level.

A buffer tank, or thermal energy storage (TES), is basically a certain amount of water which allows thermal energy to be collected. Energy demand can be balanced between day time and night time and, in the case of heat pumps, heat or cold can be produced in off-peak times at lower cost electric power and used later.

Besides just acting as thermal energy storage, buffer tanks coupled with heat pumps also play an intrinsically important role.

For air source heat pumps a buffer tank offers two main benefits: it helps reducing the number of times the heat pump has to “cycle” (i.e. times it has to stop and start) by providing a larger thermal mass that avoids triggering the thermostat to start and stop the heat pump too often, and it grants heat to defrost the heat exchanger, which runs much colder than ambient temperatures in air source pumps, and as a result may become frosted with ice.

The first aspect can be explained by thinking that the heat pump requires a certain capacity of “open circuit” within the under floor heating distribution system and the innovative PCM cooling cycle. The presence of a buffer tank from which heat is distributed to the individual zones as required prevents the heat pump from short-cycling (or continually switching on and off), which is particularly relevant as it increases the life expectancy of the compressor and decreases the amount of energy used to start the motor. As a result, it leads to lower maintenance and operation costs. Furthermore, it allows a larger degree of heating management and makes individual room control possible. An air source heat pump will work more efficiently with less wear on the pump and compressor if it does not have to continually cycle on and off when the demand for heat is low.

The aim with a heat pump is always long and low, to achieve a steady input of low-level energy and a constant internal temperature. In this way, a buffer tank can serve to extend the life of a heat pump and reduce the running cost.

Standard heat pumps operate with fixed speed air source, which means that the heat output often varies and it is strongly dependent on the temperature of the outside air. In this case a buffer tank is definitely recommended, as the heat pump always produces its full capacity when switched on and does not have the possibility to modulate its output depending on the needs. In fact, the buffer tank provides an extra amount of water; this water increases the volume of the heating distribution system. During the low load conditions, the extra volume of water would absorb any of the extra heat generated by the heat pump thus increasing its efficiency.

Both the size and the operating temperature of the buffer tank affect the efficiency and effectiveness of the tank. As mentioned above, in the Rooftop project the temperatures within the buffer tanks are maintained rather low if compared with standard practices: in fact, the water temperature at the top of the vessel (which is at the highest temperature due to stratification) is only of respectively 35 °C for the heating circuit and 45 °C for the domestic hot water. This choice enhances the energy performance and is made possible by the short pipes connection and the constant water movement the buffer tank is subjected to. Another important aspect concerns the return of colder water from the heating cycle to the heat pump: buffer tanks even out the temperature and the flow rate of the fluid going into the heat pump. This is important because any extremes of temperatures or flow rate through the heat exchanger coil would cause inefficiency of operation.

The full potential of a thermal storage is realized when it is used to store and manage a number of different heat inputs and outputs. In our case, the heat stored in the buffer vessels comes from the heat pump and is supported by the solar thermal collectors, therefore fulfiling the capability of the buffer tank to be coupled with different technologies.

Ventilation

For ecological sustainability it is important to reduce the energy consumption of buildings as the building sector is responsible for a big part of the total energy consumption. The ventilation has the possibility to reduce the consumption of heat energy, cooling energy and electric energy.

To achive this, there is a ventilation concept to work as a central ventilation system, in detail a combined ventilation and heat pump device (Stiebel Eltron LWZ 304) in the core module supplying living and sleeping room with fresh air via vent slots (Berliner Luft WSA-ZS 151 – A – 1200) located in the module in a distance of 100 mm from the lowest part of the ceiling and provide a width of 1200 mm in the middle of the wall.

The exhaust air is removed through the core module as well. It is ventilated through vent slots with a length of 800 mm in the bath and in the kitchen which are embedded seamlessly into the shadow gap of the ceiling. They are custom made by our team as a wooden box coated with tinfoil from the inside and hidden above the ceiling.

Each of the vent slots is connected to the air distributors via two pipes (Stiebel Eltron LVS system) to reduce the air flow in each of the pipes and therefore reduce the airflow generated noise. These distributors are connected to the ventilation unit of our heat pump. This connection is made by a sound absorber, reducing

the sounds coming directly from the ventilation/heat pump. To reduce the influence of other sound sources located in the mechanical room there are also little sound absorber in located in the pipes for the air supply.

The ventilation of the mechanical room is provided by a separated fresh air supply and a separate exhaust air removal which are located in the air distributors in the room. Therefore, the support of the cooling process of the technical devices in the room is assured, so they can work more efficient and the amount of energy needed for cooling them down is reduced. Additionally we can recycle this heat energy with a heat exchanger for heating the fresh air during winter.

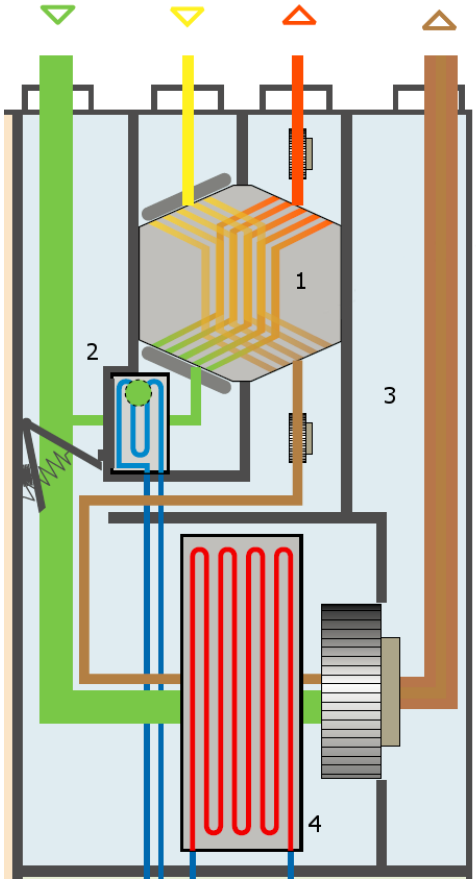


Figure 257: **Schematic diagram of the ventilation device (heat exchanger 1, preheating device 2, vents 3, heat pump 4) [Stiebel Eltron: Planung und Installation Lüftung March 2013]**

There is also the opportunity to provide a passive natural ventilation of the building by manually opening the windows to provide a fast rush airing when needed or desired. By opening windows manually in the summer nights the air in the rooms can be cooled, which helps to save energy by supporting the cooling system of the PCM-materials in the ceiling while discharging. This support is depending on the habits and preferences of the inhabitants opening the windows of the building.

We assume that the average inhabitant will open the windows on warm summer days for at least 30 minutes, which is enough to reduce the temperature of the room to a value close to the outside temperature. Then the windows are being closed and ventilation is again solely maintained by the ventilation device.

Our ventilation device is integrated in the heat pump we use for heating and cooling. Thereby, not only

space in the mechanical room, but also costs for installation maintenance and material can be saved. This is because many of the installed parts can be used for both systems, the head pump and ventilation, in comparison to a combination of two separate systems. The heart of our ventilation (see Figure 257) consists of the passive cross-flow heat exchanger with an efficiency of up to 90 percent [Stiebel Eltron LWZ 304 product data sheet] two vents consuming only 60 W together with the vent that is needed for the heat pump and a preheating device needed for frost protection in the winter times.

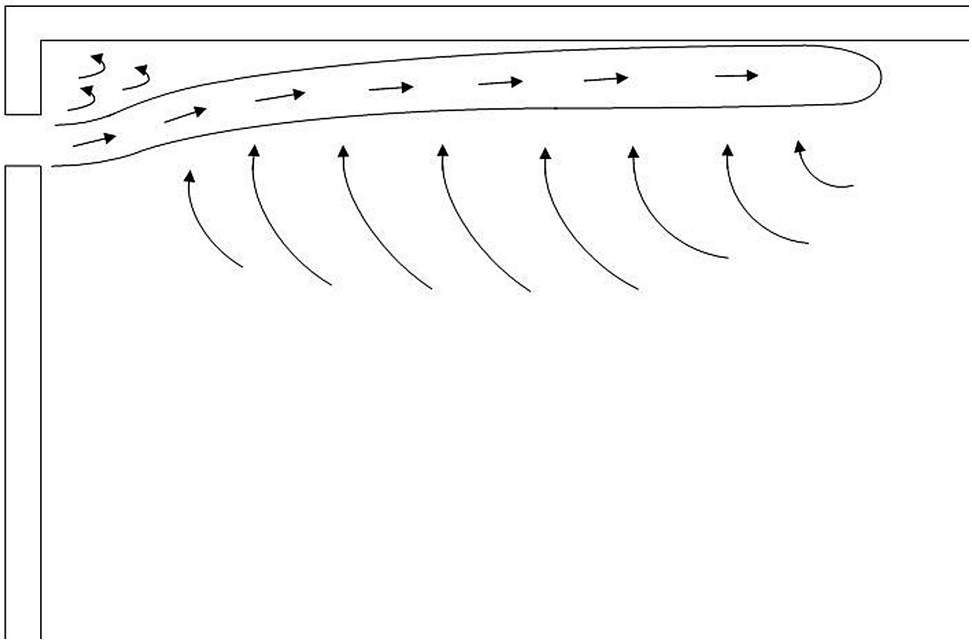


Figure 258: **Coanda effect**

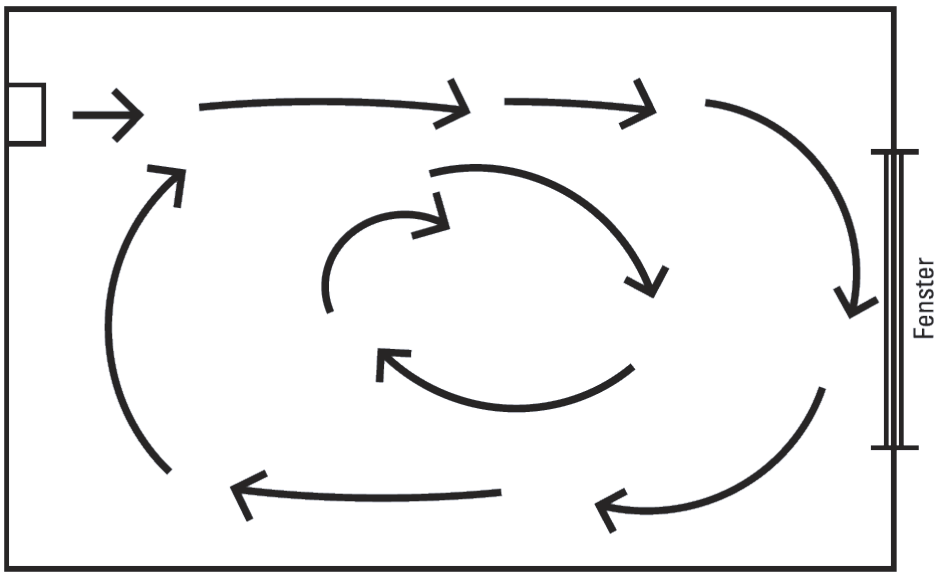


Figure 259: **Mixed air [Berliner Luft: Grundlagen der Luftverteilung January 2000]**

The heat exchanger enables us to regain heating energy out of the exhaust air in the winter times and by this heating the cold fresh air before releasing to the rooms.

The ventilation is combined with sensors for humidity and carbon dioxide located in the exhaust air pipes from the bathroom and the kitchen. They allow a regulation of the airflow rate generated by the ventilation system. The system will increase the airflow whenever a high humidity or carbon dioxide concentration is detected. So we are able to reduce the air flow that is constantly exchanged by our ventilation to a minimum of around 80 cubic metres per hour (30 per person living in the house and 20 for the mechanical room) and increase it on demand, reducing the overall energy consumption of the ventilation.

We do not use a humidification system, as there are concerns regarding development of mould because of the high humidity normally needed in such a device. Also we have concerns about the standard of hygiene we can achieve, not only because of mould, but also the development of germs in the water used by the system, especially in times the system is not running. There is also high energy consumption and a great effort of maintenance resulting out of such a system.

Although we have a central ventilation system the friction losses of the piping needed for the distribution of air and therefore the amount of energy needed for the transportation compared to convenient systems are reduced by minimizing the piping length as a result of the integration into the core module.

As a side benefit modularity is enhanced by this integration of the complete ventilation system into the core module. Furthermore it enables a discrete appearance of the ventilation system by giving us the opportunity to use small and very discrete types of ventilation openings and minimizing the visibility of the ventilation system.

Directing the air flow up to the ceiling we can use the phenomenon of the Coanda effect to regulate the indoor air flow. Therefore the flow attaches longer to the ceiling because of a negative pressure forming between both (see Figure 258). The air drops near the end of the room forming an air rotation (see Figure 259) enabling a balanced air flow and nearly constant conditions throughout the room.

This method of circulation improves the comfort of the inhabitants as there is less draft in the comfort zone of the people especially near the floor.

Furthermore the airflow below the ceiling induced by the Coanda effect leads to an improved heat transfer coefficient for our passive cooling (PCM-ceiling) by generating a forced convection. Without the need of any additional vents, just by using the normal ventilation needed any ways. This leads to a better heat transfer between the room and the PCM-ceiling.

HYBRID OR SEMI-PASSIVE SYSTEMS

PCM-System

As explained and discussed in the paragraph “Passive Cooling Strategies” we included a semi-passive cooling system, which is able to provide thermal comfort using a minimum of energy to discharge the PCM, while being passive during daytime. During night time it turns into a hybrid system, which can be discharged using a constructed wetland as a heat exchanger or, if needed, the heat pump operated reversible.

Exterior Design

The constructed wetland is situated on the gardening terrace and so is part of the exterior design solutions. It affects the microclimate in multiple ways, although because of its measurement in small manners.

With a width of nearly 2 meters profile planted with reed, the facility offers a certain wind shield for some of the incoming wind directions. Since high buildings often produce turbulence and over coating effects in upper levels, these wind directions are more often and the reed cover can offer a welcome wind shield.

Furthermore since the gravel bed of the constructed wetland is nearly complete filled with water, evaporation of the water occurs in warm seasons. This improves the humidity on the gardening terrace while simultaneously decreasing the temperature close to the facility.

The constructed wetland affects the sustainability of the dwelling by cleaning the produced grey-water. This can be used for second use, here with the concrete purpose of irrigation of plants.

Through the combination of the constructed wetland with the PCM cooling circuit, the faciliy function as a heat exchanger with a regenerative medium. Thereby the energy consumption of the cooling circuit is lowered with simultaneously heat delivery for the wetland, which is needed to maintain the cleaning process while lower temperatures.

Via the combination of warm disposal water and additional heat flow from the PCM, the constructed wetland forms a heat source in cooler seasons, which increases the environmental temperature by a small amount.

5.6.3 CONSTRUCTION SYSTEM

For the construction of our plus-energy house we decided to focus on three main ideas: a fast assembly, structural safety and of course the sustainability of our construction.

To ensure reaching these requirements we decided to segment our house into respective modules. As an advandage of this concept, the punctual delivery of the construction material is simplified. The prefabricated modules will be stacked efficiently, which saves capacity of transporting. This also saves costs, as less trucks or transportation vehicles will be needed.

The supporting structure consists execlusively of wood, the common material for the region Berlin/Brandenburg. A local distributor who guarantees the origin of the wood and the FCS certification will provide all for the construction neede wood.

As insulation material cellulose (recycled wood fibre) is implemented in all modules of the thermal envelope, except the glass façade, to guarantee a maximezed thermal insulation for an efficient energy usage. Therefore, in summer an additional cooling will not be necessary and in winter the heat loss via thermal transmittance through the thermal envelope is minimized. Additionally, by using cellulose insulation, the implementation of not sustainable product is also minimized. For more technical details, especially advantages and disadvanteges of the combination of wood and cellulose insulation see section 5.3.2 Description: Properties & Advantages of Layers - Wooden Structure With Cellulose Insulation. The social and economic advantages of wood as building material are presented detailed in section 5.6.5 Materials.

Toxic chemicals, mostly used in glues, are avoided by connecting the modules using steel bolts. Another advantage of this connection type ist the short time of assembly and disassembly, because no drying time has to be considered. Additionally, the assembly and disassembly of the building during the competition can be realized without producing any waste, as all connection components can be reused several times. Furthermore, the steel connections leave expanding space, so that the wood is allowed to expand and shorten naturally. This aspect is an important advantage considering the planned location of the house. Placed on the roof of an existing building, the envelope will be weathered. Especially the force action of wind and rain in hights of more than 13 meters has to be considered. Setting the construction wood under restraint wood increase these forces on the carrying structure. By minimizing the pressure and suspension, the risk of generating cracks in the supporting structure is avoided. Nevertheless, the protection of the materials used inside by the structural and insulating envelope can be ensured using this construction type.

The re-use of our house after the competition is an aspect we want to consider thoroughly to achieve an overall sustainable concept. This will only be reached, if the whole life cycle is planned from the beginning and will not stop at the competition.

Therefore, our house will be used afterwards for further tests and as a prototype for presentation to stutents and visitors of the UdK (University of Arts in Berlin). It will be placed on top of one of the UdK buildings - the exact location our hous is designed for. Additionally, located on the roof of the University, further attention to the project will be attracted. Also, it will be seen how he different aspects are working together in long term and realistic conditions e.g. the phase changing material with the natural cooling pond and of course

the photovoltaic-modules.

Energy Consumption

For the construction on a Rooftop, the construction tool, which will require the largest part of energe, will be a tower crane to reach the necessary heights. Calculating the needed energy, we decided to consider the properties of a tower crane 81K fabricated by Liebherr („Data Sheet Crane LIEBHERR 81K“ on page 393).

This crane can sufficiently carry all our modules up to the roof. The use of energy is supposed to be 15kWh for the lifting-engine and 15.4 kWh for the engines, which will be able to move and turn the crane. Those specifications are for an engine running with maximum of power.

For the assembly at the roof we calculated an usage time of the crane for about 4 days and 8 hours per day. During the working time never all engines will be running at the same time and moreover, they will not be running the whole time due to attach and detach the modules. All in all, it is plausible to calculate with 60% of the energy need:

$$kW = (15 + 15{,}4)kWh * 0{,}6 * (4d * 8h/d)$$

$$kW = 583{,}68$$

To operate all the tools we need during the construction, most likely cordless screwdriver, we estimate with a factor of 15 per cent. So all the energy needed to build up our house is estimated to be:

$$\underline{583{,}68 * 1{,}15 = 671\ kW}$$

Water Use

The amount of needed water for the construction of our house is very small, as we only need water for plastering the fire walls. For the finery we decided to use “Knauft Rotband Haftputzgips”; the amount for one square meter is calculated to be 8 kg/m². The given need of water is 20 l per package with 30 kg. So the estimated need of water per kg is:

$$\frac{20\,\frac{l}{pckg}}{30\,\frac{kg}{pckg}} = 0{,}667\ \frac{l}{kg}$$

Both fire walls have an area of about 64m²:

$$4\,m * 8\,m * 2 = 64\,m^2$$

The need of plastering per square meter is given at the data sheet („Data Sheet KNAUF Rotband“ on page 390) with 8 kg/m², which means the whole water usage will be:

$$8\,\frac{kg}{m^2} * 64\,m^2 * 0{,}667\,\frac{l}{kg} = 341{,}50$$

However, the water we need to fill up our heating system, is going to stay in the heatpump circle and cannot be counted for the assembly.

Another source of water consumption is for washing hands after the shifts. The water needed for washing hands is depended on unpredictable circumstances but might be calculated with 2l per worker.

For ten workers, washing hands twice a shift, we will have a need of water of about 40 l per shift.

To finish the assembly of our building with only dayshifts we estimate a time of 3 weeks with 6 workdays each week.

$$\frac{40\ l}{shift} * 3\ weeks * \frac{6\ shifts}{week} = \ 720\ l$$

All the water we use during our construction will be around:

$$340\ l + 720\ l = 1.060\ l$$

SOLID WASTE

The produced waste during the construction phases includes:

- waste material: not needed pieces of wood and insulation material, pipe clippings etc.
- package material: plastic sheets, cords, cardboard boxes
- pallets

The overall amount of wast is very low: ca. 5m³ in 5 weeks.

DATA SHEET KNAUF ROTBAND





Rotband

Haftputzgips zum Glätten

Produktbeschreibung

Rotband Haftputzgips ist ein Gipshandputz mit speziellen Leichtzuschlagstoffen für geglättete Oberflächen im Innenbereich.

- Gipsleicht-Putztrockenmörtel B4/20/2 gem. EN 13279-1
- Mörtelgruppe P IV nach DIN V 18550

Lieferform

30 kg-Sack Material-Nr. 00002862

Lagerung

Säcke trocken und auf Holzpaletten lagern. Lagerfähig ca. 3 Monate. Beschädigte und angebrochene Säcke luftdicht verschließen und zuerst verarbeiten.

Qualität

In Übereinstimmung mit der EN 13279-1 unterliegt das Produkt einer Erstprüfung sowie der ständigen werkseigenen Produktionskontrolle und trägt eine CE-Kennzeichnung.

Anwendungsbereich

Herstellung geglätteter, frei strukturierter oder abgezogener Oberflächen an Innenwänden und -decken. Als Einlagenputz für alle Mauerwerksarten, Beton sowie tragfähige Putzuntergründe. Besonders auch geeignet für Renovierungs- und Ausbesserungsarbeiten.

- Vom Keller bis zum Dach für alle Räume mit üblicher Luftfeuchtigkeit einschließlich Küchen und Bäder mit haushaltsüblicher Nutzung (z.B. WC`s in Schulen und Bäder in Hotels, Krankenhäusern, Alten- und Pflegeheimen)
- Zur Herstellung von Oberflächen in den Qualitätsstufen „Q1-Q4 geglättet“ * und „Q1-Q3 abgezogen“ *. „Q4 geglättet“ * in Verbindung mit Knauf Multifinish bzw. Readygips
- Als Untergrund für nachfolgende Anstriche oder Tapeten
- Als Fliesenuntergrund
- Als Untergrund für Oberputze

Eigenschaften und Mehrwert

- Haftputzgips für Innenanwendungen
- Mineralisch
- Leicht und ergiebig
- Schafft behagliches und wohngesundes Raumklima
- Feuchtigkeitsregulierend und diffusionsoffen
- Brandschutztechnisch wirksam
- Abrieb- und nagelfest
- Auftragsdicke bis 50 mm
- Händische Verarbeitung

** Merkblatt „Putzoberflächen im Innenbereich“, herausgegeben von der Industriegruppe Baugipse im Bundesverband der Gipsindustrie e.V. und dem Bundesverband Ausbau und Fassade im Zentralverband Deutsches Baugewerbe*

P121.de Rotband

Haftputzgips zum Glätten

Ausführung

Untergrund	Vorbehandlung
Schalungsrauer Beton	Benetzungsprobe, nicht saugende Oberfläche mit Knauf Betokontakt oder Knauf Spraykontakt grundieren.
Glatte Betonoberfläche	Filmbildende Schalungstrennmittel sowie evtl. vorhandene Sinterhaut entfernen. Mit Knauf Betokontakt oder Knauf Spraykontakt grundieren.
Mauerwerk aller Art	Bei zu großer Saugfähigkeit, oder stark unterschiedlichem Saugverhalten mit Knauf Aufbrennsperre grundieren.
Gips- und Gipsfaserplatten	Staub entfernen und mit Knauf Aton Sperrgrund vorbehandeln.
Kritischer, nicht tragfähiger Untergrund	Putzträger einsetzen.
Holzwolle-Leichtbauplatte	keine
EPS - Schalungssteine	Mit Knauf Betokontakt grundieren.
Bestehende Gips- und Gips-Kalk-Putze	Ggf. vorhandene Sinterschichten, Altbeschichtungen etc. entfernen und mit Knauf Grundol grundieren.

Vorarbeiten

Putzgrund nach VOB Teil C, DIN 18350, Abs. 3.1 bzw. nach VOB Teil B, DIN 1961 § 4, Ziffer 3 prüfen. Alle Untergründe müssen tragfähig, trocken, eben, fett- und staubfrei sowie frei von haftmindernden Rückständen sein.

Untergundvorbehandlung gemäß obiger Tabelle.

Schmutzempfindliche Bauteile vor Beginn entsprechend dem Merkblatt „Abklebe- und Abdeckarbeiten für Maler- und Stuckateurarbeiten“ des Bundesverbandes Ausbau und Fassade schützen.

Betonuntergründe

Merkblatt „Gipsputze und gipshaltige Putze auf Beton“, herausgegeben vom Bundesverband der Gipsindustrie e.V. beachten. Maximale Restfeuchte von Betonflächen ≤ 3 Masse-%. Bei der Verwendung von Knauf Spraykontakt kann die maximale Restfeuchte von Betonflächen ≤ 4 Masse-% betragen.

Betondecken müssen frei von Oberflächenwasser (z. B. Niederschlag, Kondensat) sein.

Ist die oberste Decke eines Bauwerks zu verputzen, müssen vor Beginn der Putzarbeiten die Wärmedämmung sowie die Abdichtung aufgebracht sein.

Anmischen

Einen Sack mit (ca. 20 Liter) sauberem Wasser ohne weitere Zusätze mit einem Rührquirl auf verarbeitungsgerechte Konsistenz anmischen. Beim Anmischen sauberes Wasser verwenden und keine Fremdstoffe zusetzen. Geräte und Werkzeuge nach Gebrauch sofort mit Wasser reinigen.

Verarbeitung

Innerhalb 20 Minuten nach dem Einstreuen Putzmörtel anwerfen bzw. aufziehen. Zur Herstellung geglätteter Oberflächen, angeworfenes bzw. aufgezogenes Material mit einer H-Kartätsche lot- und fluchtgerecht verteilen. Nach Beginn des Ansteifens mit einer Trapezlatte abziehen und Ecken ausrichten. Bei Bedarf kann anschließend noch einmal mit der Flächenspachtel nachgearbeitet werden. Nach dem Anfeuchten der Putzoberfläche mit einer Schwammscheibe genügend Schlämme erzeugen und kleine Unebenheiten ausgleichen und filzen. Nach leichtem Abbinden der Putzfläche diese mit Flächenspachtel oder Glättkelle abglätten.

Bei nicht kraftschlüssig verbundenen Bauteilen, zwischen Wand und Decke, Laibungsanschlüssen etc., muss die Trennung mit einem Trennschnitt in der Putzschicht fortgesetzt werden (Kellenschnitt). Anstelle eines Trennschnittes wird der Einsatz von Knauf Trenn-Fix als Trennband empfohlen. Selbstklebendes Knauf Trenn-Fix auf das benachbarte Bauteil kleben und dagegen putzen. Nach dem Aushärten des Putzes überstehenden Streifen abschneiden.

Weitere Maßnahmen zur Herstellung der geforderten Oberflächenqualität - siehe Merkblatt „Putzoberflächen im Innenbereich“.

Q4 in Verbindung mit Knauf Multi-Finish bzw. Readygips.

Putzdicke

Mittlere Putzdicke 10 mm, Mindestputzdicke 5 mm. Stegleitungen mind. 5 mm überputzen.

In Sonderfällen kann auf Wände eine Putzdicke bis 50 mm einlagig aufgebracht werden, jedoch sollte ab einer Putzdicke von 35 mm eine zweilagige Ausführung in Erwägung gezogen werden, da einlagig eine erhöhte Austrocknungszeit bis zur weiteren Beschichtung notwendig ist. Durch das schnellere Austrocknen der ersten Putzlage wird die Gesamtaustrocknungszeit reduziert. Die erste Lage mit einer Trapezlatte o. ä. rau abziehen und nach vollständiger Austrocknung mit Knauf Aufbrennsperre (1:3 mit Wasser verdünnt) grundieren. Wiederum nach Austrocknung kann dann die nächste Lage aufgebracht werden.

Betondecken sind grundsätzlich nur einlagig und mit einer maximalen Putzdicke von 15 mm zu verputzen.

Als Fliesenuntergrund erfolgt der Aufrag einlagig in einer Mindestputzdicke von 10 mm. Wandflächen nach dem Aufrag begradigen und rau abziehen. Oberfläche nicht glätten und nicht filzen.

EPS-Platten und -Schalungssteine sowie Holzwolleleichtbauplatten einlagig verputzen und ganzflächig armieren (siehe Putzbewehrung), Mindestputzdicke 15 mm.

Putzarmierung

Bei Materialwechsel im Putzgrund, bei Dämmplatten etc. Knauf Unterputzgewebe oder Knauf PFT GITEX mit mindestens 100 mm Stoßüberlappung und 200 mm allseitiger Überlappung zu den angrenzenden Bauteilen ins obere Drittel des Putzes einbetten. Der gesamte Putzauftrag erfolgt zweischichtig frisch in frisch, wobei die erste Lage noch keine Hautbildung aufweisen darf, wenn die 2. Lage aufgetragen wird.

Verarbeitungszeit

Je nach Putzuntergrund ca. 90 Minuten.

Verarbeitungstemperatur / -klima

Nicht bei Raum- und/oder Bauteiltemperaturen unter +5 °C verarbeiten. Frischen Mörtel und aufgebrachten Putz bis zur vollständigen Trocknung vor Frost schützen.

Trocknung

Für eine gute Lüftung zur schnellen Austrocknung des Putzes sorgen.

Wird nach dem Verputzen Heißasphalt verlegt, so muss, um Wärmespannungen zu vermeiden, für eine ausreichende Querlüftung gesorgt werden.

Trocknungszeit: bei 10 mm Putzdicke, je nach Raumfeuchte Raumtemperatur und Lüftung im Mittel 14 Tage. Bei ungünstigeren Temperaturen/Luftfeuchtigkeit kann sich die Trocknungszeit verlängern.

Besonders beachten

Für die Putzausführung gelten die EN 13914, DIN V 18550 und VOB Teil C (DIN 18350).

Sicherheitshinweise und Entsorgung

Siehe Sicherheitsdatenblatt.

P121.de Rotband

Haftputzgips zum Glätten

Beschichtungen und Bekleidungen

VOB Teil C, DIN 18363 bzw. DIN 18366 beachten. Für alle Beschichtungen und Bekleidungen muss der Putz trocken, bewegungsfrei und staubfrei sein.
Grundierung auf nachfolgende Anstrichmittel/Beschichtungen/Bekleidungen abstimmen, in der Regel tiefengrundieren, z. B. mit Knauf Grundol. Bei Tapete vorkleistern mit Tapetenkleister.

Anstriche
Geeignet sind Dispersionsfarben (z. B. Knauf Intol E.L.F., Malerweiss E.L.F.), Hybrid-Innenfarbe (Knauf Diamantweiss E.L.F.) Dispersions-Silikatfarben (z. B. Knauf Silikatweiss E.L.F.).

Fliesenuntergrund
Vor dem Kleberauftrag darf die Restfeuchte max. 1 Masse- % betragen, Tiefengrundierung, z. B. Knauf Grundol, ausführen.
Fliesenverklebung im Dünnbettverfahren mit zementgebundenem Dünnbettkleber (z. B. Knauf Bau- und Fliesenkleber**) oder kunstharzgebundenem Dispersionskleber (z. B. Knauf Superkleber**).
Für den Spritzwasserbereich wird zusätzlich eine Abdichtung, z. B. mit Knauf Flächendicht, empfohlen, die Verklebung der Fliesen erfolgt dann mit Flexkleber, z. B. Knauf Flexkleber eXtra**.

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Brandschutzertüchtigung

Ohne Putzträger (bis 15 mm Putzdicke)
Für den Einsatz zur Betonüberdeckung der Bewehrung können 10 mm Putzdicke gleichgestellt werden mit 10 mm Normalbetondicke.

Mit nichtbrennbaren Putzträgern
Bei Putzdicken > 15 mm bis 25 mm ist ein nichtbrennbarer Putzträger erforderlich. Hier können 8 mm Putzdicke über Putzträger gleichgestellt werden mit 10 mm Normalbetondicke.
Der Putz muss die Putzträger ≥ 10 mm durchdringen.

Technische Daten

Brandverhalten:	A1-nicht brennbar	EN 13279-1
Biegezugfestigkeit:	≥ 1,0 N/mm²	EN 13279-1
Druckfestigkeit:	≥ 3,0 N/mm²	EN 13279-1
Oberflächenhärte:	≥ 6,0 N/mm²	EN 13279-1
Wasserdampfdiffusionswiderstandszahl μ:	Trocken: 10 Feucht: 6	EN ISO 10456
Wärmeleitfähigkeit:	0,34 W/(m·K)	nach EN 13279-1 Tabelle 2
Haftzugfestigkeit:	≥ 0,1 N/mm²	EN 13279-2
pH-Wert:	10-12	
Trockenrohdichte:	ca. 1.000 kg/m³	
Ergiebigkeit:	100 kg = ca. 125 l Mörtel	

Die technischen Daten wurden nach den jeweils gültigen Prüfnormen ermittelt. Abweichungen davon sind unter Baustellenbedingungen möglich.

Materialbedarf / Verbrauch

Rotband	Verbrauch kg/m²	Ergiebigkeit m²/Sack (30 kg)
Auftragsdicke 10 mm	8,0	3,8

Alle Angaben sind Zirka-Werte und können je nach Untergrund abweichen. Genauen Verbrauch am Objekt ermitteln.

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Technische Änderungen vorbehalten. Es gilt die jeweils aktuelle Auflage. Die enthaltenen Angaben entsprechen unserem derzeitigen Stand der Technik. Die allgemein anerkannten Regeln der Bautechnik, einschlägige Normen, Richtlinien und handwerklichen Regeln müssen vom Ausführenden neben den Verarbeitungsvorschriften beachtet werden. Unsere Gewährleistung bezieht sich nur auf die einwandfreie Beschaffenheit unseres Materials. Verbrauchs-, Mengen- und Ausführungsangaben sind Erfahrungswerte, die im Falle abweichender Gegebenheiten nicht ohne weiteres übertragen werden können.
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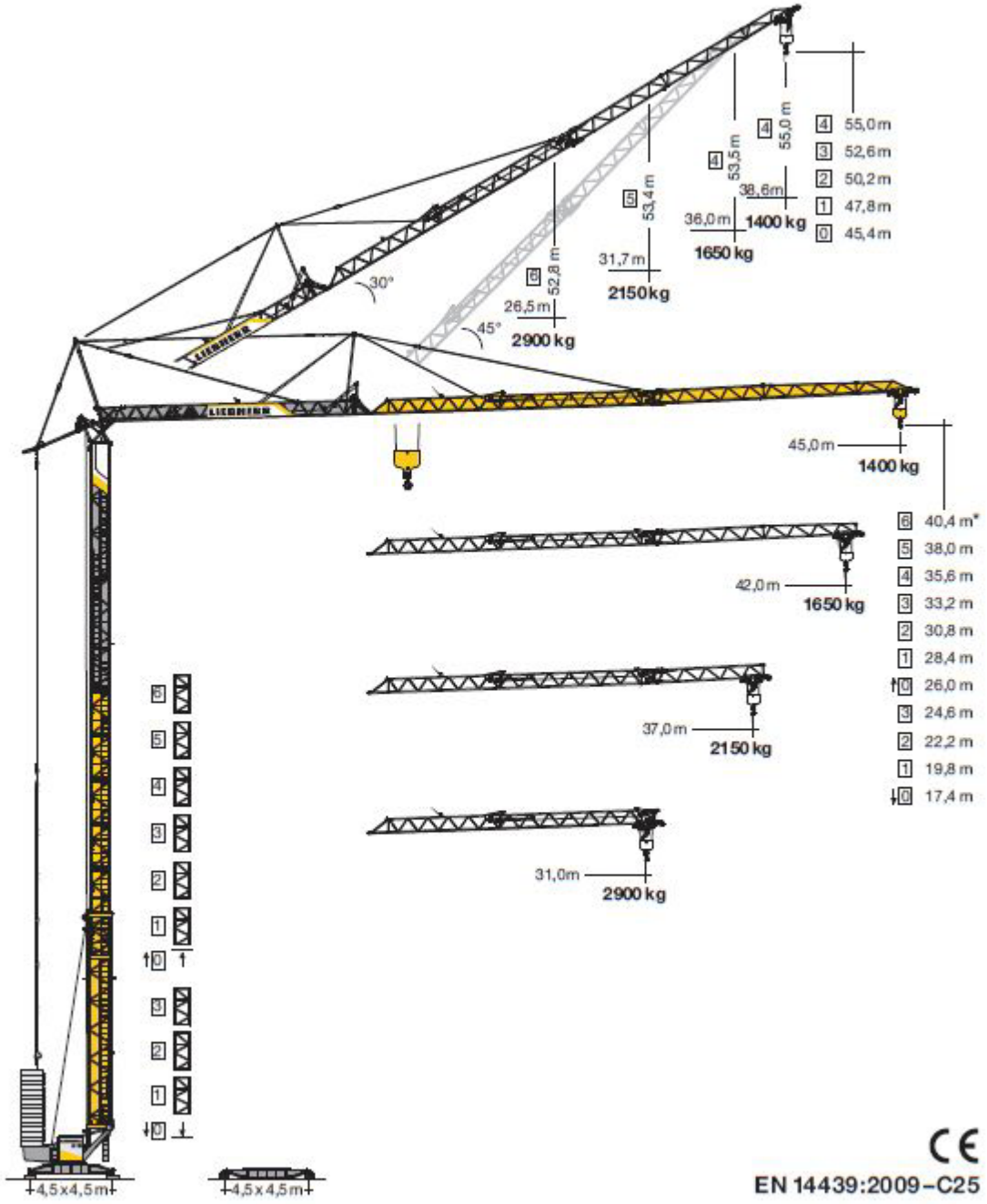
P121.de/dtsch./08.13/FB/D

Konstruktive, statische und bauphysikalische Eigenschaften von Knauf Systemen können nur gewährleistet werden, wenn ausschließlich Knauf Systemkomponenten oder von Knauf empfohlene Produkte verwendet werden.

DATA SHEET CRANE LIEBHERR 81K

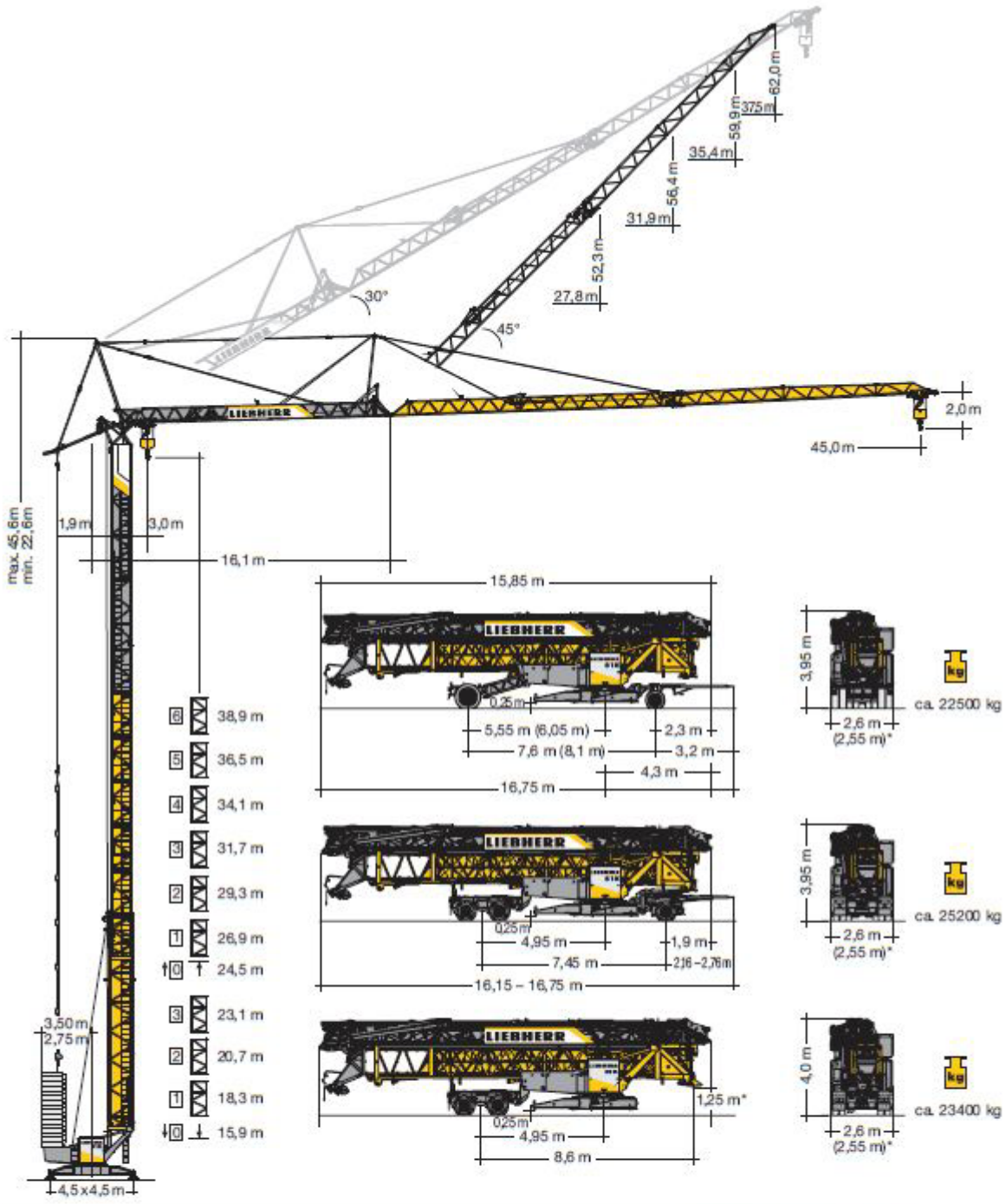
Turmdrehkran 81K

Tower Crane / Grue à tour / Gru a torre / Grúa torre
Guindaste de torre / Башенный поворотный кран



CE
EN 14439:2009–C25

LIEBHERR



Gewicht Weight / Poids / Peso / Peso / Pesos / Масса

r = 3,50 m r = 2,75 m	35000 kg 40000 kg	20000 kg

* **siehe Betriebsanleitung.** / see instruction manual. / voir manuel de service. / vedi manuale d'istruzione. / ver manual de instrucción. ver manual de instruções. /см. инструкцию по эксплуатации.

Ausladung und Tragfähigkeit

Radius and capacity / Portée et charge / Sbraccio e portata
Alcances y cargas / Alcance e capacidade de carga / Вылет и грузоподъемность

m	m/kg	m/kg															
		13,0	15,0	18,0	21,0	24,0	27,0	29,0	**31,0**	33,0	35,0	**37,0**	39,0	41,0	**42,0**	44,0	**45,0**
45,0	3,0 – 13,3 / 6000	6000	5220	4230	3540	3030	2640	2420	2230	2070	1920	1800	1680	1580	1530	1440	**1400**
42,0	3,0 – 14,1 / 6000	6000	5570	4520	3790	3240	2820	2590	2400	2220	2070	1930	1810	1700	**1650**		
37,0	3,0 – 15,1 / 6000	6000	6000	4930	4150	3560	3110	2870	2650	2460	2300	**2150**					
31,0	3,0 – 16,3 / 6000	6000	6000	5370	4520	3890	3400	3130	**2900**								

m	m/kg	m/kg	**Auslegersteilstellung 30°** / Elevated jib 30° / Flèche inclinée 30° / Braccio inclinato a 30° Pluma inclinada 30° / Lança inclinada 30° / Положение стрелы под углом 30°														
		12,0	14,0	16,0	18,0	20,0	22,0	25,0	**26,5**	28,0	30,0	**31,7**	33,0	35,0	**36,0**	37,0	**38,6**
45,0	3,0 – 15,8 / 3000	3000	3000	2970	2730	2520	2340	2100	2000	1900	1790	1700	1640	1550	1500	1460	**1400**
42,0	3,0 – 17,7 / 3000	3000	3000	3000	2960	2740	2540	2290	2180	2080	1960	1860	1790	1700	**1650**		
37,0	3,0 – 21,2 / 3000	3000	3000	3000	3000	3000	2910	2630	2510	2400	2260	**2150**					
31,0	3,0 – 25,3 / 3000	3000	3000	3000	3000	3000	3000	3000	**2900**								

Antriebe

Driving units / Mécanismes d'entraînement / Meccanismi / Mecanismos / Mecanismos / Приводы

	0 ↔ 0,8 U/min. sl./min tr./min	5,0 kW FU
	0 ↔ 60,0 m/min	3,0 kW FU
	0 ↔ 25,0 m/min	2 x 2,2 kW FU
	0 – 45°, 110 sec.	3,0 kW FU



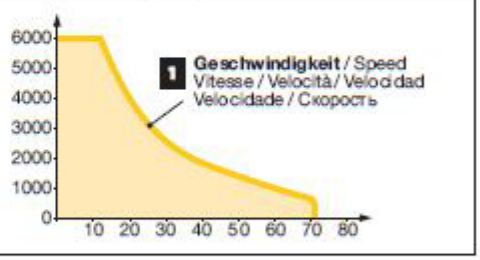
↔ **stufenlos** / stepless / régl. continu
regl. progressiva / sin escalones
sem degraus / бесступенчатый
kg m/min

15,0 kW FU
WIW 210 MZ 404



Geschwindigkeit
Speed
Vitesse
Velocità
Velocidad
Velocidade
Скорость

1 6000 0 ↔ 12,0
400 0 ↔ 70,0



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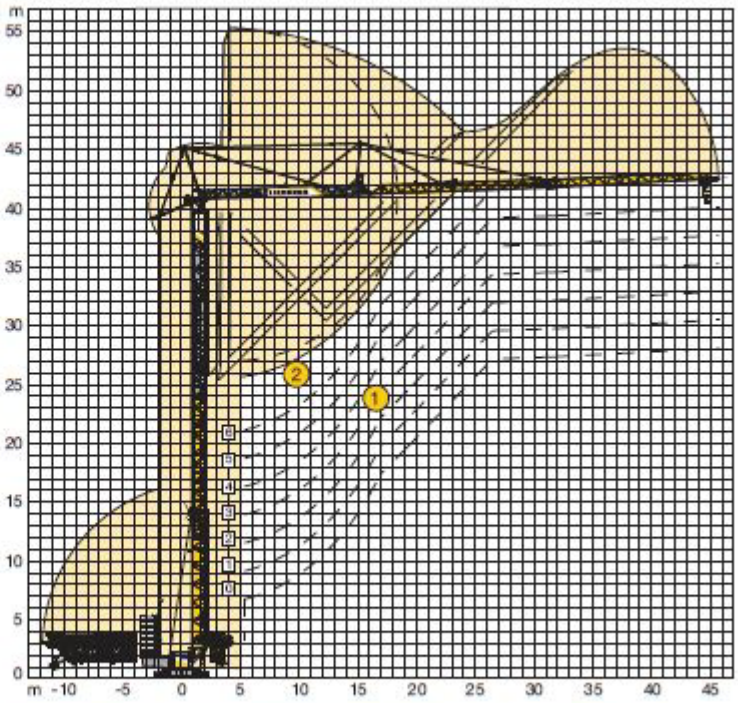
380 – 480 V	50/60 Hz	22,0 kVA (FU)

Aufstellvorgang

Erection procedure / Déroulement de montage / Procedimento di montaggio
Procedimiento de montaje / Sistema de montagem / Процесс развертывания

① **Standard Aufstellkurven von 0 bis 6 Turmstücken** / Standard erecting curves from 0 to 6 tower sections / Courbes de montage standard de 0 à 6 éléments de mât / Curve di montaggio standard con 0 fino a 6 elementi torre / Curvas de montaje estándar (0-6 tramos de torre) / Curvas padrão de montagem de 0 até 6 segmentos de torre / Стандартная монтажная высота с 0–6 башенными секциями

② **Erhöhte Aufstellkurve (+4,5 m) am Beispiel von 6 Turmstücken** / Elevated erecting curve (+4.5 m) using the example of 6 tower sections Courbe de montage élevée (+4,5 m) en prenant pour example 6 éléments de mât / Elevata curva di montaggio (+4,5 m), come per esempio con 6 elementi di torre / Curva de montaje elevada (+4,5 m): ejemplo con 6 tramos / Curva elevada de montagem (+4,5 m) como exemplo para 6 segmentos de torre / Увеличенная монтажная высота (+4,5 м) на примере 6-ти башенных секций



Kolli-Liste

Packing List / Liste de colisage / Lista dei colli
Lista de contenido / Lista de embalagem / Упаковочный лист

Pos. Item No. Voce Pos. Ref. Поз.	Anz. Qty. Cons. Qta. Cant. Кол-во		L (m)	B (m)	H (m)	kg
1	4	**Turmstück (ohne/mit Turmauflage*)** / Tower section (without/with tower support*) / Elément de mât (sans/ avec support de mât*) / Elemento di torre (senza/con pedana di servizio*) / Tramo de torre (sin/con soporte de torre*) / Tramo de torre (sem/com suporte de torre*) Башенная секция (без/с опорными выступами*)	2,50	1,10	1,10	500
2	2*		2,50	1,10	1,10	600*
3	1	**Ausleger-Verlängerung** 31,0 m – 37,0 m / Jib extension / Rallonge de la flèche / Elemento estensione braccio / Prolongación de pluma Extençao da lança / Удлинение стрелы	6,20	0,87	0,84	320
4	1	**Ausleger-Verlängerung** 37,0 m – 42,0 m / Jib extension / Rallonge de la flèche / Elemento estensione braccio / Prolongación de pluma Extençao da lança / Удлинение стрелы	5,20	0,87	0,76	160
5	1	**Ausleger-Verlängerung** 42,0 m – 45,0 m / Jib extension / Rallonge de la flèche / Elemento estensione braccio / Prolongación de pluma Extençao da lança / Удлинение стрелы	3,10	0,87	0,61	80
6	1	**Transportachse vorne** / Road transport axle front Essieux de transport avant / Asse di trasporto anteriore Eje delantero para transporte / Eixo de transporte dianteiro / Транспортировочная ось, передняя — Tra 100 KY 6 / Tra 100 KY 6 A	3,65 – 4,15	1,45	1,10	920 920
7	1	**Transportachse vorne Tra 115** / Road transport axle front Essieux de transport avant / Asse di trasporto anteriore Eje delantero para transporte / Eixo de transporte dianteiro / Транспортировочная ось, передняя	3,80	2,50	1,28	1900
8	1	**Transportachse hinten** / Road transport axle behind Essieux de transport arrière / Asse di trasporto posteriore / Eje trasero para transporte / Eixo de transporte traseiro / Транспортировочная ось, задняя — Tra 120 GY 1 A / Tra 120 GY 1	1,90	2,50	1,05	1100
9	1	**Transportachse hinten Tra 204** / Road transport axle behind / Essieux de transport arrière / Asse di trasporto posteriore / Eje trasero para transporte / Eixo de transporte traseiro / Транспортировочная ось, задняя	3,10	2,50	1,10	1900
10	1	**Transportachse hinten Tra 203** / Road transport axle behind Essieux de transport arrière / Asse di trasporto posteriore / Eje trasero para transporte / Eixo de transporte traseiro / Транспортировочная ось, задняя	3,00	2,50	1,20	2500
11	1	**Transportachse hinten Tra 205** / Road transport axle behind / Essieux de transport arrière / Asse di trasporto posteriore / Eje trasero para transporte / Eixo de transporte traseiro / Транспортировочная ось, задняя	3,00	2,50	1,20	3000

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5.6.4 MATERIALS

GREEN MATERIALS

Lightweight Construction

Floor, roof and solid walls consist mostly of wood. As explained before (see 5.3.2, 5.4.3.2) wood shows great positive properties as a building material. The possibility of selecting less ecological materials such as PE film as vapor barrier, concrete or steel as carrying structure has been excluded to guarantee an environmentally friendly construction. An exception from this construction principle are the glass façade and the folding façade. To guarantee stability and the ability to sustain wind suction, humidity or further weather impact, the chosen profile frame has to be constructed of aluminum. The advantages of this selection are reflected in greater security for habitants and a higher load capacity. However, almost all materials used for the glass façade (glass, aluminum) and great parts of the folding façade (substructure) can be reused.

Ecological Aspects: Material Footprint

The developed structure of walls, floor and ceiling manages to cover almost all required functional layers with building materials made of the raw material wood. Wood combines many advantages of substances used for building constructions. Therefore, it is becoming more popular as a building material.

First of all wood is a renewable raw material with solar energy as almost only energy source for its growth. The production of wood-constructions causes, because of the simple preparation, diminutive energy demand. In contrast, seeing Table 45, to produce and refine metal or stone great amounts of fossil energy sources are required. [BaustoffHolz]

Secondly for the growth of trees CO2 is converted and saved inside the fibre structure. If used for building construction the CO2-cycle of wood is interrupted by postponing the rotting process. [BaustoffHolz]. After its lifetime as building material it can be used to produce biogas as a fossil fuel substitute or to produce eletricity and heat in a cogeneration process without releasing additional CO2, only the bound CO2 inside the wood is returned back to the environment.

The following table stresses the sustainability of wood compared to other typically used materials.

building material	material consumption	energy consumption
wood	60 kg	60 kWh
steel profile	78 kg	561 kWh
reinforced concrete	300 kg	221 kWh
sand-lime bricks	420 kg	108 kWh

Table 45: **table for energy consumption of materials**

Wood - and cellulose fibre is a versatile and even historically commonly used insulation. As a result in this project the great base of experience of production and processing of this material can be used. Boards of cellulose can be produced without any additional adhesive. It is therefore absolutely non-toxic, environmen-

tally friendly and can be processed without additional afford to secure the building site.

Ecological Aspects: Passive House Standards

The wooden constructions as well as the glass façade are designed to meet German Passive House Standards. In concrete terms there are requirements especially for the thermal transmittance of components of the thermal envelope for new constructions. [EnEV2009, p.7]

As shown in the sections *5.4.2 Thermal Envelope* the thermal transmittance as planned meets easily the required passive house standards.

Economical Aspects: Lightweight Construction

Saving costs for material purchase, construction, operation, maintenance and recycling of a building is essential to create a sustainable concept.

The largest share of the building envelope material is wood. Since wood has a low own weight, it is particularly attractive because it reduces transportation costs. For this reason it is environmentally even more attractive, because less CO2 will be emitted.

In addition to that, wood needs a low energy demand during the production because there are nearly no additional materials necessary for processing. This saves production costs.

Wood can easily be installed because of the simple construction. Furthermore wooden constructions can be recycled effortlessly and be reused in manifold variants.

Next to the advantages of the lightweight construction the glass façade present further aspects. The use of large windows supports the use of much daylight, which reduces the lightening costs and the internal heat demand during daytime. These aspects are undesirable in a passive house because of the high thermal insulation.

Social Aspects: Comfort

Typical for passive houses is the high thermal comfort. The ventilating system ensures amiable air quality and the artificial heating and cooling can be reduced to a minimum.

Using the natural material wood creates a warm atmosphere in the building. Also wood is a breathable material and regulates the moisture in the room partly on its own.

The large windows allow plenty of sunlight entering the fronts. Especially in winter, this reduces a part of heating requirement. Furthermore the residents are close to the environment and have a great view out over the city roofscape.

INCORPORATED CO_2

A comparison of the production process considering the materials shown in table 21 and assuming the same measurements of the products, shows a huge difference not only in energy consumption but also in CO_2 emissions as an indicator for climate change. All in favor for the material wood (see „Figure 260: Comparison CO2 equivalent“ on page 399) . Considering the uptake of CO_2 during the growth of trees, wood even has a negative amount of CO_2 production like explained above. The related processes and their emissions that are needed to extract the materials from the environment can be further reduced through the use of local or regional materials. With native commercial timberlands and therefore use of local types of wood the impact of the ressource wood can be kept very small. In comparison fossil materials like iron ore which is needed for the production of steel can't be found in a local context but it has to travel a long way combined with much more complicated steps for processing and treatment which again has a strong influence on the environment, not only regarding the demand of energy and therefore use of fossil fuels but also because of needed additives for the different processing steps.

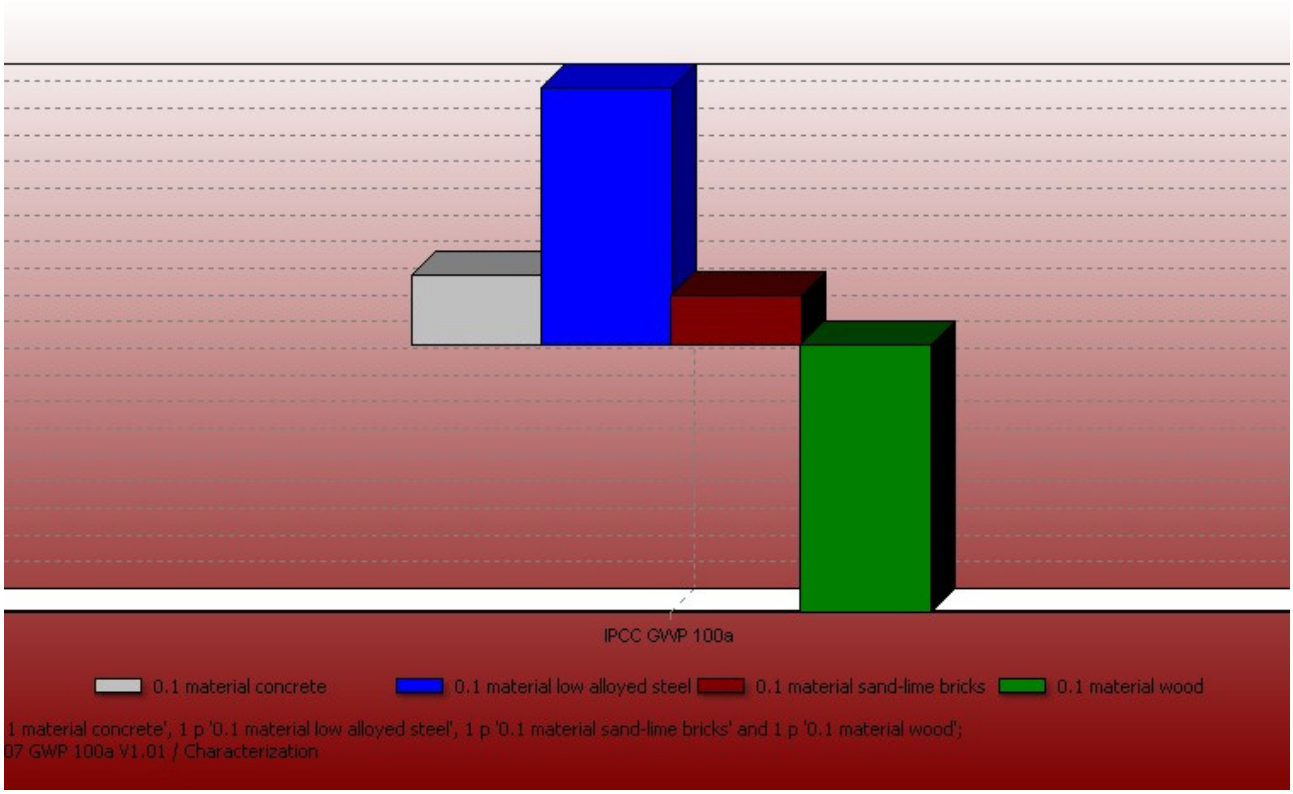


Figure 260: **Comparison CO2 equivalent**

Often forgotten but still important is the recognition of the afterlife of materials. Wood is a CO2 neutral material with a long lifetime, it can contribute to the environment even after deconstruction. After a preperation process it can be used for further construction of new wooden products or as substitute for fossil fuels and therefore the reduction of further CO2 emissions.

For example through a gasification process of wood methane can be produced and gathered to function as a sustainable biofuel or partly being used as additive to the natural gas grid and therefore a reduction of natural gas consumption.

An other possibility is the combustion of wooden pellets in a cogeneration process. In this scenario electricity and heat can be produced without further consumption of fuel oil or natural gas. Again the impact especially on climate change, natural land transformation and fossil depletion can be reduced (see Figure 260).

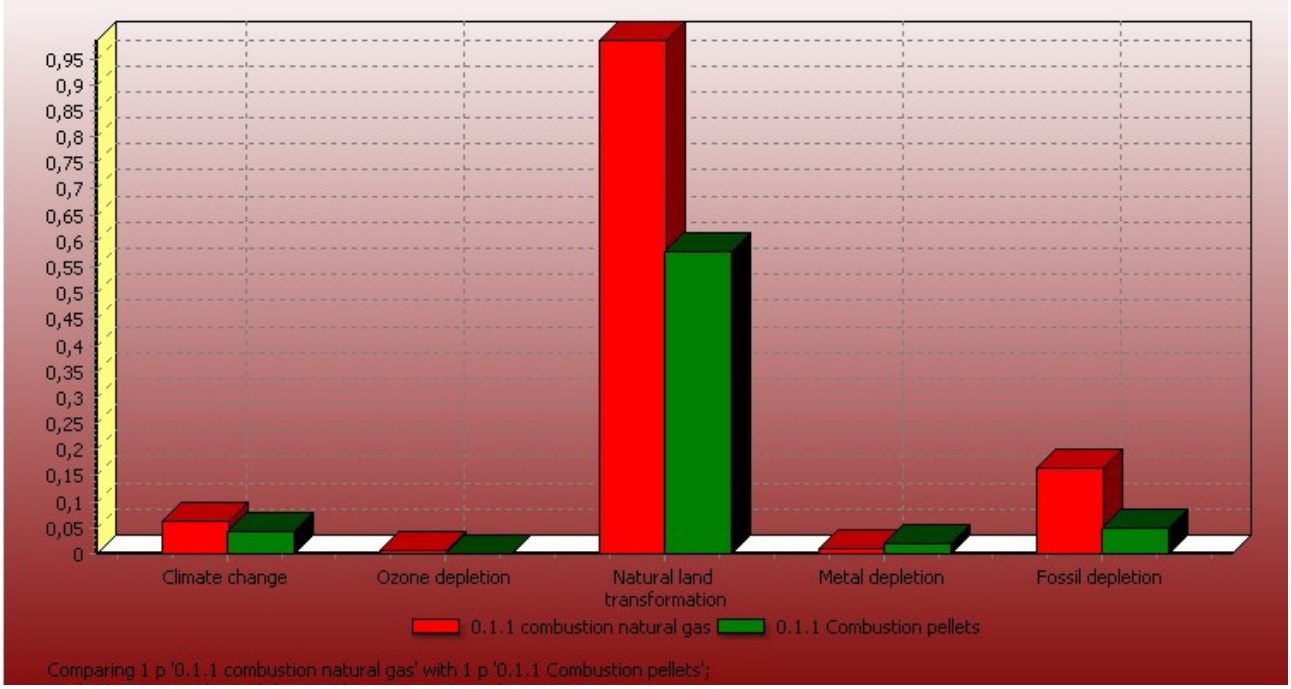


Figure 261: **Comparison of cogenaration process of wood chips and natural gas**

INCORPORATED ENERGY

Sustainable look at the Rooftop Building:

To get an impression of the entire housing unit and to find the best approach to reduce further energy consumption and CO2 emissions a look at the cumulative energy demand of the different material sections of the house can help. The main energy consumer related to the material production is the whole section including the exterior joineries and façade elements (see Figure 262). The value amounts to 592000 kPt, which is the same as the yearly environmental load of 592000 average european inhabitants. Still it can be covered to a great part through the energy production of biomass. With the production of the high energy demanding materials steel and glass it stands in great distance to the next main energy consumer, the energy production facilities including the whole photovoltaic system mainly defined by energy from fossil fuels. These high values can be reduced by the production of sustainable domestic energy as explained in the LCA section of this sustainability report.

Even if the section exterior joineries and façade elements is the biggest energy consumer, the main impact on climate change defined by CO2 equivalent is dictated by the section partitioning, interior joineries, façade (see Figure 263). The main perpetrators are rockwool, which is needed to insulate the mechanical room, and the production of PCM. To improve this balance one could look for an alternative for rockwool. Still if the whole building is in the spotlight, and recognizing the whole energy production,consumption and savings

during the use phase, the overall emissions of the materials production is almost completely covered. An explanation can be found in the LCA section of this report.

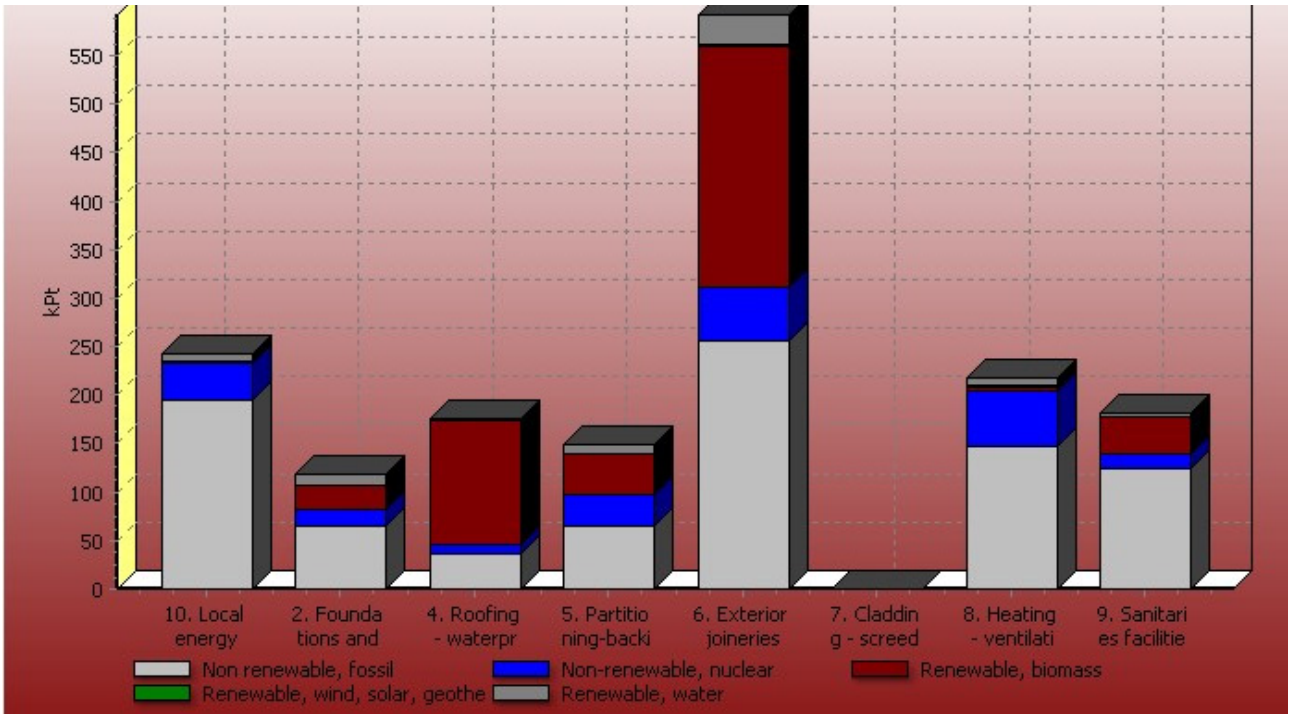


Figure 262: **Cumulative energy demand of Rooftop material sections**

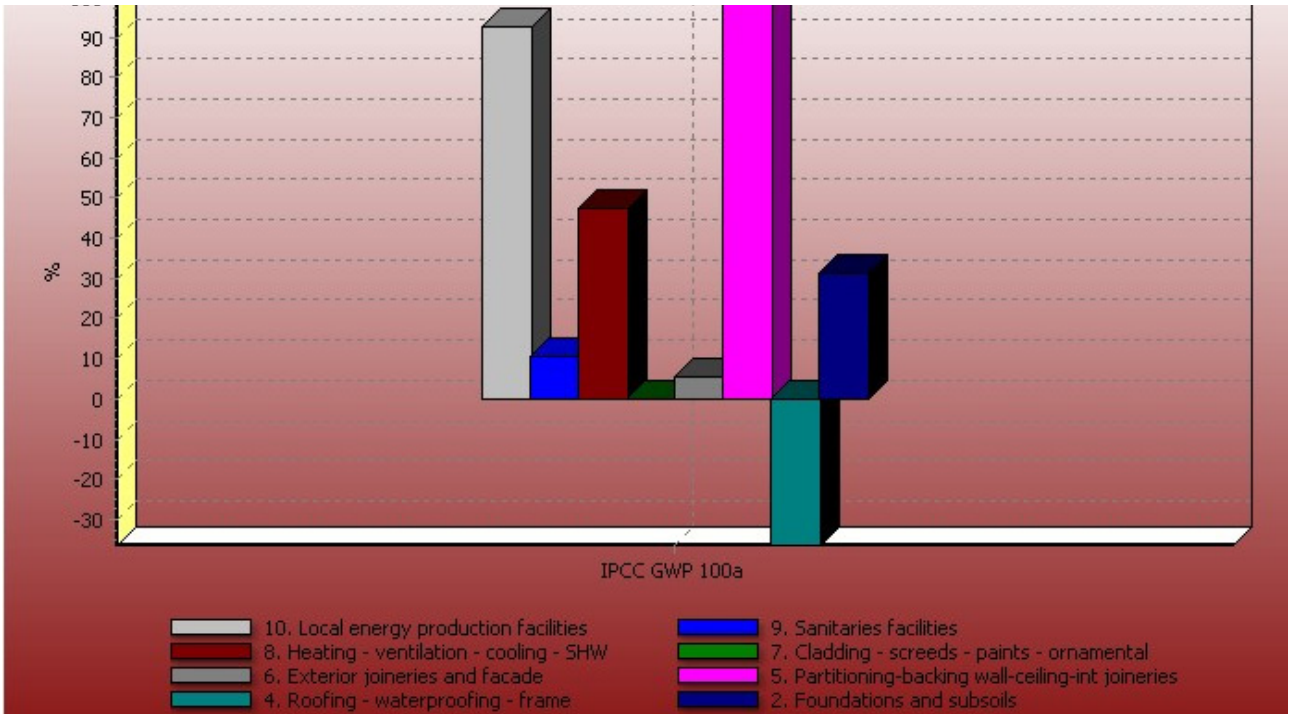


Figure 263: **IPCC CO2 equivalent**

MAINTENANCE PLAN

The main part of the Rooftop Building exists of wood with a long lifetime of over 50 years. Therefore the maintenace and replacement of parts from the house is mostly confined to the change of the engineering and energy production systems, like the heat pump and the photo-voltaik system. Because of the frequent use, the sanitary facilities are also a part of the house which need observation related to the overall condition over the years.
The replacement of wood during a use phase of 50 years could only occur on highly loaded areas like the weather boarding or the wooden surface of the floor.

5.6.5 ACTIVE SYSTEMS AND EQUIPMENT

PCM Ceiling

As explained mainly in the chapter "Engineering and Construction Design Narrative" there is an option to discharge the PCM-ceiling using the heat pump. The operation of this system is explained with more detail in the paragraph "Passive Cooling Strategies" in this chapter.

Artificial Lighting

The whole lighting of our Rooftop House runs on LEDs. LEDs are way more efficient than any other light source on the market. In consequence they need less energy to enlighten the building. They are also easier to dismantle and to recycle and they run up to 100.000 hours. This will reduce the amount of primary energy used to produce light sources. And at the end of their life time, the user just can throw it to the trash. In contrast to energy saving energy saving lamps, which contain very dangerous substances for the human being and environment. Energy saving lamps and halogen lamps are contained with quicksilver. So using LED lamps will reduce the quicksilver production of the world, also due to the reason that electricity generation in hard coal plants sets free quicksilver.

Appliances

Furthermore we have very efficient appliances. The fridge is a combination of a refrigerator and a freezer, what is more efficient than seperated freezer and refrigerator. It fulfils the requirements of the SDE-Rules concerning the volumes of of the cool rooms. It consumes approximately 228 kWh in one year (A++). The washing machine has the function of "Thermoschleudern". This reduces the energy needs due to reduction of the water content with a combination of warm air flow and spinning before the actual drying cycle. To wash and dry one full load it will take 3,7 kWh (A). The dish cleaner takes 0,84 kWh per wash cycle (A+++). It has a timer function for a starting delay, so that the owner can also run the dish cleaner at midday when PV delivers the most power although he/she leaves the house in the morning. It also recognize the amount of dishes inside the cleaner so that it adapts the water and energy consumption. The oven is able to use the residual heat for finish the cooking and so it switches off earlier for saving energy. It takes 0,89 kWh per standard meal. The hob is a very efficient induction hob and i consumes in average 0,79 kWh, but it is still depending on the meal the owner cooks. Another appliance we need according to the rules of the SDE is a television. The SDE organization allowed us not to have an extra DVD-Player due to the reason that the television we use (LG 32LA6678) has a video player feature integrated. The TV runs with 40 W.

For more information see the section „5.3.6 Electrical Energy Balance Simulation“.

Ventilation

We reduced the active parts of the ventilation to a minimum in order to reduce the energy consumption and the maintenance cost of the system. Therefore left out any humidification or active cooling system has been left out. There is only an electrical preheating device used for frost protection during winter. It is located before the cross-flow heat exchanger in order to prevent the development of ice between the ribs.

Heating and Domestic Hot Water

The heating system uses both a passive and an active technology. Solar thermal collectors act as a passive support of an air/water heat pump which extracts thermal energy from the outside air and stores it into a buffer tank. From there, with the additional heat from the solar thermal collectors, the heated water will be used to meet Domestic Hot Water needs and heating requirements through an under floor heating system. Under floor heating systems, opposite oftraditional radiators, allow to reach satisfying indoor air temperatures using a fluid at a relatively low temperature (30 – 40°C max.).

As far as it concerns the drinking water heating, we use a fresh water tank that allows us to run our heating system on a low temperature and to maximize the efficiency of our heat pump.

Electricity

We changed our plan of two separate system designs to one system. Now we have a combination of the on-grid and the off-grid system. Therefore the energy for our battery will be produced from all 50 PV modules. Integrated in an intelligent system we will have a combined use of self produced electricity and electricity from

the utility grid. The possibilities with such a system are explained in more detail in the photovoltaic system design section. We will have 2 SL2 thin – film modules from Solibro on each of the 8 façade element facing south which makes 16 modules with each 100 W. Therefore the façade elements would provide place for a 1.6 KW PV installation. To reach the maximum of the allowed power output of 5 KWp (rule 7.3 d) we have to install at least 34 of the same Solibro modules on the roof. The choice of the Solibro modules was based on the idea of sufficient space for our installation. Even if they are not as efficient as monocrystalline modules, since we have the luxury of enough space on our roof we can use the advantage of those thin-film modules related to the thermal independence and less impact through shadowing.

There is also a change in the choice of the battery. We decided against the neeoQube, our first contestant for a battery, because we encountered problems related to the required configuration of the inverter and the charge controller, which is already integrated in the neeoQube system. With this fixed constellation and the high output Voltage of thin-film panels we couldn’t make a flexible wiring of the system in the way we imagined it. Also to integrate an acceptable mobility concept we decided to reduce the capacity of our house battery. Now, the choice of 2 lightweights lithium on traction batteries of the type SB12V160E-ZC Super B connected in series, which would provide a capacity of 3,84 KWh still allows space for one Velotaxi from Veloform with a capacity of 1,536 KWh and 2 e-bikes from Bosch performance line with each 300 Wh capacity. The possible varieties on this topic are closer explained in the Mobility section (reference to mobility). In this example our total storage capacity would therefore amount to 5,976 KWh close to the 6 KWh given as a limit in the SDE rules (rule 7.4 b).

5.6.6 SOLAR SYSTEMS

PV technology

We decided to use thin film technology because of their good ecological performance compared to the classic silicon technologies. The big advantage of the thin film technology is revealed in their name. They are constructed out of very thin layers of material, which is positive for minimizing material consumption. About 95% of their module mass is regular glass which is very easy to recycle and mostly gained out of recycling processes.

GWP 100 [kg CO2-Äqu.]	193	154	74	59	115
KEA-cummulated energy effort [MJ-Äqu.]	3853	3064	1186	1052	2013
Human toxity [kg 1,4-DCB-Äqu.]	80	75	66	79	36
Ocone destruction [kg CFC-11-Äqu.]	0,072	0,07	0,003	0,005	0,006
Eutrophication[kg -PO4-Äqu.]	0,026	0,019	0,001	0,004	0,006
Acidification [kg SO2-Äqu.]	0,8	0,6	0,4	0,4	0,4
demand in ressources [kg Sb -Äqu.]	1,4	1,2	0,5	0,7	1,1

The properties provided in this table show the advantages of the thin film technology compared to the silicon technology. An important benefit of the CIGS-modules is the low value in the category of human toxicity. As we want to minimize the negative effects on humans and the environment provoked by every part of the building, this advantage led to the choice of using CIGS modules.

Another reason for the decision of CIGS modules is the high efficiency factor wich exceeds those of the modules produced via other thin film technology. This factor has a great impact on ther power to space ratio. Compared to poly silicon cells, the used space to gain 1000 kWh/a is slightly larger using CIGS modules (see figure above). The space, used by the PV panels, has to be minimized, because the solar thermal plant, which is a central idea of the renewable production of energy for the house's inhabitants, has to be considered.

	type	efficiency [%]	area [m²]
cristalline silicon cells	Monocristalline	15 - 19	5,3 - 6,7
	Polycristalline	13 - 16	6,3 - 7,7
thin film technologies	CIGS	10 - 12	8,3 - 10,0
	CdTe	9 - 11	9,1 - 11,1
	Amorph. silicon	6 - 8	12,5 - 16,7

In first pilot projects there are recycling processes for PV modules which can reach recycling rates of more than 98 %. This is very important for reducing the waste produced by the PV generator after its lifetime.

Solibro is producing the SL2 120 modules in Bitterfeld-Wolfen, Germany, which keeps transporting ways as short as possible and therfore causing as less CO_2 emissions as possible. Another positive effect is caused by the strict European environmental legislation. The manufacturers are subordinated in strong restrictions for hazardous materials and production steps and have to avoid negative impacts on the environment.

Energy management

In times of the energy transition, based on the example of Germany, it is important to create possibilities to store renewable generated electricity. With growing use of renewable energies, we need to be able to intercept a lot of energy fluctuations as power peaks in production and consumption within the grid.

The time and amount of electricity produced is dependent on the radiation from the sun, the ocean (tidal power plant), wind and more. With a great system of decentralised storage units all over the country, in private use and in combination with a smart grid, we can contribute a huge part to this problem. This means that we have to think about the possibilities we can use to store the energy.

Additional to storage systems, isuch as pumped storage hydro power stations or compressed air reservoirs in old coalmines, the use of mobile batteries inside e-cars as an energy supplier in times of maximum consumption is possible.

Building a supporting system for renewable energies is an essential issue for a changing future towards sustainable development within the process of decentralization and therefore the democratization of the outdated energy system.

One step in this direction would be our Lithium-Ion battery. We want to use as much as possible energy generated by the PV modules for the Rooftop House and the building that will present itself as the host of it. To reach that aim, the battery increases the own consumption rate by storing PV energy during the day and providing it, if it is needed. With an intelligent energy management we can avoid most of the power peaks reaching the grid at all – both power peaks in gain and consumption. So we can contribute our part to the grid's stability.

Façade elements

The façade elements have got an energy consumption of 75 kWh/year. Furthermore, the additional energy generation created by the sun tracking concept is at least 200 kWh/year. Overall, we are able to gain a plus of 125 kWh/year by tracking the sun. So the façade provides not only an improvement in the residents' comfort and insulation but also in energy production.

5.6.7 WATER

General water use, management and conservation concept

Water is one of the most important ressources, that people need to exist. At the earth's surface water is existend by around 70 % but only 3-4% is potable. Therefore, there is an obvious need to save drinking water and it should be carefully handled.

The average household can make a big difference related to the consumption of water with a change of the personal behavior of the inhabitants. Even if most people would change their routine it still would not lead to a sufficient improvement. The toilet, the bathtub or shower and the dishwasher are the three sanitary objects, which are consuming the most amount of water. In assumption, that most people in the western hemisphere are taking a dayly shower with an average value of 80 Liter/Day, a well-intended value of 32 L/day for the toilet if the use is twice a day. It also can be assumed, that the dishwasher will be used every second day with 6 L. This results in an overall water consumption of 115 L/Day for those three elements and two people.

In conclusion, the advantageousness to use innovative technology, developed for reduced water consumption is clarified.

Strategies for the reduction of consumption

Based on the Rooftop Building the water consumption will be minimized while maximizing quality, endurance and design. These goals are achieved with special hygienic drink water installation systems and a smart grey water reuse concept.

The soundless effluent systems and the grey water reuse are ensuring an efficient way of water use in the building.

Economical and recyclable fittings from the company Catalano will decorate the bath and kitchen. The fittings are equipped with a special "EcoSmart Technology", which are designed to save up to 60% of water compared to conventional ones. This way not only the water consumption is reduced, but also the needed energy to heat the water. The toilet flush is adjustable so that the amount of water can be chosen between 3 to 6 liters. To maximize the efficiency a rinse hold function within this system can reduce the use even more for one rinse cycle.

Treatment of waste water

Since the Rooftop Building is designed to become a part of an already existend building a great advantage is the already existend infrastructure for the sewage. The concept of the building within it self offers the possibility to use the existend pipes and therefore the use of new building materials is reduced.

Additionaly through the seperation of black – and grey water further use for a sustainable water recycling system is given as explained in the section below constructed wetland.

Recycling and Reuse

Designing a sustainable building involves a various range of choices. This range goes from materials eco-friendly production, to low energy consumption, to sustainable waste removal.

In our house, a solution for the last aspect is given by the integration of a constructed wetland. Such facilities are classified by architecture and water types. Disposal water is divided into greywater and blackwater. Blackwater includes all components of disposal water, while greywater only includes water coming from the shower or bathtub, the bathroom basin and the washing machine. Water coming from the toilet and the kitchen sink are excluded.

Since the connection to the Berlin water disposal system is very good in all parts of the city, and the economic viability of the wetland is gained only after approximately 15 years, we combine the disposal water treatment with the cooling-system of the PCM-cooling circuit. Through this an economic upgrade related to the sustainable system takes place.

Constructed Wetland

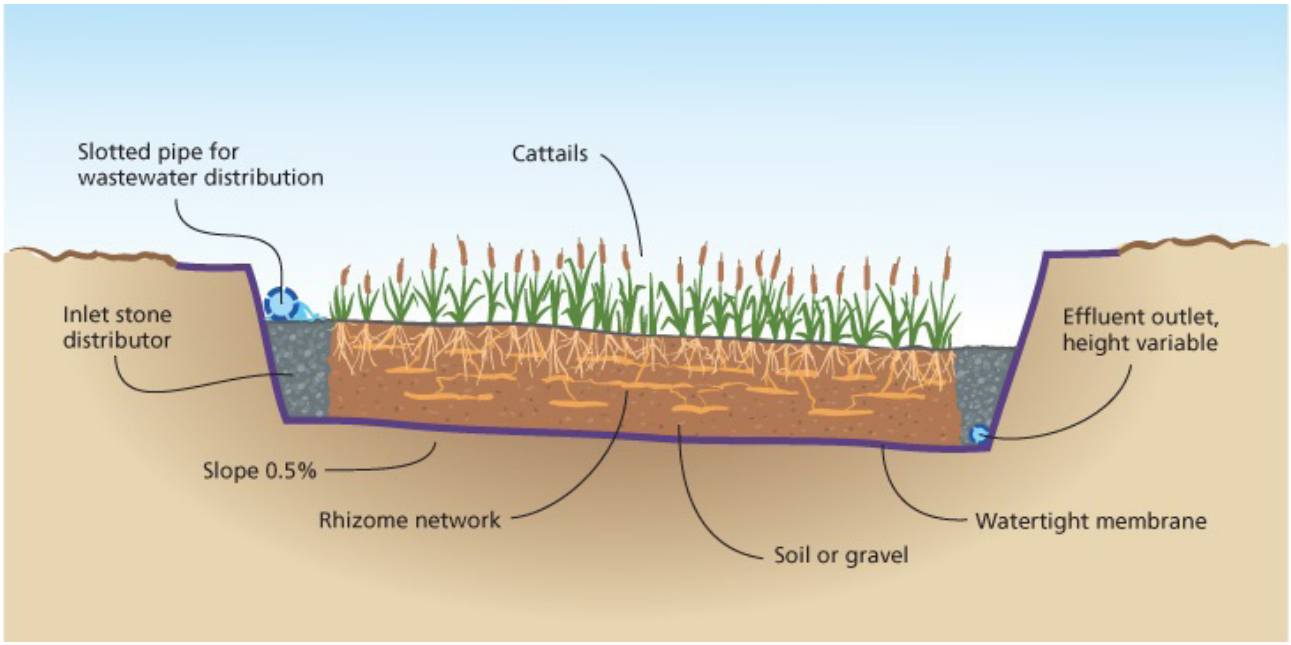


Figure 264: **general construction of a constructed wetland**

The overall structure of a constructed wetland consists of a gravel bedding for filtering of disposal water which is planted in most cases with reed.

The reed roots thrive up to a depth of 1 m and consume nutrients from the water. Furthermore, bacteria settles between the roots and supports the water treatment process.

Depending on the construction choice, the disposal water fills the facility in different ways. Here we distinguish into horizontal and vertical filter. Horizontal constructed wetlands are longer than the vertical ones and they obtain their filtering volume from their length. The water is applied on one side on top of the reed bed with a single drainage pipe, and drips through the gravel. By means of a declivity the now clear water is purged in another single drainage pipe on the other side of the bed.

Vertical filters have more depth, and the water drips vertically through a larger amount of gravel. The water is applied in multiple rows of drainage pipes on the surface and purged on the ground with a single drainage pipe; also in this case, a certain declivity is used to ensure the flow.

An accumulation tank is required before the constructed wetland in order to homogenize the disposal water flow; it is designed so that it can collect up to half the daily disposal water. Furthermore, an additional filter chamber is needed to collect clearing sludge. The water can then be pumped onto the bed.

The constructed wetland which we implemented in the project is a complete self-made construction, designed for our special requirements of space and cooling capacity. In close collaboration with the architecture and cooling teams, we adapted our dimensions to achieve the different needs of all sectors.

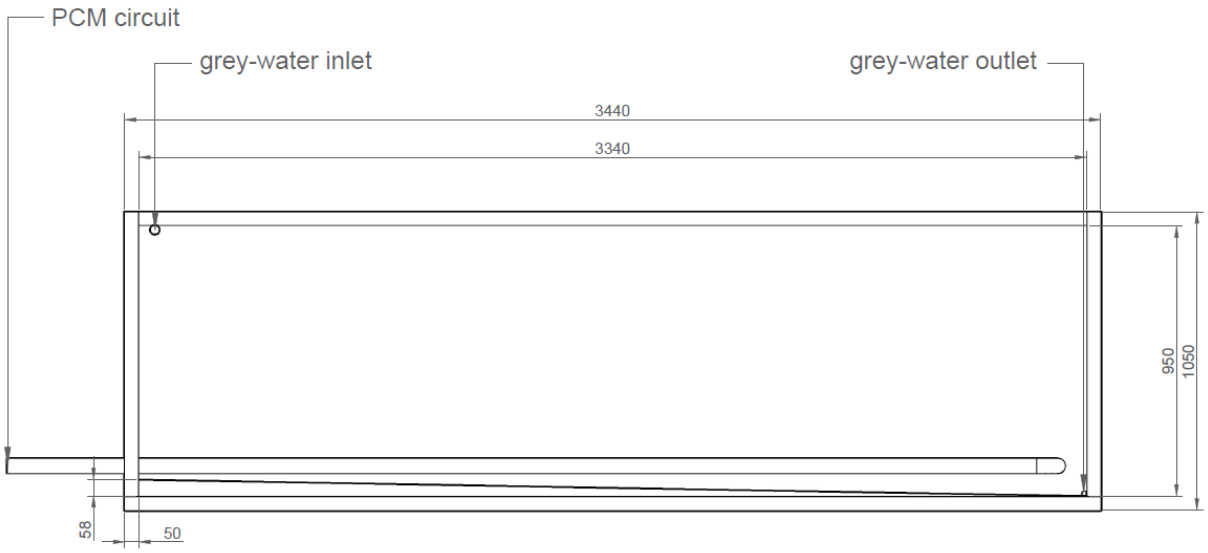


Figure 265: **measurement of the constructed wetland**

Grey Water System

It is necessary to clarify that our wetland is a greywater treatment facility, thus no water disposal from kitchen, sink and toilet is applied. Thereby, we do not need an additional filter chamber for clearing sludge, which will be purified in subsequent use by local water disposal companies.

The facility is calculated with a daily greywater flow of 125 l per day with help of Darcy's Law and is situated next to the staircase to reach the maximum clouding. This is needed to maintain the facility cool over the day in order to maximize the cooling effects of the PCM. Also the measures are highly adapted to the PCM, to ensure the needed volume as a cooling-water storage. The exact outer measures without cover panel are 2.07 m in width, 3.44 m in length and 1.05 m in height. The inner measures are respectively 2.02 m in width at the upper part, 1.92 m in width at the ground and 3.34 m in length. A ramp is located over the entire length of the bottom of the casing with a slope of 1° to ensure that the water flows downwards to the drainage pipe.

Inside the casing are contained not only the gravel and the reed, but also the pipes of the PCM-cooling circuit. The gravel and the containing water work as a storage medium where the heat gathered during the day from the PCM circuit is discharged at night-time. Further information can be found in the chapter specifically dedicated to cooling.

To homogenize the disposal water flow an accumulation bin is placed next to the existing accumulation bins of the sanitary sector, which can gather 65 l of greywater. Due to the relatively low flow rate, only a small pump with a power of 7 W is needed to pump greywater to the clarifier. Once the process is completed, the cleaned greywater can be extracted by means of a small pump and can be used for the washing machine, toilet flushing or irrigation purpose in accordance with SDE rule 8.5.

The outside located wetland, is not only responsible for the purification of grey water but also for an increase of the living comfort by the closeness of plants and nature.

5.6.8 SOLID WASTE

This article is divided into three chapters: the life cycle phases construction, project maintenance, and end of life. In Del #5 we have developed the end of life phase, and we will provide further information on the previous phases for the final deliverable.

Construction Phase

in development

Project Use and Maintenance

Since the 1960s waste is collected, separated and recycled in Germany. Nowadays the standard is that the consumer separates wastepaper, waste glass, organic waste, packageing, batteries and electronic waste. For this purpose you will find trash containers in the backyard of every building, which are used by all residents in common.

In Berlin the enterprise BSR (Berliner Stadtreinigung, in English: Berlin City Cleaning) is the public waste disposal company, responsible for waste removal, recycling and road cleaning. In our building we are going to make use of this service as we consider it most sustainable to integrate the existing infrastructure into our concept.

End of Life Assessment

The Advantage for the end of live for the Rooftop Building lies in its modular Design. Because of this it is not only relatively easy to assemble the different parts but also to disassemble it after its lifetime. Like this the different materials can be well sorted depending on the further steps of waste management or re-use scenarios. Since the building is constructed with common materials it is possible to restrict the further processing to a regional environment to minimize the related transport impacts. For most materials recycling scenarios can be planned. For example the used aluminum of the building can be transported to an aluminum recycling facility in Hamburg which is about in 290 km distance to Berlin. Because of the recycling process a huge part of the grey energy needed to produce primary aluminum can be saved for its new life cycle. The recycling of aluminum for example needs about 10 percent of primary energy compared to the grey energy demand regarding the production of new aluminum. To a part because the re-melting from scrap aluminum needs less energy than the production of new one and in addition the whole upstream processes starting from the extraction and refining up to the last final production steps don't need to be perceived. For wood, of which the Rooftop Building consists to a great part two scenarios for using its stored energy are to consider. The use of wood as pellets in a cogeneration process would reduce the need for electricity and heat from fossil fuels in other places and a reduction of for example fuel oil or diesel can be achieved. Also in this scenario the preparation process of the used wood to process it to become wooden pellets and the related drying and storage steps are negligable compared to the steps of extraction, refining and every conversion in beetween to receive fuel oil or diesel. The other scenario can be the use of wood in a gasification process to produce methane or biogas in a biogas plant. The Berliner Stadtreinigung (BSR) is the utility responsible

for waste disposal and recycling in Berlin. Since 2013 a new biogas plant opened operated by the BSR. This produced biogas is used to run 150 garbage trucks and substitutes about 2.5 million liter diesel each year. An other byproduct is natural compost and liquid fertilizer.

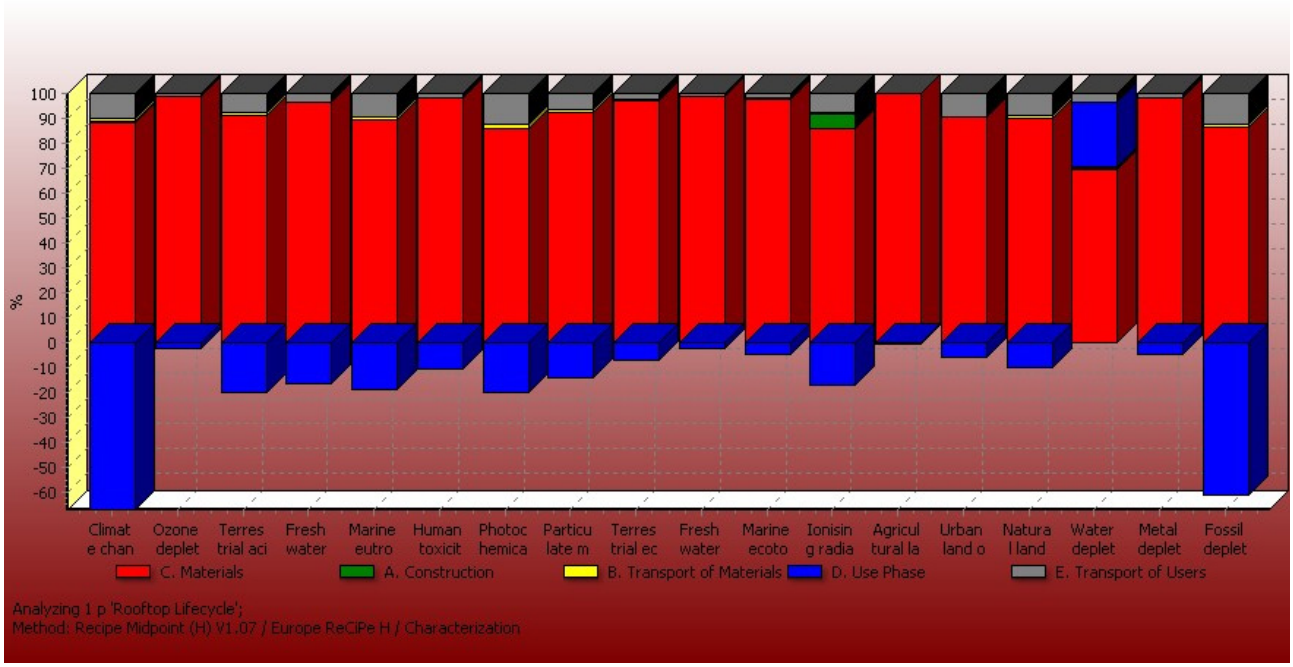
The replacement of parts in the Rooftop Building during its lifetime is mostly related to the photovoltaic system and the engineering system with a ifetime of 25 to 35 years. For those parts the possibility of disassembling them into individual materials again is given through the related production companies, or the forwarding to a re-seller as second hand parts is cogitable (see section 5.6.4) .

Life Cycle Analysis

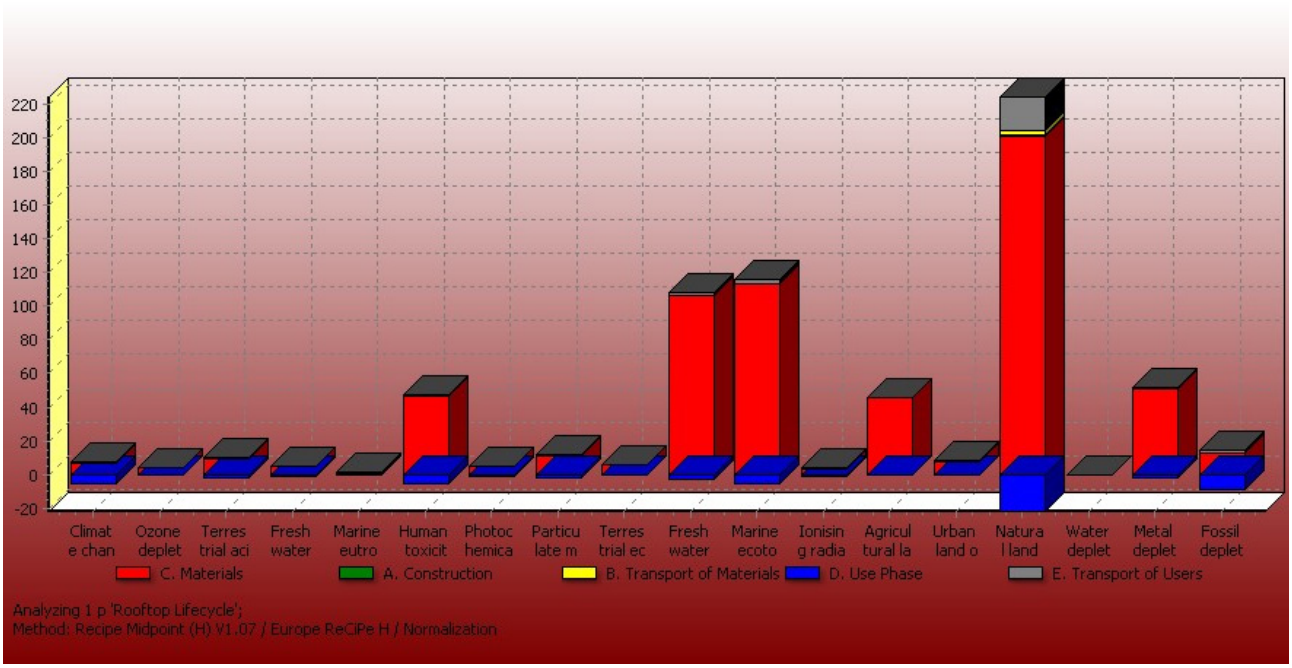
The impact assessment of the Rooftop Building is a first impression of its sustainability as a whole. It shows the interaction between the production and transport of materials, as well as the construction- and use phase of the building. As was expected the production of the used materials is responsible for the most negative impacts „Impact assessment of the Rooftop Building characterization“. It is especially responsible for the transformation of natural land, the consumption of fresh water during the production as well as the impact on the ecotoxicity in marine environments „Impact assessment of Rooftop Building normalization“.

Other sources already describe the impact of materials used in the builing sector. According to the 'Deutsche Bundesstiftung Umwelt' 40 % of the world's consumption of resources and about 30 % of the world's CO2 - emissions are caused by the construction sector. This can be easily seen if the perspective is directed to the entire upstream processes which are needed to extract the raw material, for further preperation and conditioning, the final production process and every effort in between.

In comparison to that the transport of materials and the construction phase are almost negligible. The use phase of the building is dominated by positive effects for the most on climate change through the production of the plus energy and the avoidance of fossil depletion. The surplus production works basically as an 'opponent' to the material production. Negative impact on the environment during the use phase comes with the depletion of water since not all of our used water can be recycled. Also the transport of the inhabitants shows steady negative impacts. The use of fossil fuels for public transportation like the use of a standard passenger car with diesel as fuel is responsible for this and depends on the behavior of the inhabitants. By using domestic produced energy in a modern electro car this impact can be further reduced.

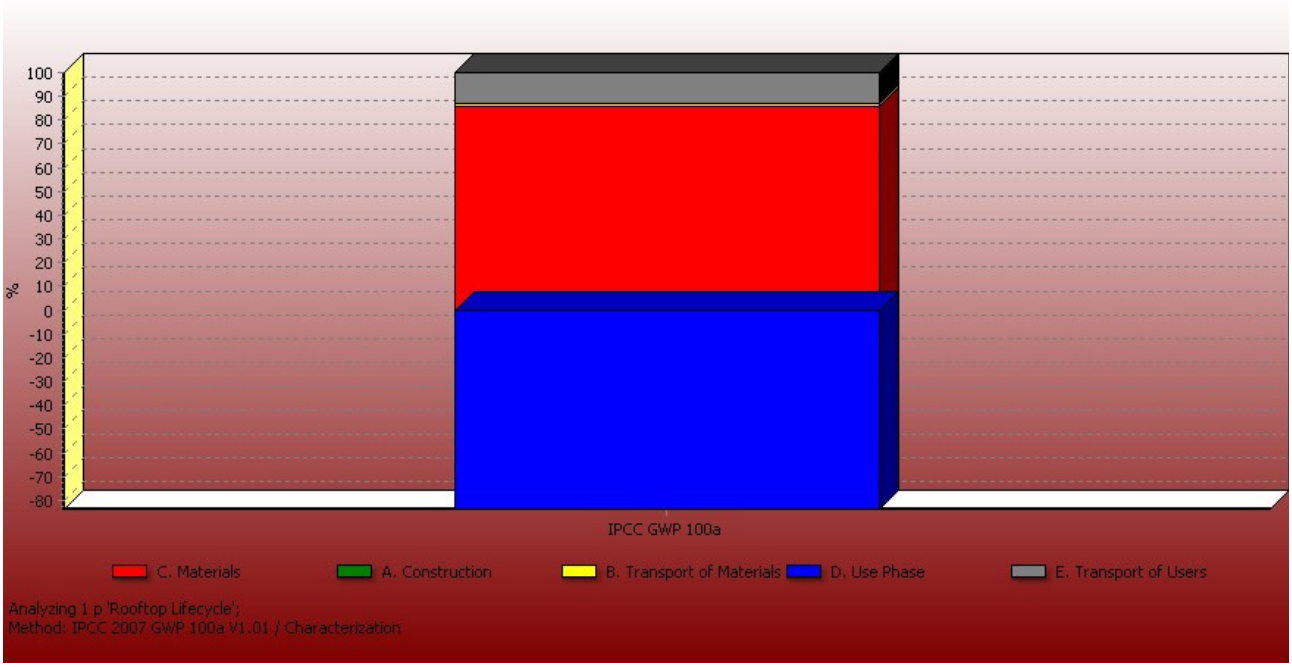


Impact assessment of the Rooftop Building characterization



Impact assessment of Rooftop Building normalization

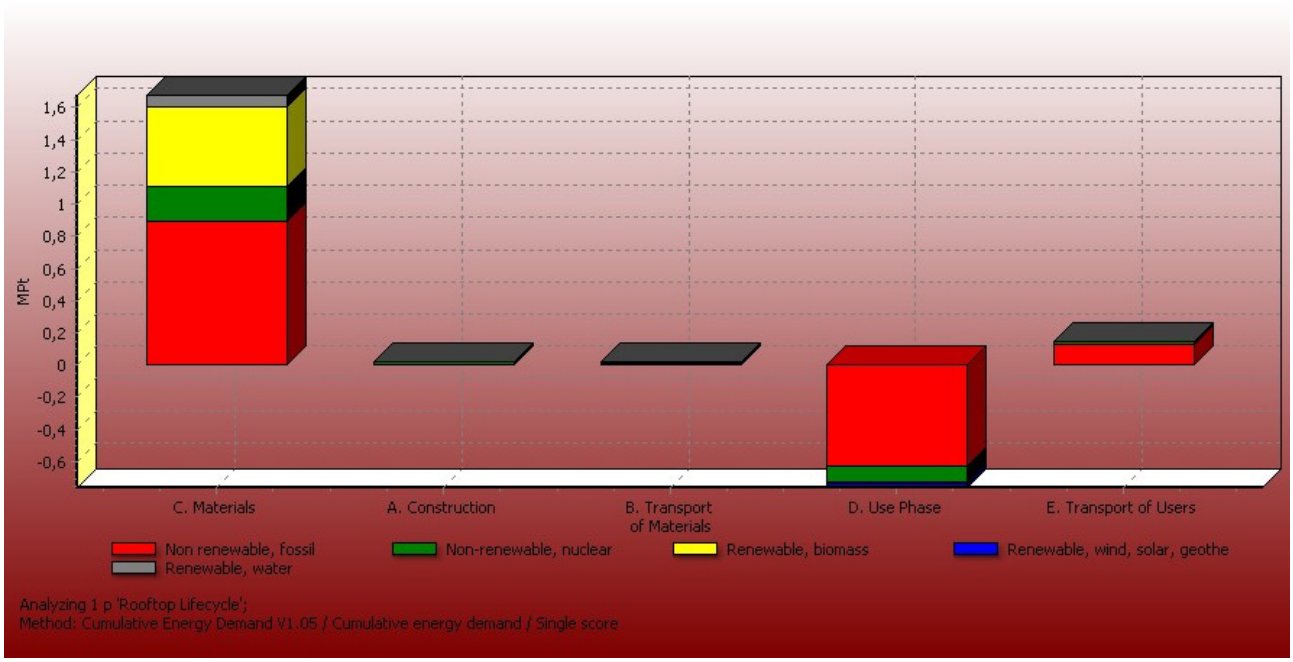
The influence of the Rooftop Building on climate change is better to conceive as we take a look at the CO2 equivalent which the Rooftop housing unit produces over its lifetime of asumed 50 years. Only the materials the use phase and the transport of users seems to have an recognizable impact. As before the surplus of sustainable produced energy can cover the most part of the material production process. Its related saved CO2 equivalent amounts to 55100 kg, whereas the production of materials produces 56300 kg of CO2 equivalent.



CO2 equivalent Rooftop Building

The difference of 1200 kg could be avoided through the use of electric cars, or even better bikes to get a positive balance by reducing the transport impact of 8460 kg CO2 equivalent.

The demand of energy is again dominated by the material production. The energy mix is mostly defined by fossil fuels, nuclear and biomass. This can only be undone to a small part by the sustainable energies produced during the use phase „Cumulated energy demand“.



Cumulated energy demand

5.7. COMMUNICATIONS PLAN

New ideas are not relevant unless they are heard. This section describes our efforts, strategies and successes in communication management and how we are creating the brand Rooftop.

5.7.1 COMMUNICATION PROJECT

STRATEGY

Communication is the first thing humans learn. It is the only way of solving any of the world's issues and its lack always leads to problems. Apart from basic daily interaction, everything someone does needs to be communicated in according ways to reach specific target groups. Because where is the point of doing anything if no one hears us?

The following strategy presentation is designed in a way that we hope will make you understand that at Team Rooftop, communication elements are originally a result of imagination and spontaneity that we process into a well matching and working concept while being faithful to our character. The project in its entirety — the people, idea and city behind it as much as the house we are building — is the key element of our communication. Therefore it is vital to briefly introduce you to context, team and concept before outlining our main communication goals.

Global & local context

What are you looking at? A relatively nice-looking sheet of paper or a backlit LED screen, maybe retina, maybe 90s-Gameboy-like. A small piece of a European tree or — it becomes a little complicated here — glass or plastic from somewhere in the world, able to convey information thanks to Moore's Law, Asian factories and a number of patents. The world is an amazing organism, undergoing rapid change as it always has and always will. Lately this change has largely been induced by humans. And it has not always been perceived as positive change.

As humans, we are, compared to nature, huge energy-wasters. Our numbers are increasing; no one knows how the world can keep on sustaining us. We enjoy big changes but the planet has to suffer its side effects — it is impossible to safely calculate all scenarios before starting off. But one needs to start somewhere, as they say, "start small, but do start." That's why we as Team Rooftop started right where we are: in Berlin.

„Start small but do start: that’s why we as Team Rooftop started right where we are: in Berlin.“

The city of Berlin has been undergoing massive changes throughout the last couple of years. Since the fall of the wall, large parts of the city have been rediscovered and destroyed buildings made hospitable again. The city is attracting a dynamic crowd that keeps on waking up sleepy Berliners with strange tongues and great ideas — despite the incapacity of the city government. As always, this is accompanied by unforeseen side effects: the unique social equilibrium in the different neighbourhoods is being shattered. Berlin was a city of heterogeneous, mixed spheres, it is now becoming a more stratified, classical capital. Aggressive gentrification is a direct consequence to the magnetic attraction Berlin has on people from all over the world. Day by day, the remaining war wounds, so typical for this city, and green lungs of the city have to yield; characteristic “Altbauten” — Berlin's typical turn-of-the-century apartment blocks — are being replaced by new buildings - everything in order to satisfy the constantly increasing demand for high-quality urban space.

A recent example is the Tempelhofer Feld. Since the closure of the airport, this huge and unique field has been opened to the public and is being used by Berliners for sports, BBQ and other free time activities. The neighbourhoods around it used to be largely neglected by the Berlin government and became attractive thanks to the personal energy of close-by residents. Now private interests with the government in tow want to take advantage of the new flair, build expensive and lucrative apartments on it — and might just as well destroy the particular charm that attracted them in the first place, undoing the delicate social balance in the process. It took a concerted public campaign to preserve the Tempelhofer Feld as a public green spot in May 2014, when all citizens were asked to give their vote in a plebiscite about the field's future.

No doubt, Berlin needs living space. Nevertheless, not primarily for cosmopolitan investors, and not at the expense of its soul. And that is where we jump in. It is our goal to create living space on top of the Altbau, thus avoid their replacement and conserve the allurement of the past century. Additionally, we do not want to design a house only affordable for well-funded interested parties but for someone who incarnates our goals and beliefs, meaning being devoted to alluring and upscale energy efficient and sustainable buildings.

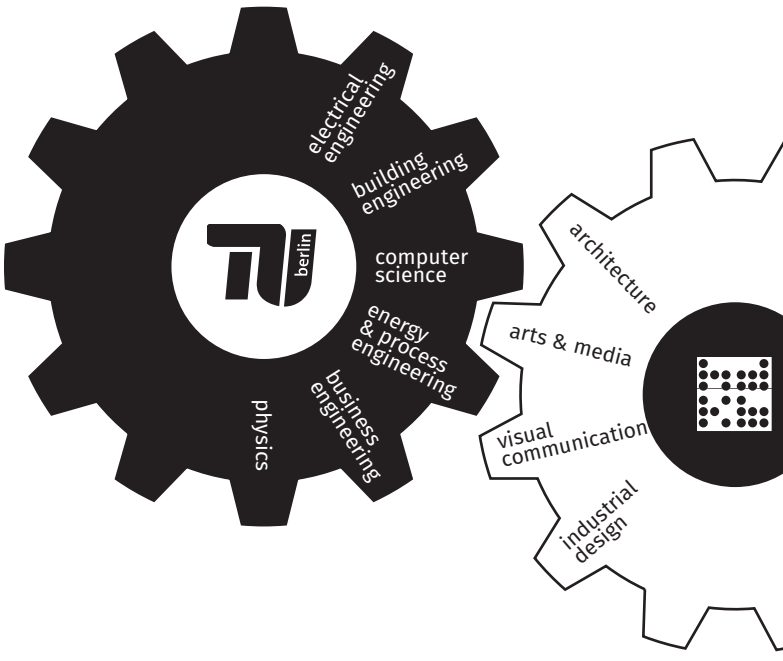
Team

There are slightly more than 3,500,000 people living in Berlin. What are they like? What are we like?

If you come to our office, you will get an answer as multi-faceted as this city. If you define a Berliner by its place of birth, only a third of our team qualifies. That is not the standard we apply, though: we are Berliners in mind-set and attitude, exactly what the city is fed upon: its subcultures and creativity.

Our team was born in that timeless and uncertain state of the late 80's and early 90's, at the start of something new, when the city was still divided in two. People born in Berlin, around Berlin, in Germany, in Italy, in France, in Sri Lanka, in Iran, in India ... — people from Berlin studying at two radically different universities: A technical one and one that is focused on arts. These people are coming together against all odds: We are Team Rooftop. (Sorry for sounding a little pathetic here.)

Technology and Art are often characterised as polar opposites. Number-crunchers vs. artists. Money-making realists vs. daydreamers. Resource-burners vs. ascetics. But it is also said that opposites attract. Only where different ideas come together, new ideas can arise. We bundle our competences to create something new, something that would have never been possible with just one of these disciplines.



Our team brings together roughly 35 students of the Technische Universität Berlin (TU Berlin, Berlin Institute of Technology) and the Universität der Künste (UdK Berlin, Berlin University of the Arts). Even though the two are located right next to each other on an area called Campus Charlottenburg, besides some work together in research, no institutional cooperation has existed until the Rooftop-idea was born.

The status quo is that we share a canteen but not our ideas. We want to do our part in changing that: giving the Campus Charlottenburg a house, which embodies the coming together of both universities.

You must think we were set up by two professors. No. We put the project in motion by ourselves. We convinced the two universities' officials to work together on the Solar Decathlon Europe. We still work fully self-organised and build the house by ourselves. Naturally we can ask professors if we need expert advice, but make all decisions on our own — our primary motive force is passion, not expertise.

"Against all odds: Team Rooftop in its diversity marks a whole new level of creating new ideas."

And this passion is exactly what we want to communicate: We want to open people's eyes so that they think about their environment and actually take responsibility by supporting and using sustainable energies and innovative energy solutions. You can contribute and you can make a change. That is what we want to radiate — expertise is secondary.

Concept

And this is where you can start: in your hometown. A closer look at Berlin shows that our city has a big number of Altbauten. These typical turn-of-the-century buildings are the focus of our project.

Berlin enjoys one of the biggest stock of pre-war buildings of Europe, yet their biggest attraction — age — makes them huge energy wasters, maintenance often being hampered by complicated ownership situations.

Our concept is to use this existing Altbau, create the required living space on top of it and improve its overall energy balance – thus we are finding one solution to two pressing challenges. The Rooftop House replaces the makeshift inefficient roof truss and gives energy back to the building below. And, every bit as important, it is not destroying the charm of the typical Berlin Altbau while creating modern living space.

We know that the renovation of the Altbau cannot be a top-down process though. A strong cooperation with the house community builds the base for the following. Instead of selling the Rooftop House the way many investment funds sell rare living space in the center of Berlin, we propose a crowd-investment solution. The owners of the Altbau let us use their rooftop for our house and, in exchange, we replace old electrical appliances, remediate windows and façade and renew the heating system — depending on the particular Altbau situation. Thus the Rooftop House acts as a catalyst to galvanise a local movement, encouraging and supporting the owners to bear responsibility for their homes. Once you commit to the project (as we can all tell at first hand), the community spirit takes over and the house community will feel like bucketing water from a seemingly infinite fountain.

For a more extensive assessment of our Altbau concept, please refer to section „Individual and Collective Housing Building Project".

In order to put this concept into practice it is crucial to dive deep into Berlin's 'Kiez'-scene; 'Kiez' describes a relatively small community within a bigger city. To be established in these local neighbourhoods, it is essential to have a strong basis through the residents' support. Therefore, bringing the Altbau into the 21st century has to be a bottom-up evolution, initiated by the Rooftop project but carried by the com-

„Our concept is to use this existing Altbau, create the required living space on top of it and improve its overall energy balance."

munity. Hence communication is a key component of the Rooftop idea.

Brand Rooftop

In the following abstracts you will notice that we talk a lot about our originality and authenticity, sometimes throw in a humorous line or two. From time to time we also use anything related to the colour orange to characterise a piece of our work. That is because it is our team colour (and we really like it!). It always stands out and definitely captures your eye. We use it rarely but precisely because, to us, it works as a symbol for the characteristics defining our team spirit. As a team we stand for innovation combined with infinite passion, being smart, eco-sensitive, down-to-earth without losing the vision of flying high in the sky, sneaky and cheeky. We are a group of students, and that is something we really want to point out. We define ourselves as a vivid part of the house and vice versa: the house is a part of us. We aim to transmit this image that we have in our mind onto our communication strategy, thus sell the brand Rooftop. Wait, we need to correct that. Our goal is not to sell it in terms of making big money, but to transmit the characteristics and feeling we get when seeing our house grow.

Rooftop Fundamentals

The best way to attract attention towards our brand is by always respecting and remembering our team's fundamental values.

We established three key principles that chaperone our work and thinking process and that our communication is oriented towards:

- Responsibility
- Connectivity
- Adaptability

Combining and pursuing all of these values at once, we aim to realise the goals mentioned above: creating a beautifully designed house that is ecologically, economically as well as socially attractive for the unique Berlin neighbourhood.

These Rooftop Fundamentals set the base for the design of our house as well as our communication. Once you have thumbed through the following communication strategy you will soon notice – despite not being clearly assigned to one of the three fundamentals – that each action is connected to them on a meta-level. This way, they automatically resonate whenever we talk about the project.



Responsibility

A responsible mind-set is the basis and motor for sustainable progress. It is the bigger reason why we work on such a project and it strengthens solidarity in everyday situations. We transport this feeling through the house, i.e. by the right choice of materials, and through our everyday actions, by switching off the light when we leave the office at 5 a.m. In a

bigger sense, we are looking to protect and make better use of what is already there: green areas, Altbauten, war gaps — instead of tearing down and irresponsibly building out of context.



Connectivity

To connect one another is probably the strongest tool humans have. Today's problems are too complex to be solved by anyone alone or top-down. Energy efficiency and living space are not two distinct problems but one interconnected challenge. For the shift to renewable energy to become sensible and reliable, a flexible network with smart players such as the Rooftop House is just as necessary as are responsible citizens. The Rooftop House on the Altbau is not a parasite, but enters a symbiotical connection between old and new. We have already brought students and universities from entirely different backgrounds together, now we want to reconnect the slowly disintegrating city-dwellers of Berlin into a real community, sharing our ideas and passion.



Adaptability

Adapting to new situations and environments has always been an inevitable feature of life. Our ancestors took this to the extreme when they shifted their home from day to day. Nature does it, too: every kid enjoys watching birds on their spring and fall passage. We are not rolling stones, but we like to wear shorts in the summer and scarves in the winter. Why don't our houses? The Rooftop House adapts to daytime and seasons through its façade. And of course it adapts to its users, their personal needs and moods. Our house can also adapt to the particular Altbau situation it encounters: the modules around our Core change depending on the dimensions of the host. In our communication we adapt to whoever we listen to and speak with.

Communication goals

Based on the Rooftop Fundamentals and with the brand in mind, we aim to achieve three objectives through our communication. Having our goals in mind is crucial in order to implement a clear and structured communication.

Raise public awareness

The Rooftop concept is a selected example to transmit the values of the Solar Decathlon Europe 2014 and, at the same time, to support a shift in values towards a less resource- and energy-intensive lifestyle in today's society. By providing useful and easily understandable information about the project and the contest, we want to raise public awareness on project-related topics like sustainable densification, energy efficiency and innovative housing.

Eliminate fears and barriers

Technological progress enables the development of new integrated concepts for energy-efficient living. These innovations require a change in existing thought processes that often raise internal fears and barriers. Through a clear, honest and sensitive communication, we want to remove barriers and motivate people simply to get into it. Our house and our team are the best examples that you do not need to be an expert to make a change.

Inspire for action and further thinking

We see ourselves as humble pioneers and want to be a driving force in developing new solutions for urban living by connecting design and technology. As a student-run team we want to convey our ideas and our concept physically through our house and, emotionally, through our behaviour. The goal is to encourage people to reflect, think further and to take action.

„Our house and our team are the best examples that you do not need to be an expert to make a change.“

It is relevant for our strategy that these fundamentals are ordered chronologically. They do not vary in importance, each being equally essential for a maximum achievement of our communication. Obviously the goal of every marketing strategy is to raise public awareness in the first place. We do not differ from that. But our work is not finished just by having people know about it. Since – well we all know that – you see an interesting ad or your friend tells you about a cool NGO, but do you really get your hands on deck every time? Probably not, because you think you are not capable of it or you do not know where to start. The problem is, however, the falsity of that assumption. If you take the first step you will be surprised how quickly you are up the stairs. Hence, that objective is an immediate successor of getting out there originally. Once we eliminated fears and barriers, whether physical or emotional, the last obstacle is to inject the Rooftop spirit. Remember, the brand Rooftop stands for infinite passion and flying a little high in the sky. It is very important not to lose the motivation to keep climbing the stairs until you reach the top and setting oneself new goals. We want you to stop quashing seemingly unrealisable ideas but to dive deeper into the subject doing your best to find support and a community to share your idea with.

„Unfortunatley we actually do need sleep from time to time, which is why we have to ration our time wisely“

Resource Analysis

To achieve these three objectives we have to use various channels that will later be outlined in detail. Based on limited financial and personnel resources, we face a big challenge developing and implementing our communication strategy (which is one reason why we mostly use online channels). To support our communication strategy and to help us make the right decisions concerning the implementation of our communication channels, we created a compact SWOT matrix illustrating the team’s communicative potential.



Figure 266: **SWOT-Analysis**

None of what we do would be possible if we did not have an incredibly hard working team, going considerable lengths and beyond what was imaginable back when an idea sprung and someone said: „Wouldn't it be cool to build a house on the roof?" Well, let's face it, no team member (or our mothers for that matter) thought we would actually be part of something this big and time consuming. In the communications team, we have especially benefitted from the multifaceted skills brought into the team. Albeit our generation is being criticised very strongly for wasting time on social media platforms, living in a virtual world and burying our infantine imagination, we can in fact say the opposite. The time we have spent on these channels before helped us to fully integrate that knowledge into the communication strategy and to profit from their indeed endless scope of possibilities.

Nevertheless, we are only humans after all. With only few hands and brains to do the work, time flies by. Furthermore, time is limited because everyone on the team helps actually building the house since we do not enjoy maximum support through our chaperoning universities. Then again, we simultaneously see that as a cardinal opportunity for our team since it allows us to operate much more independently and really run this as a student project.

In the end, we withstand threats in different forms, be it personal dependencies and differences that can cause miscommunication or simply the fact that – since we are humans – we actually do need sleep from time to time. Altogether, our strengths and weaknesses that we acknowledge, the opportunities we can seize and the threats we manage to bear lead to a contoured strategy that is implemented in order to market the

brand.

„Our goal is not to sell a product but to inform, inspire and educate our target public: actives and passives.“

Target public

Since our goal is not to sell a certain product but to inform, inspire and educate our target public, it is difficult to define our target groups by classical means such as demography. Instead, we use two levels of differentiation in order to make the groups more graspable:

Level 1: engagement and interest split society into three different clusters (see Figure 267). As we said, we want to inspire people for action. In order to adress the right people in the right way it is crucial to know who is already taking action (engaged) and who is open to new ideas and input (interested). We can save important energy here.

Level 2: the first level clarifies the way to adress our target audience. But we still do not know where to actually find this audience. That is why we rely on the classical tools age and field of work/study to help us track down the prey of our communication.

Using this pattern we can bundle all the people we want to address and provide them with an adequate message. Figure 267 allocates our three target groups on level 1 by their engagement and interest in competition related topics.

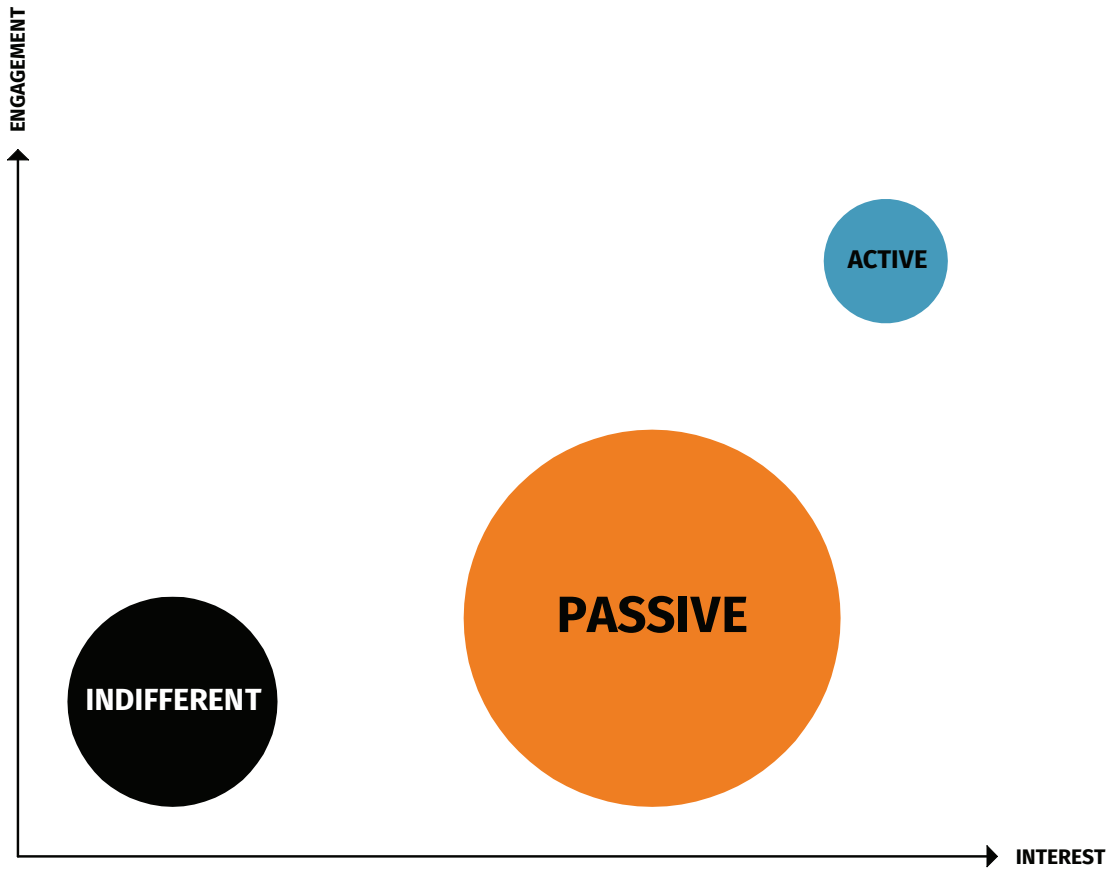


Figure 267: **First level of diffentiation: engagement and interest splitting community into 3 groups**

What follows is level 2, illustrating the representatives of our three target groups acitve, passive and indifferent. We do have to generalise a little bit at this stage. Of course ideally we want to the whole world to hear us

.

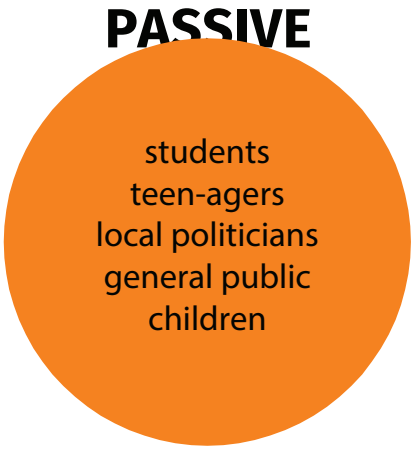


Active Group

People who are actively dealing with the problems we address form the active group – i.e. professionals, students and partners acting in our subject field. Permanent urge for knowledge, motivation and passion to change something are the important aspects characterising this target segment.

We want to share new and useful information about and experience gained from the design, building and operating phase of our house with this group. Thereby we want to encourage them to rethink established concepts and to connect each other in order to find a more suitable solution. Our communication activities aim to inform and inspire the representatives of this target group.

Passive Group



As the name indicates, a passive attitude towards our field of action describes representatives of this group. We consider the general public, most politicians, most students, teenagers and kids as a passive audience. They form an interested but not (yet) engaged group.

Divergent state of knowledge and the age difference within the group are the main challenges we have to consider in our communication activities.

We attach major importance to this target group because we think there is a big potential sleeping in many of them. The focus of our communication is activating and motivating this group. By breaking down existing barriers and reducing fears to develop and realise innovative solutions, we want to reinforce existing interest and encourage their engagement. If all parties fulfil their roles we can change our living area into a better place.



Indifferent Group

In this group we summarise everyone else: people who actively decided not to care about renewable energies and a responsible lifestyle or people who have no connection to it at all. For example there are still people who do not believe global warming is really happening or cannot keep up with the innovation progress, which leads to increased indifference. Our challenge is to reach this target group through the emotions and passion shared by us and the other target groups. Sometimes peo-

ple are immune to any kind of rational information so they can only be reached on the emotional level.

We primarily focus on the active and passive groups in our communication due to our limited resources and in order to distribute our energy wisely.

This project enables us to stimulate thought processes and to influence the behaviour of these target groups concerning the responsible use of resources, energy efficiency and renewable energies. That is why we want to develop and implement a local solution taking our environment into account and including the target groups to solve parts of the global problem of energy consumption.

With our integral communication we aim to create a positive influence effect – we call it cross-communication – between the target groups to achieve our goals.

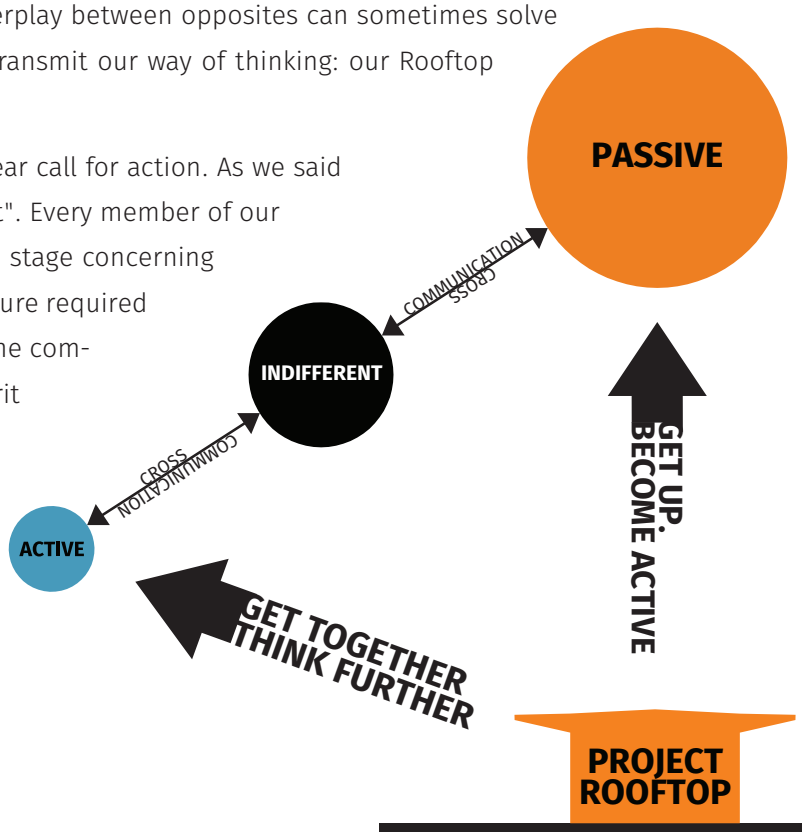
Message

We have two different messages for the two target groups we want to adress directly:

- **Active:** "Get together and think further."
- **Passive:** "Get up and become active."

With our message to the active group we want to stimulate new and innovative ideas, referring to the individual competences and interaction between motivated people. Our house and our communication are designed to demonstrate how the interplay between opposites can sometimes solve problems on a bigger scale. We want to transmit our way of thinking: our Rooftop Fundamentals.

Our message for the passive group is a clear call for action. As we said in the beginning: "Start small, but do start". Every member of our team definitely had some doubts at some stage concerning his or her personal skills or the time exposure required for the project. But once the step out of the comfort zone had been taken, the group spirit took over and things started to flow by themselves. You do not have to be an expert to have an impact on your environment – clear goals and passion to achieve them is more than enough.



ADAPTABILITY
CONNECTIVITY
RESPONSIBILITY

ACTION PLAN

To develop a message and to define target groups is only the very beginning of a communication strategy. What follows is the real action.

It is our goal to use our channels efficiently in order to reach as much people as possible. We want to keep people updated about the project, spread our message and get them in touch with the topics related to our work.

We try to get into people's minds by being a good example and carrying our information in a descent, neat and simple way.

Due to the different interest and awareness levels of our target groups, it is necessary to have a number of various communication channels to reach all of them. Hereby the internet as well as the offline media are powerful instruments.

"Good communication is as stimulating
as black coffee and just as hard to sleep after."

– Anne Morrow Lindbergh

Our website is the heart of our communication, it contains both bundled information about the project (house, team and competition) and current developments. We inform the active group about details of our work and progress, and offer the passives a platform to lose themselves in, so as to closing the page afterwards being very imbued.

The biggest part of our target groups uses social media every day. Therefore Facebook and Twitter play an essential role for our communication, not at least because they are convenient and cost saving but they also enable a dialogue between users and team. Eye-catching visual elements can be shared instantly and are the best way to get the people's attention, even those who have not heard of us.

Besides all these opportunities, we did not forget that there is a world besides social media. A big part of the general public can be reached by using traditional media, such as local newspapers, professional press and radio stations to raise the awareness for our project.

To interact with our target groups personally, we visited and organised a number of different events covering the whole spectrum from formal presentations to casual festivities.

Thanks to our channels, the radius of awareness emerged from the walls of our universities – through Berlin and the whole country – to an international dimension.

In the following Action Plan, we will illustrate our channels explicitly and the purpose we attribute to them. There will be certain example cases to show how we realised our strategies, followed by an analysis. In the end, we provide a tracking table to give an overview of all our actions.

"This is the real action. While most of our team members get their hands dirty on site we carry our messages out into the world"

I. BEFORE THE COMPETITION

Website

"Bundled content is being transmitted within a clear and simple design."

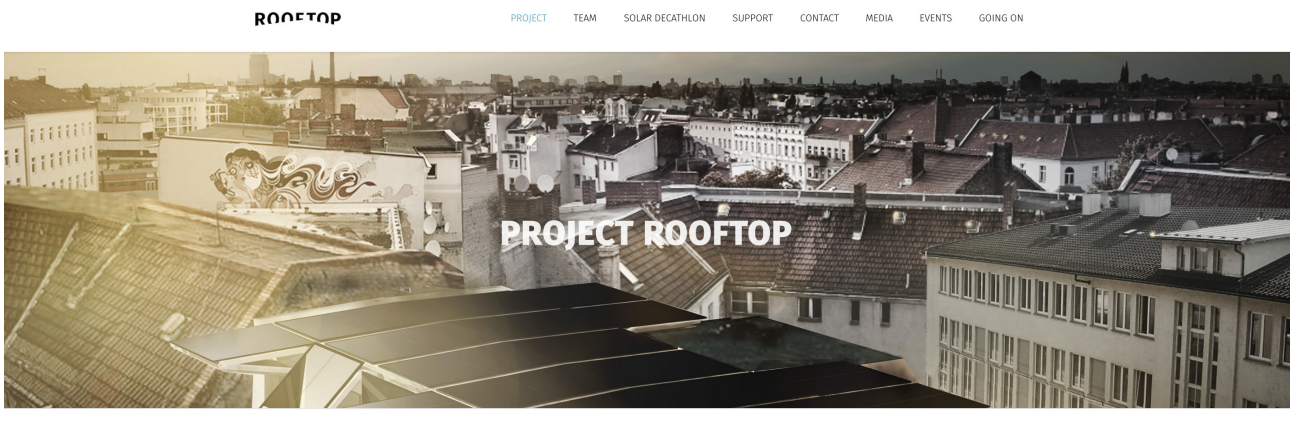
We use our website as the main communication hub concentrating emerging traffic from other channels. The clear, decent and simple design allows us to transmit bundled content smoothly on desktops and mobile devices. Through this channel we offer information for everybody. We aim to share new ways of solution finding with the actives, while supplying the passive public with profound know-how and trying to fascinate them with pictures, videos and graphics.

Visitors, whether they speak English, German or French, will find themselves on a well-structured page with a lot of visual and interactive elements that even make the complex aspects easy to understand. Every immersive section is designed as a one page: a landing picture, followed by segmented details. Imagine there is a layman scrolling through the house explaining page, he has got a clear picture of how everything works once he reaches the bottom. This way, newcomers will be fascinated by the clarity and appeal of the site. By being told exactly what we do in a very neat and simple way, laymen's and newly interested parties' creativity and sense of responsibility will be stimulated. Meanwhile, actives with an existing image in mind will click through our website, really diving into the depths of the subject and learning more about it. Thus, teamrooftop.de connects the actives, the passives and us: it is very important that visitors understand the down-to-earthness and reality of our team when looking into our very ordinary and human faces in the teams section. We are just a bunch of students working on something amazing.

We developed a crucial equilibrium of information between social media and our website. For example, we want people on Facebook to proceed to our website in order to be provided with more information. At the same time, our website functions as a direct link back to our Facebook fan page.

Our "going on" section – in contrast to the short posts on Facebook and Twitter – provides a bigger information load filled with upcoming events, updates from the site and articles written by team members.

Additionally, we offer downloadable material especially for the press to encourage media coverage about our project. The success of our page is analysed. With the help of Google Analytics we can review the success of the website, for example by analysing the user's dwelling time on certain parts of the page. Our content is thereby adapted to our user preferences.



Newsletter

The idea behind the Newsletter is to provide our recipients with up-to-date information about the construction, upcoming events and facts about the competition via email. We communicate specific work related content to the active and passive target group.

In order to correspond with the active group, the newsletter is mostly a sign of trust and act of implicitness. By continuously sending out news to our active subscribers, we mostly hope to remind them that their interest and investment is paying off. On the contrary, the newsletter undertakes more of a motivational role when being sent to passives. Of course, those subscribers already took a step towards being active since it is their free choice to sign up. However, we all know how it is, we see something on Facebook or hear about it on Twitter, click like and then forget about it. By reliably receiving the newsletter, we accompany this main target group on their way towards awareness and taking action: get up and become active!

The newsletter has a very simple design and we always find the perfect words to cover all the topics in an easy and understandable way. Obviously, part of our strategy is to generate traffic towards all our channels to get further information. Therefore, we implement social sharing buttons into our newsletter.

“We update everyone, even those who do not actively check out our website or other channels”

We use mailchimp to send our emails. This tool helps us to create an appealing newsletter and to analyse the success of our campaigns. You can sign up for it on our website, by scrolling down to the bottom every page or in the contact tab.



Team Rooftop - Solar Decathlon Europe 2014 View this email in your browser

Es steht.

Nach dem Aufbau des Core Modules steht nun der Rohbau inklusive Dachstuhl. Zusammen mit Bauhandwerkern der Knobelsdorff-Schule erfolgte der Aufbau innerhalb weniger Wochen. Ganz klar: Zeit für das Richtfest!

Letzte Woche fanden sich unser Team, seine zahlreichen Helfer, Sponsoren, Professoren und Interessierte auf der Baustelle in der Peter-Behrens-Halle der TU Berlin am Humboldthain ein und feierten - wie es sich gehört - inklusive Kranz und Richtschmaus.

Der Bau geht weiter: am Montag wird schließlich der Aufbau der Fassade erfolgen. Ein weiterer wichtiger Schritt auf dem Weg zur Fertigstellung – wir können es kaum erwarten!

SOCIAL MEDIA

Facebook

Our Facebook page is more than a second website to us. It allows us to instantly share information, links, pictures and videos and interact with all the people who decided to “like” our page. Currently we have around 1,250 fans. They can follow the development of the project and will notice new posts on their news feed.

Facebook is especially being used by a big part of our passive target group. Therefore it is a powerful dialogue medium with a wide radius of impact: students, teenagers, politicians, other activists, etc. can be brought together on one page, hearing our message to get together and think further. By posting capturing visual elements and facts, we use this instrument to reach as many people as possible and involve them into our project. Those who are already interested and engaged are being supplied with up-to-date information and educating third party content. Facebook is a great way to make our project be heard. There is always a chance that someone randomly lands on the page, thus suddenly taking our name recognition to different cities, maybe continents.

“As a dynamic channel Facebook reaches a big majority of our target groups instantly”

Only little general information about the team and the Solar Decathlon can be found on the top of our page. Moreover, we express ourselves by the things we post and by the pages we like. We decided to “like” our sponsors and partners as well as the other German teams taking part in the competition. Periodically, we share content from our partners, which informs about project related topics, such as renewable energies and sustainable densification - because we really like those things.

Based on insights provided by Facebook and free page-analysing tools like “fanpage karma”, we decide what to post and when to post.

Due to these insights and related to our concept, we keep our posts decent, neat and simple.

Questions in our posts encourage the user’s interaction with us and among each other.

Visual elements have a much bigger impact than text posts do: In average, they get 50% more likes. Therefore almost all of our posts contain pictures, videos or at least a thumbnail of the pages we share.

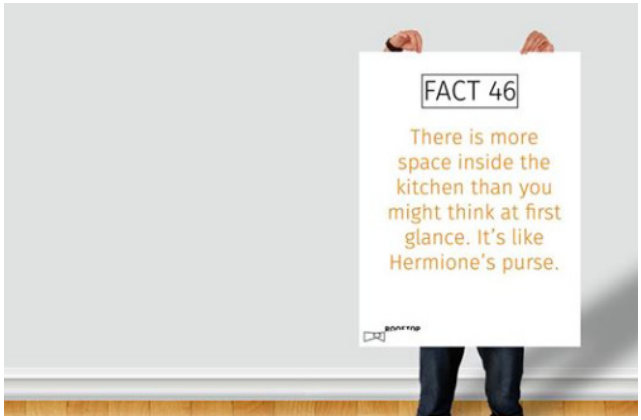
Our daily facts are good examples for the interpretation of statistical results. Every day at the same time, a new fact about the house, the team or the competition – sometimes in an entertaining way – is posted. We chose 10 p.m. to hit the crucial media consumption bracket between dinner and sleep.

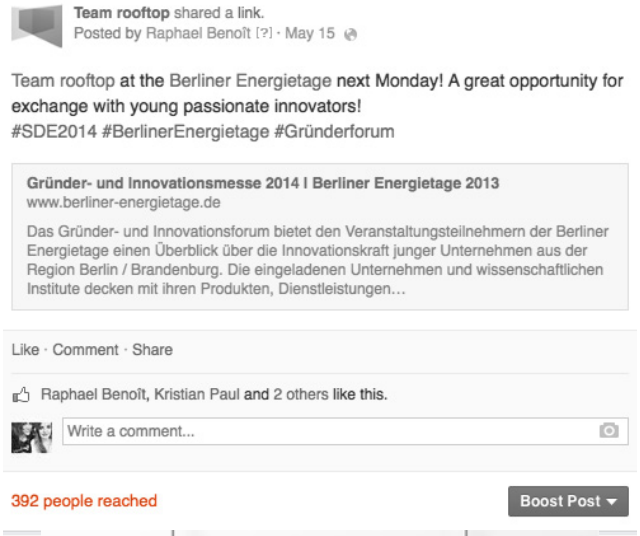
Facebook offers a full range of interesting functions. We are able to create events and invite our users online. It is an important part of our strategy to make the usage of our page as convenient as possible. Therefore we make sure that messages and comments will be replied within a short period of time. Another example for the aim of convenience is the implementation of WooBox, a third party tool, which allows the user to go to our Youtube and Twitter channel without leaving Facebook.

Last but not least, Facebook is the platform to make our messages be heard: to get together, think further, get up and become active. It creates a sense of community like no other and comprises a tremendous

potential of creating a movement towards making building greener (eh, oranger). When we share pictures or videos of the construction site showing us in action, getting our hands dirty, our fans' eagerness to get up and do the same is being triggered.









Twitter

Twitter is the most popular micro-blogging platform that is free and easy to use. Nowadays, it is not only used by individuals but is also adopted by brands and businesses to both promote their business on this network and to be a part of a wider conversation at the same time. Following those profiles allows us to get hot news and be part of relevant conversations. Integrating Twitter in our communication strategy enables us to inform about our project (of course including various milestones of our work progress) and contest, and to share engaging and useful content from other sites. Using Twitter can have a leveraging effect on

"Twitter allows us to be part of relevant conversations"

our communication raising social awareness towards project related topics, such as energetic efficiency and sustainable lifestyle.

Primarily, our tweets contain status updates of our work process, notifications about participating and hosted events, as well as own and third party content. To reach both the actives' and passives' attention and to improve interaction with them, we use visual elements in our tweets. We always use the official Solar Decathlon Europe hashtag #SDE2014 to classify our tweets for targeted conversation. Thereby, Twitter allows us a much easier and faster communication.

Youtube

"The whole Rooftop experience is displayed in a graspable and emotional way"

Youtube is the biggest and most popular video sharing platform on the web and it's entirely free to use. The wide range and the easy handling are changing YouTube to a powerful tool for viral marketing. It becomes also more important because of the increasing video consumption on mobile devices. When using Youtube in our overall communication strategy we can reach a huge sector of our target audience. Additionally we cross-promote Youtube on other social media channels and of course on our website by link to related videos. It allows us to transmit information about our work in a more graspable and emotional way, mainly targeting the passive group that still needs fuel to „get up and become active." This channel facilitates it to record the whole process of our time at Team Rooftop through visual and auditive means. The videos are of different lengths, sometimes simply recording a cool event we were at, other times including detailed animated information. For example, it is both convenient and highly educational to watch our main team video where we orally present the house with all its facets and from every imaginable angle. Mapping the Rooftop house and technology through the very clear 3D movements is what makes this channel so wonderfully unique from all the others. If one missed a fun event that we hosted or wants to learn about how our project is integrated into our universities, YouTube is the ideal platform to quickly be taken back in time.

"Flickr is described in pictures, not in words"

Flickr

Flickr is a database for pictures with high definition resolution. The idea behind the Flickr-Account is to provide a large set of photos from events and the house building process, open for access by the press and anyone who is interested.

Press

The press is another way to reach a broad and diverse audience. We contact newspapers as well as professional journals and blogs in order to provide according target groups with adequate articles. In the beginning, it was much easier to serve the professional press, e.g. "Detail". They are open to new ideas and their readers have the basic knowledge to understand our complex topics. Right now, as our house is being built and the competition is about to start, we recognise a constant rise of interest by the press. We are excited about the increasing attention of the print media and looking forward to the impact the competition will bring with itself.

Specialised press

When articles are published in professional architectural and technical journals and blogs, we point out our innovative ideas to activists and professionals who deal with project related topics. By explaining them new solutions, we want to inspire them to think out of the box, to „think further".

Our universities publish articles in their newsletters and newspapers, so that fellow students and scientists get to know about our project. It creates a feeling of community spirit within the universities.

„The good old fashioned way of printing is just as important as media channels."

Broadband press

Articles in the broadband press can reach a wide, mostly passive, audience, especially those who are not often online. The content of the articles is informing, but easy to understand and visualised vividly. We believe that interest will arise and discussions with fellows will be provoked.

Give-Aways

For the time before and during the Solar Decathlon, we designed a small collection of give-aways to stay in people's minds and to provide something useful for them at the same time. Of course, typical dissemination material such as business cards and flyers are available whenever we present ourselves in public.

„We wish we could keep all give-aways for ourselves because we love them so much."

Cotton bags

In Berlin, everybody likes to carry cotton bags with meaningful subjects on them. They are light, can be used in many situations and save the environment by replacing plastic bags. We decided to print a technical drawing of our house's concept combined with the Rooftop logo on a fully fair-trade bag. By that, our idea will stay in people's minds and it is eye-catching, mostly reaching our young fans and supporters from the universities.

Yardsticks

Giving someone a yardstick is probably the most obvious way to tell them: „Get up and become active!". Yardsticks help people to create, to build things and that is exactly what we are doing all the time. We want people to do-it-themselves and a yardstick with our logo on it perfectly transmits our message on the one hand and on the other hand, it is a gift which can be used directly when being active.

Pencils

As students we know that a lot of people appreciate getting new pencils. When writing down thoughts or drafting, the Rooftop pencil will be there and our logo will stay in the user's head. Just like it happens in IKEA, they will be disseminated quickly. If there are people who have not heard of us yet or forgot us already, they will get curious and try to find information about the project.

Postcards

We print postcards with a selection of our Facebook facts on it and disseminate them among the visitors of our house in the Cité du Soleil. They can either take it home and keep it as a souvenir or send it to all their relatives and friends with best regards from the Solar Decathlon. In this way, our message will be transmitted to the world.

Institutions

The closest way for us to get in touch with our active and passive target group is to use our universities and our partner institutions as a stage. Classrooms, cafeterias and hangout areas form a wonderful platform for direct communication of our work. In the beginning, this was our most valuable form of publicity. A current goal is to spread our message further, meaning to reach the numerous passive students who are nevertheless open and responsive to new ideas. A number of different university based initiatives and events allowed us to pursue that objective as you will find out hereafter.

„How would we have found each other if it wasn't for our shared campus?“

EUREF Campus

In cooperation with the TU, the EUREF-Campus pursues a vision of an “intelligent city” right in the middle of Berlin. The EUREF-Campus is organised into different events, symposiums and workshops. Our project was presented in front of a sustainable architecture class in form of a lesson. Since this event focuses on intelligent cities, our focus laid on talking about how the Rooftop house is attacking the problem of urban densification and the resulting lack of affordable living space, while simultaneously smartly implementing sustainable factors. This event made it possible to get in touch with students who actively decided to deal with modern urban problems, reflecting upon related topics when in class. We noticed that many students were very fascinated and inspired by our house and were motivated to stay dedicated.

Collision Week

In this annual project week, different faculties of the UdK Berlin collide to create new solutions. Students from all fields can sign up for a project of their choice. This year, Team Rooftop was the first project ever to be organised entirely by students. Our team leader Alessandro and communication director Raphael gave students an insight into our project and allowed them to actively become a part of it for five days. Some of our furniture has been designed by the participants who thoroughly enjoyed seeing the manifold sectors of our project.

The Collision Week was an excellent opportunity for us to reach our fellow students, especially passive ones. Some of our now very valuable team members first heard about us during that collision and were ultimately inspired to participate. Julian, our interior designer, also developed the concept for our moveable furniture within the scope of the Collision Week. This is why reaching out to our passive target group is so essential – there is so much hidden potential and passion in many of those who didn’t know it.

Events

To accompany the progress of our project, we appear at events and spread purposeful content to our target groups. Professionals, students and even the youngest can get an insight into our work and get involved in the project and all its related issues. We organise parties and other festivities to present the house and ourselves to our supporters and fans personally. Additionally, team-intern events strengthen the interdisciplinary work and enhance the team spirit, which is essential for our success.

In the following we selected a few of our key events to be presented that we thought reflected our commitment best.

Berliner Energietage (Berlin Energy Days)

Externally organised fairs which relate to our work provide a stage for us to present our project. At the Berlin Energy Days, our team leader Alessandro gave a speech to the visitors and we had a stand for three days where we displayed our concept and got into conversation with professional visitors. It was an opportunity to get involved with members of our active target group, including professionals and politicians who want to make a change in the world's energy sector.

Biomimicry workshop

Biomimicry is the scientific discipline of studying and emulating nature's natural forms, processes and design concepts. According to the motto „Innovation by mimicking nature", a workshop was being held in Berlin. We were part of a panel discussion, where we talked about what our house learned from nature. At this event we were able to talk more about the design aspects and abstract innovations of the house. One of the features was that our PV-panels open towards the sun like a flower.

„We cover the whole spectrum from formal presentations to casual festivities "

Energiewende-Demo

As responsibility is one of our fundamentals, we want to be a good example by standing up for our values. On the demonstration for the energy transition (Energiewende), we reached the activists personally and got into exchange with them. Since the participants were very passionate about the subject of renewable energies, they were very reachable for our project. As a highlight of the day, our four team representatives were invited onto the truck of the organisers and had the opportunity to exchange ideas and passions first hand.

Ready-for-Versailles-Party

At our closing event in Germany, we invited journalists, our sponsors, friends, fans and family to see the house before we left for Versailles. Visitors were asked to inspect our house and got an idea of how much work has been put into it. Simultaneously, we wanted to show our gratitude for the great support during the whole project.

While we were at it, we nourished our orange image by serving orange juice en masse as a refresher. You can take that literally (and be jealous since it was very good), but also figuratively: we are full of passion and inspiration, and determined to share these ideas and feelings. We wish to put new refreshing thoughts about solar power and innovative architectural solutions into the heads of our guests as well as a glass of cool, freshly squeezed orange juice into their hands. Mmmmmh!

VIP-Tour at the “Lange Nacht der Wissenschaften” (Long night of science)

City events, like the “Long night of science” are a good opportunity to reach the wider public. Each year, thousands of events are organised across the city where scientists present their projects and researches for one night and are available for any questions visitors might have. At an event like this, we can raise the awareness for our project by illustrating new ideas. Cooperations with possible sponsors and partners can be formed, an enrichment for both parties. This year, our project (as the biggest project of the TU and UdK yet) was part of the private VIP-tour of the TU president. Highly influential representatives of companies and research institutions were present and thus their interest for our project was sparked. Naturally, we were very proud to prove to the newly elected president that our work has been going in a great direction.

Kinder Science Slam

As another part of the “Long night of science”, we took the chance to confront our youngest target group with the idea of the Rooftop house. One of our team members engaged the kids in an entertaining way to understand the problem of urban housing development. We remember being taken to the children's museum, helping our parents build a terrace or cut a tree, building miniature cities out of toy building bricks and asking questions about the most fundamental things of life (oh don't we miss being a child sometimes?). And we do not doubt for a second that these things set the base for our critical thinking and the scrutinising creativity that provoked this project. Thus, we could not think of any better way to pass on our interest and passion for architecture, engineering, electricity, design, etc. than to playfully present the latter to those who are probably more receptive for them than anyone else: children.

Connect the dots

To raise public awareness and get people involved at the same time, we created interactive posters and put them in our universities. Walking past them, people could “build” the Rooftop house by connecting numbered dots on a white space. Once they realised this was not just a random piece of paper with a white gap in the middle of it hanging on a wall, they quickly drew the lines from the first to last dot and were rewarded with a wonderful and simple sketch of the house. We gave them a few days time to draw and after that, when everybody started to be curious what this was all about, we put another poster with further information right next to it.

II. DURING THE COMPETITION

While exhibiting our house in Versailles, we organise a number of things in order to attract visitors. At this point we would like to re-enact chronologically how we present ourselves at La Cité du Soleil.

As visitors are strolling around the site, they are probably overwhelmed with all the impressive houses they see in front of them, to their left, to their right. Then suddenly, while still trying to decide where to go first, orange creatures will appear. As an eye catcher, we will wander around the site in orange morphsuits, very tight overalls that even cover feet and heads, and hand out flyers explaining where to find the Rooftop House. Once the visitors arrive at our house, various things can be seen outside. While waiting to enter the house for our public tour, visitors can look at our grand wooden information boards to get a first idea of what they are about to experience. To bring some of Berlin's flair to the Solar Village, the fire wall behind the boards is sprayed. In the city, there is almost no free standing house wall that is not covered in a strange looking painted animal or some quote by an unknown hobby poet. Additionally, the fire wall is a drawing space for children, on which they can paint in the contours of the Berlin skyline with chalk. It is part of the city culture to conquer the poor looking spaces and give them a soul – we want to transmit this idea to our visitors. For those who stayed young in their hearts we bring an orange 'kicker' – table football – to play some friendly games. Towards the end of the competition weeks, we plan on hosting a Solar Decathlon intern kicker world cup with all 16 competing countries. Some of us will play together with other team's members, ending these two years of hard work on a communal note – because in the end, it is not about winning or losing but about the amazing houses we all built and the values for which we stand. Every single solar home is unique and the result of many creative and constructive ideas. Nevertheless, the main attraction is, of course, the house itself. Entering it through our simulated staircase, the first thing all visitors will see is our Sponsor's Lounge. We dedicated this interior space to all those who believed in our project and invested in us. Not a single wall could have been erected if it was not for them. The walls are covered in little tables with name and logo of the big patrons, institution and each partner on them. You can read more about what happens inside the house in our public tour text.

III. AFTER THE COMPETITION

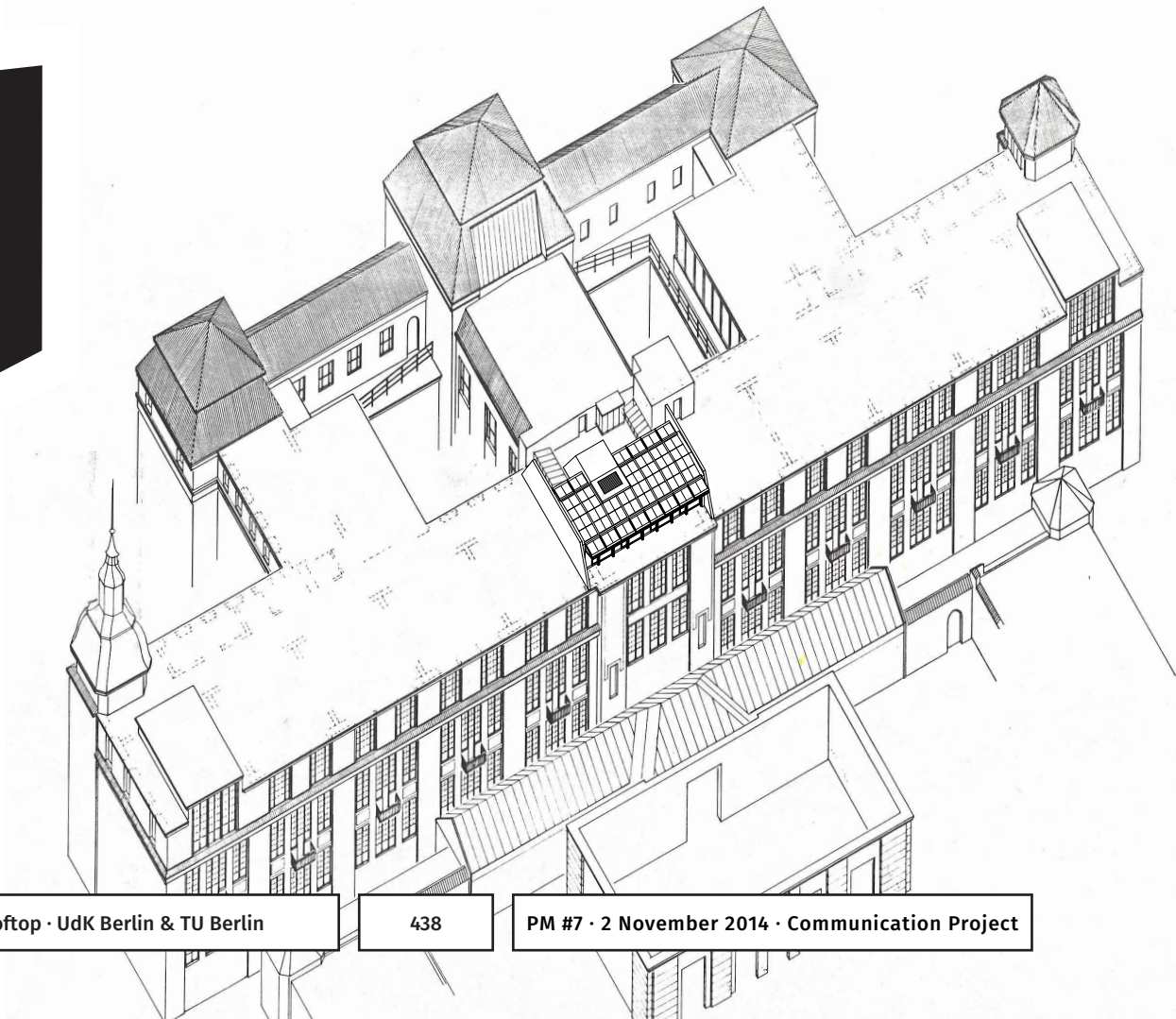
In many cases, everything is over after a competition. Whether or not you won the first price, chances are that the lack of a goal you are working towards, leads you to slowly but surely forget about the object of the competition. In the case of the Solar Decathlon that would mean the house will somehow find its way back to its team's country where it will be put somewhere no one really cares about it or sees it. Team members will go back to their normal lives (or maybe we don't actually remember what that is like after almost two years?) and the whole project will gradually vanish from everybody's lives.

We do not want any of this to happen. Of course the house will come back to Germany. We will keep it in close distance, with its place on the roof of the UdK already being guaranteed. It will be used as a research facility for students and staff, as well as a visitor centre to continuously inform the public. We are still trying hard to convince the university's authorities to make a student cafeteria out of it – somehow we are still facing barriers on that issue. But as we said we want to eliminate fears and barriers.

Our work as a communications team also continues once we come back home. Let us face two scenarios. It is simple, really: either we win the first price, or we do not. In both cases we will face communicative challenges and opportunities. Deutschlandradio, a German radio station, is already planning on broadcasting a second show with us after the competition, as well as the Deutsche Welle, whom we would love to make a tv report with.

The brand Rooftop is not going to perish – we believe in quite the opposite. Remember, we did not want to sell our house in order to make money, but to make people share our passion and devotion when seeing it grow. So whether we win or not, we as a team will stay devoted to this project and will keep working on it with fervour, since the dream is still to actually see the Rooftop house on ... a roof top!

„Our house on top of such a prominent building - the perfect place to keep on elevating our radial impact“



5.7.2 PUBLIC TOUR DESCRIPTION

CONCEPT: THE STAGE

Since the Rooftop house is not ordinary at all, the public tour will not be either. We want our visitors to get an idea of how living in our house can be like. Our team is performing live during the public tour using the house as a stage and thus vivifying it.

One particular thing about the house is the free-floating space. The smooth shifts from one room or terrace to another part of the house are illustrated by integrating the terraces into the tour, by walking around as if there were no boundaries at all.

All the other highlights of the house can be discovered at the different stops within the tour. The visitors will quickly become a part of the house and gather information while experiencing the Rooftop lifestyle. Our goal is not to drop them off with a bunch of dry facts that quickly dissolve in the swirl of our fast-paced world but to leave a lasting impression: we want to share our excitement for the innovative solutions used in our house and offer our visitors a whiff of our joyful passion for sustainability.

To reduce the waiting time in front of the house, there will be two tours simultaneously. Since we already have five “actors” and one guide in the house at once, the group size will be varying around 10 persons – depending on the current situation.

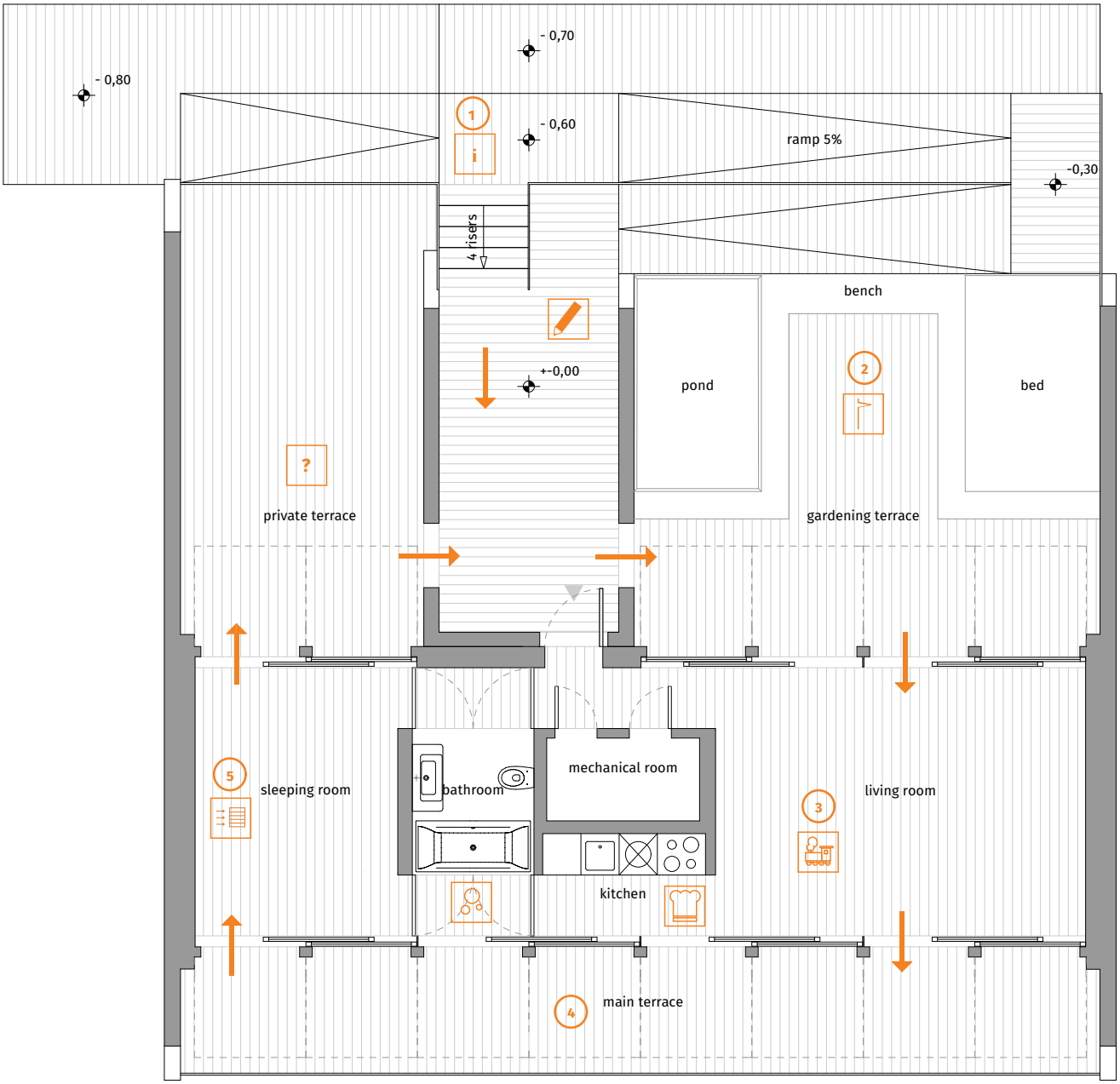
Thanks to our internationally oriented team, we are able to provide tours in German, Italian, Turkish, Arabic and Chinese besides regular tours in English and French.

Furthermore, there will be two different tours according to our two target groups: One tour for the passive general public, also including teenagers and undergraduates, and one for the active group consisting of professionals and specialized press. For the second group, our leading architects and engineers will provide (technical) insights in greater detail than during the general tour and answer more extensively to the probably more specific questions.

As for a special tour catering solely to children, we believe that our general tour already includes enough fun and exciting acts in order to make it easy to grasp the house and its concept and not be boring or overcharged with complicated technical details. We do not want the people to hear too much of our technology, they should feel and experience it first hand. Our public tour is directed to both children and to the child in every adult while still transporting just enough technical and architectural information to be of serious value.

In total, the tour should not take longer than 10 minutes. If there is a big rush of visitors, we are also able to shorten the tour by cutting out some information.

PUBLIC TOUR PLAN



CONTENT: THE PLAY.

Prologue

Intrigued by team members in morphsuits (looking ridiculous, let's face it) everywhere in the area and attracted by all the activities next to our house, visitors will succumb to their curiosity and decide to not only read the informative panels but also line up for the next available tour.

1. ACT

Location: Rooftop House. North side, just in front of the stairway imitation.

Enter Guide from inside the house, wearing the team uniform.

GUIDE (Text Abstract): briefly welcomes our visitors and introduces them to our project by giving general information about the house, the team and the connection to the Altbau. He or she explains the context in the city of Berlin, mentioning its history of housing construction and current problems such as gentrification, and outlines the basic principles of our concept. Since our house will be built on top of an Altbau in reality, the guide prepares our visitors for the "long" way up to the rooftop.

Guide leads group of visitors up the stairs and through the stairway imitation towards the second act.

2. ACT

Location: Gardening terrace.

Enter guide with group of visitors from stairwell imitation. Visitors sit down on bench, with view towards the house. The façade elements are closed.

GUIDE: welcomes the visitors again, now on the imaginary rooftop, explains the terrace concept, introduces the reed bed they are sitting right next to and the PCM panels which are directly connected to the bed. He or she then continues to explain the façade concept.

While the guide is still talking, two façade elements are set in motion behind him, opening the way into the house (and amaze visitors!).

Exit Guide plus visitors from terrace, enter the house.

3. ACT

Location: Inside house, living room.

Enter guide plus visitor group.

Enter three team members wearing orange morphsuits, pushing two chairs and the table around the living room using the free-floating space and demonstrating different furniture arrangements.

GUIDE: points out the "furniture train" and thereby explains that the main feature about the furniture is not primarily their unique design, but the ability to float freely through the given space. He or she will lead the visitor's attention to the ceiling referring to the PCM panels explained earlier.

Exit visitor group onto main terrace.

4. ACT

SCENE I

Location: Main terrace, just in front of the core module.

Enter visitor group. The sliding door is open giving the visitors the feeling to stand right inside the kitchen.
Enter a chef. Pulls out the telescopic work space and begins to chop vegetables (cucumbers, carrots, celery) while guide is talking. Offers them to visitor group.

GUIDE: gives information about the kitchen and the core module in its entireness; mentions the bathroom behind the closed doors.

SCENE II

Location: Main terrace, just in front of core module.

Suddenly, bathroom doors are opened from inside, opening up the bathroom and separating the kitchen from the sleeping room. Team member in morphsuit is lying in bathtub, blowing soap bubbles towards visitors.

GUIDE: points out the core module's function as space defining anchor point and explains the bathroom features, including its transformation into a panorama room. He or she suggests the visitors to take a little walk around the main terrace before heading to the next station.

Exit guide plus visitors, towards sleeping room.

5. ACT

SCENE I

Location: Sleeping room.

Walk-in closet is pulled out, blocking the space between bed and core module.
Enter guide. Pushes the walk-in closet back onto the core module, demonstrating its adaptability.
Enter group of visitors. Follows guide one by one through now open space onto private terrace.

SCENE II

Location: Private terrace.

GUIDE: introduces the last terrace to the visitors. He or she will ask the visitors for their first impression and lets them guess how big the living space is. He or she thanks the group for its visit.

VISITORS: can (and will) ask questions.

Exit guide plus visitors.

Epilogue:

Before leaving the house, visitors are asked to leave us a message in the partners lounge in the stairway. We will provide pens and space for them to write down their thoughts, ideas and wishes on the walls.

Visual Identity Manual

Introduction

To clarify the visual identity of Team Rooftop, we had to deal with the house's appearance and its characteristics in a very specific and profound way. The key characteristics are: energy-efficiency, flexibility, sustainability, self-sufficiency and urbanity.

Starting from that we had a foundation to establish criteria that would work as design principles. Those are: dynamics, openness, concentration and transparency.

We also worked out contrasts in design that we wanted to establish in our visual identity that could visualise Rooftop's architecture: open/closed, light/dark, inside/outside.



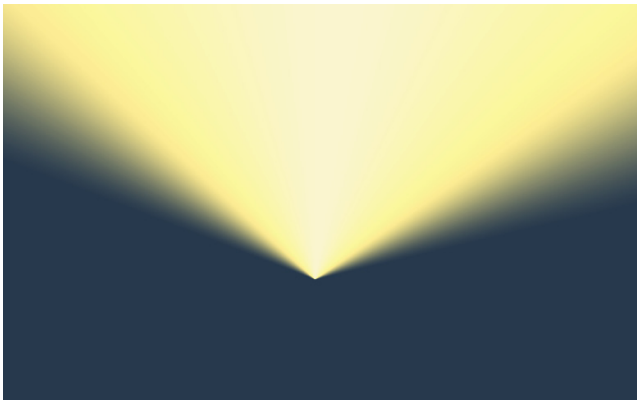
Tonality

Because of the formerly introduced contrasts it was very important to introduce a second colour, that would work as an antagonist to the primary colour, which had been a very vivid orange from the start.

In this way, we can ensure that we are also able to define our contrasts like inside/outside through the colours used.

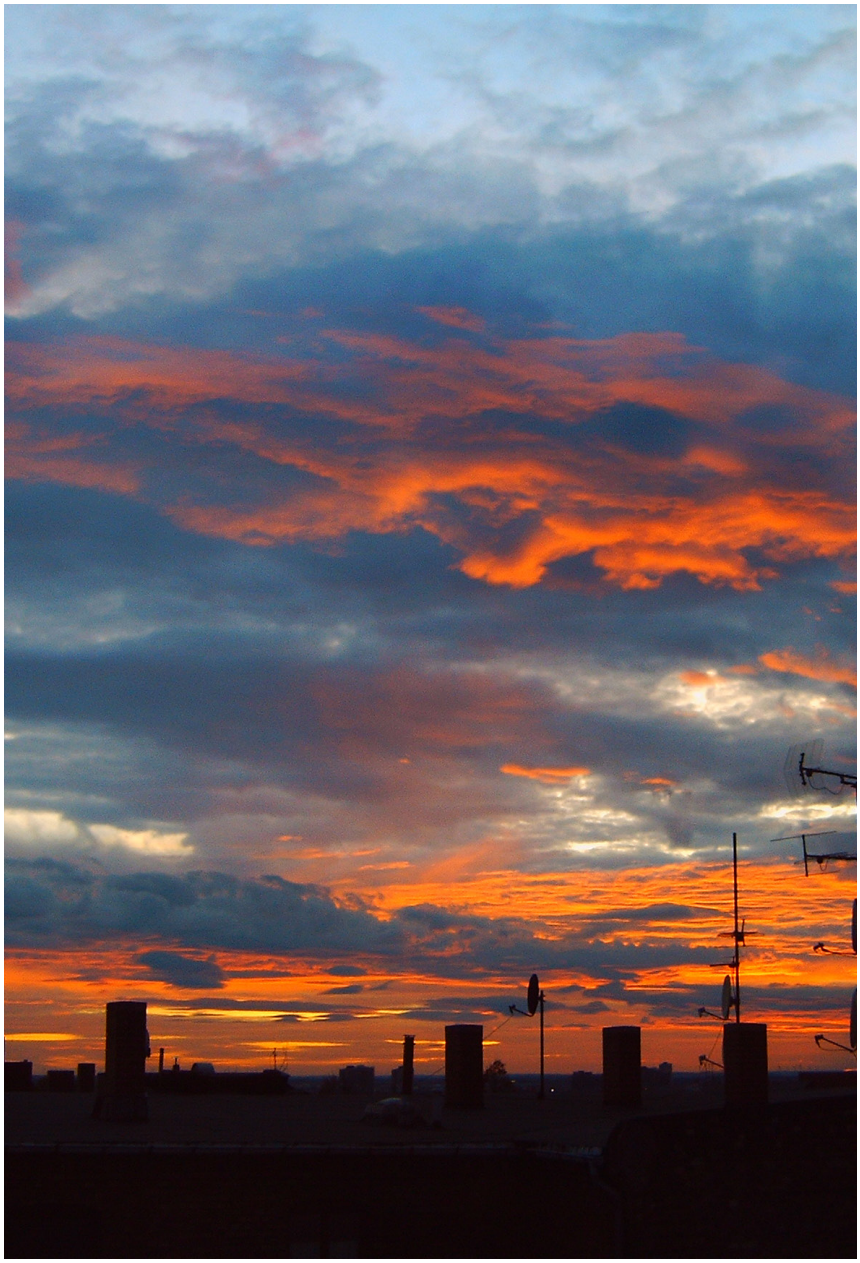
Blue works perfectly as a metaphor for a free flowing space, energy and the sky above Berlin, while orange represents the sun and its energy, activity and dynamics.

Another very important aspect is how we deal with colours when it comes to transparencies. This is just a logical consequence when we talk about the house and its two huge glass façades that flow freely into the blue sky above Berlin.









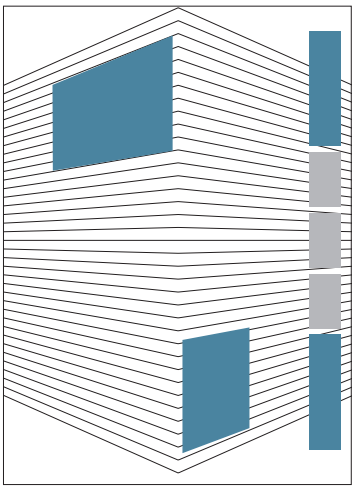
Grid

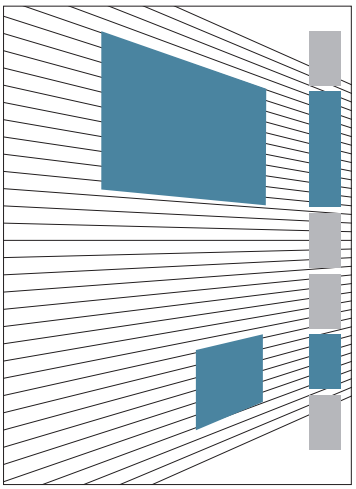
The grid is a derivation from the houses' windows, it therefore consists of eight columns.

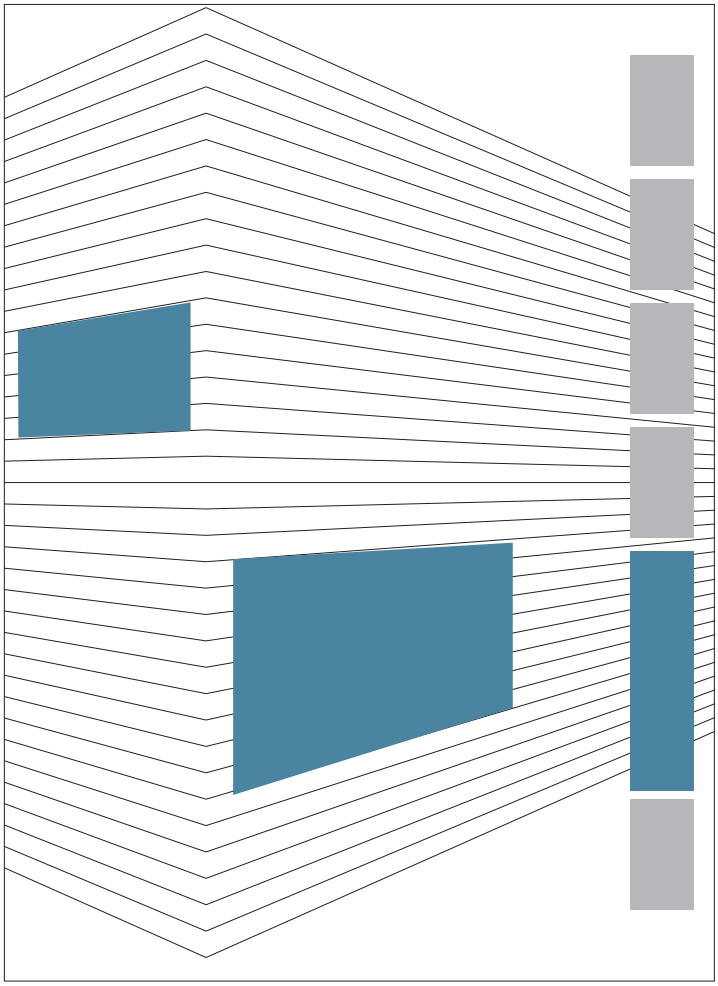


Formal principles

Concerning the handling of images we align the content with a perspective grid, resembling the horizontal lines of the house.







exterior view







interior view





Typography

The humanistic font Fira Sans is essential to the visual character of Team Rooftop. Besides the fact that it looks very neat, it is easy to read in printed and web media and also has a natural and vitalising impact.

Using light and bold fonts is the main design tool we are working with. When it comes to continuous text, it helps the text being easy to read and invites the reader to get into the topic. For a special distinction it is also possible to truncate headlines, as we did in our logo — using lines skewed by 7° and 10° from the horizontal axis respectively.

Fira Sans 1234567890.,!?%&#+* Team Rooftop

Fira Sans 1234567890.,!?%&#+ Team Rooftop*

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POSTER

HEADLINE

UNTERÜBERSCHRIFT

Fließtext in Blocksatz Team Rooftop ist das offizielle Team der TU Berlin und der UdK Berlin. Wir sind eine interdisziplinäre Gruppe von Studenten der beiden Universitäten und arbeiten seit über einem Jahr an unserem Entwurf, mit dem wir die Baumkrone Berlins ein wenig grüner gestalten wollen. Ganz nach dem Motto „Stadtverdichtung statt Verdrängung“ soll der ungenutzte Wohnraum auf den Dächern des typischen Berliner Altbaus bewohnbar gemacht werden und so Konfliktthemen wie Klimawandel und Gentrifizierung entgegenwirken. Pudis nimpos endelitatem. Elescidis dolo te nobissi abo. Tem voloruptas atur, volecte caeria comnis volupitam experemperem di con nonsequi occae. Omnis necte rest, corporepero tem nullorentis restis ex explisi con reius ese pori velicab oreiciunt, is dolorumquos volore, corerum dolupta tibusdam faccum nos accus, consequi ommoluptur? Nem et magnis minvend antiunt dolo blantibus quaerita comnihit, aspic tem harchil laboratior si doluptio. Apelici psandition cum dem comnitium ipisciisinus sim sus eario debitium utentium dolorem ut aute volenec eperiberio essequi doluptatEtIbus explate nonsectusti tem fugitibus arum quas di illabo. Itatias id quaspie nimintis mo dolupta dolorum, cus eatior molorat ium qui con est ea di od quam fuga. Alis re odi volorias res doles rempercius.

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Engineering schematic drawing

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Fira Mono 1234567890.,!?%&#+* Team Rooftop

Logo

The logo combines every aspect of the visual identity. Both surfaces combined are creating an area that represents a cube, which can be seen as the heart of our building: the Core Module.

The colours and the perspective are playing with our formerly defined design parameters.

The truncated edges of the word „Rooftop“ are indicating the houses' position – over Berlin's skyline.



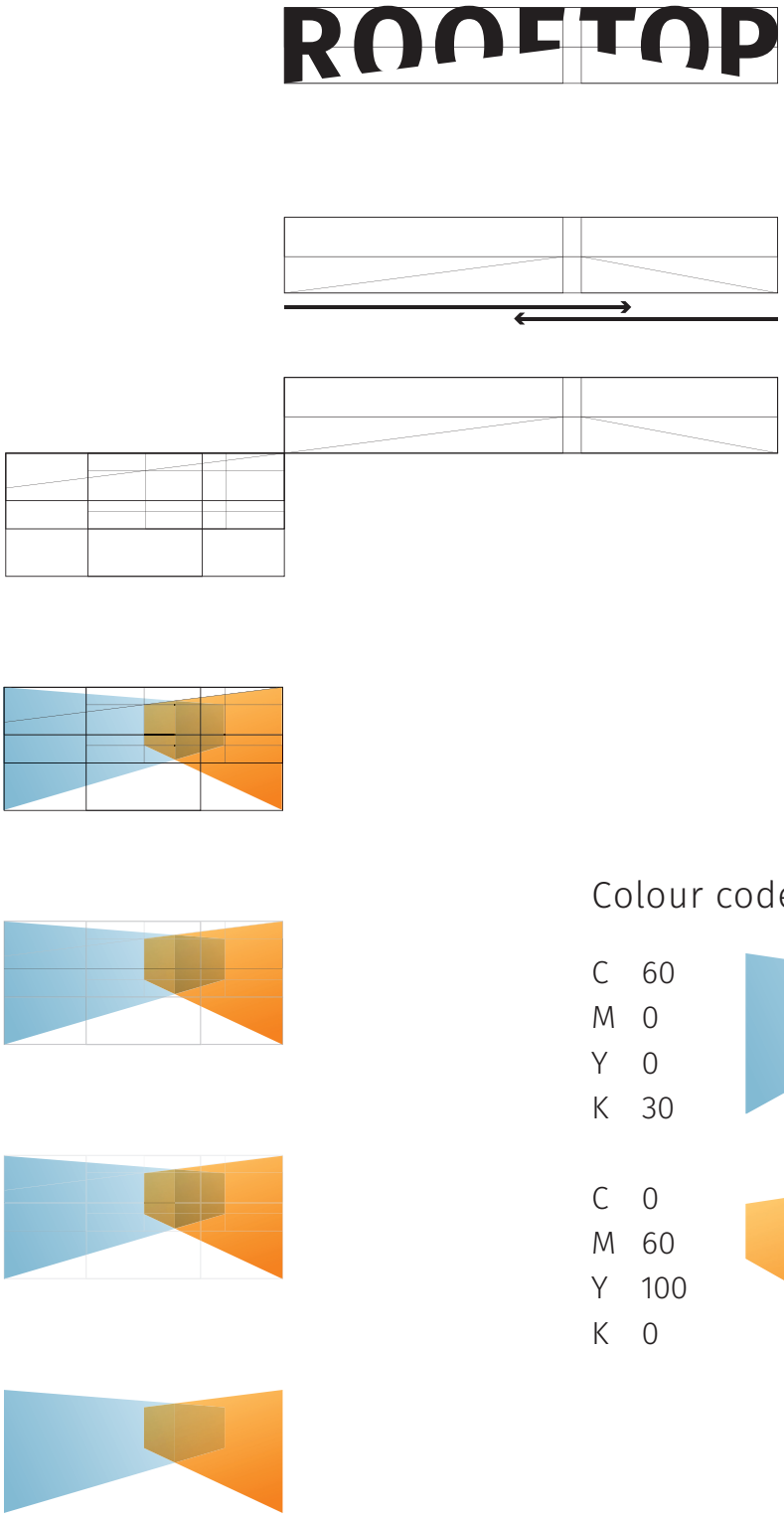
Black-and-white version



Wordmark version



Derivation



Colour codes

C 60
M 0
Y 0
K 30

C 0
M 60
Y 100
K 0

Safe Area

The safe area defines the minimum distance towards other objects in the layout, thereby guaranteeing a high readability. Pictures, colour fields and other design elements have to be placed outside of the safe area.

Around the logo it takes up 1/3 x.

1 x equals the logo's height.

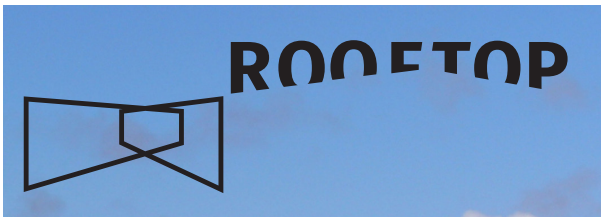


Handling

The logo can be used in the defined colours or in a black-and-white version. The colour version is to be used only on white or black backgrounds, while the black-and-white version can be used across nearly every background — in black for light-coloured backgrounds, in white for darkly coloured backgrounds.

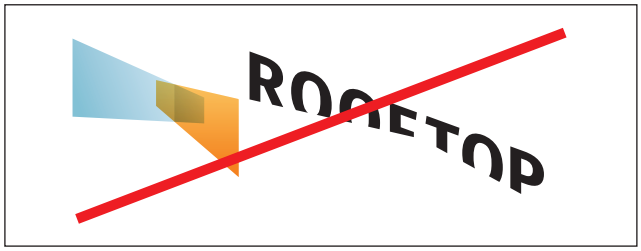




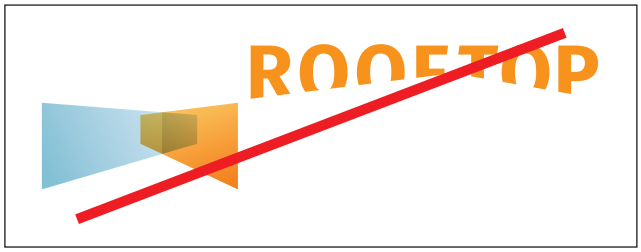


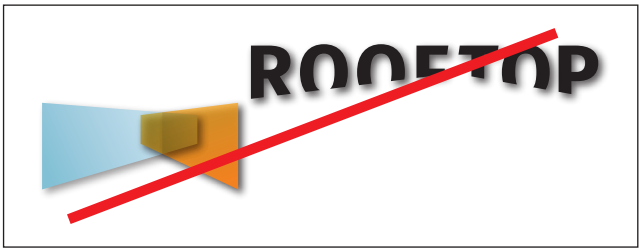


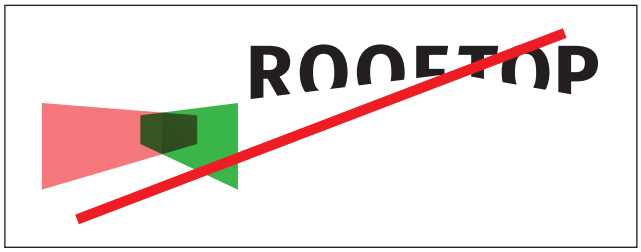
WRONG HANDLING

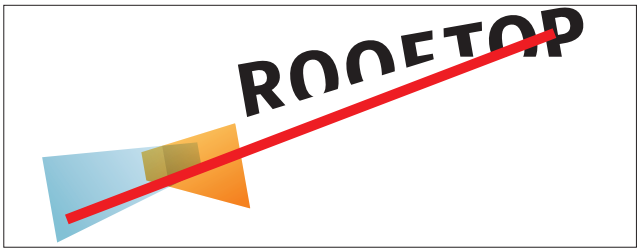
















5.7.3 SPONSORSHIP MANUAL

You can find the Sponsorship Manual in the appendix — the layout is different from the Project Manual as we feel the Sponsorship Manual is a document in its own right and style. Please refer to „Sponsorship Manual“ on page 737

TRACKING TABLE OF COMMUNICATION ACTIONS & MATERIAL FOR THE PROJECT DISSEMINATION

We decided to put the Tracking Table for Communication Actions, giving a detailed overview of our presence in the press and on events, in the appendix. The same goes for the Material for the Project Dissemination — a list of our budget used to promote our project — and the current version of our Team Uniform.

- „Team Uniforms“ on page 735
- „Press“ on page 738
- „Events“ on page 739
- „Material for Project Dissemination“ on page 740

DINNER PARTY MENU

This section is designed to make you jitter with anticipation for the big show: the Rooftop dinner!

Unfortunately paper is not edible. Please wait for that fresh evening breeze after a hot summer day to savour Berlin's local specialties.

TEAM ROOFTOP'S DINNER PARTY MENU

"My grandmother was an excellent cook and housewife. Like most women of her generation, she knew how to bake bread, make pudding from scratch or prepare a Christmas dinner for an extended family. Every meal she made was simple but heart-warming, and she never indulged in processed or foreign foods. As much as I can praise her straightforward style of cooking from the current trend of retrospective, I am aware that it had its origins in the austerities of World War I and II, which my grandmother, born in 1910, had to witness.

Our team's menu values the knowledge that was generated and transported over the generations. We incorporate sustainability, regional products, the preservation of food and the conscious use of resources into our style of cooking. The menu that was created for the dinner party is rich, but healthy and offers a wide range of local flavours mixed with the intercultural and cosmopolitan seasoning of a city like Berlin."

— Laura Beyer, Rooftop cook

Local content of ingredients (according to local context)

Different styles of food and cuisine are easily found in Berlin. Our menu shows Italian, French and Turkish influence but is compiled to a large extent from typical German products, like meat, carrots, dark bread, butter and elderberry. All products were bought from regional suppliers.

Cost Evaluation of the Menu

In total, we spent 82,86€ on the menu, adding up to roughly 10€ per person. The more expensive ingredients were those that were not used completely, but had to be on stock, for example vinegar, oil, spices, clarified butter. Once purchased, they can now be used for many meals and thus add variety to basic purchases. The products we used were organic.

I must, however, say that it was nearly impossible to create a summer menu at this time of the year. We used deep frozen or preserved fruit, vegetables that can be stored for a long period of time, as well as grain that can be dried and stored easily.

Energy consumption for cooking evaluation

The meal was prepared in a standard equipped kitchen with a ceramic glass cooktop and electric oven. Furthermore, a blender and an electric kettle were used. We managed to keep cooking and baking to a minimum for the menu by using traditional techniques of preparation. The pearl barley, for exampled, was boiled up and then wrapped in a blanket to macerate while the other dishes were being prepared.

Nutrition data compared to guest needs

We estimated the guests' caloric needs to be at 2200kcal for women and 2800kcal for men. This estimate is based on a person with an office job, moderate activity during recreational time and a generally healthy nutrition. Our menu adds up to 1800 calories per person, mainly due to the dessert. It has 90g protein, 130g of carbohydrates and 96g fat. Therefore, the menu is rich, but it is possible to easily incorporate it into a healthy lifestyle by exercising a little more and having decent meals for breakfast and lunch on the same day.

Course	Dish	Ingredients	Possible intolerance
Hors d'Oeuvre	rye bread crisps	rye bread, garlic, olive oil, salt	gluten
	strawberry butter	butter, honey, lemon juice, strawberries, pepper, confection-er's sugar	fructose, histamine, lactose
	chilled cucumber soup	plain joghurt, cucum-ber, buttermilk, garlic, mint, parsley, olive oil, salt, pepper	lactose
Aperitif	Eclipse	Gin, acacia sirup, prosecco, pansies or raspberries	fructose, histamine
Starter	Wildflower Salad	various herbs and salads	
	Flaky Pastry	flaky pastry, cream cheese, parmesan, rocket, olive oil, garlic, salt, pepper, sunflower seeds	gluten, lactose, nuts
	Dressing	Elderberrysirup, apple vinegar, honey, mustard, salt, pepper, olive oil	fructose
Main Course	Pearl Barley	pearl barley, salt, olive oil	gluten
	Pork Loin	pork loin, garlic, chervil, salt, pepper	
	Steamed Vegetables	carrot, beans, butter	histamine, lactose
	Sauce	cream, tabasco, cognac, onions	lactose

Course	Dish	Ingredients	Possible intolerance
Dessert	Berry Cakes	butter, honey, cookies, cinnamon, gelatine, blueberries, raspberries, strawberries, cream cheese, sugar, cream freche, cream	lactose, histamine, fructose
	Chocolate Cookies	cocoa, butter, orange, sugar, egg, almond, corn starch	gluten, lactose, nuts
	Rhubarb Squares	rhubarb, lemon juice apple pectine, sugar, vanilla	fructose

List of courses

The ingredients indicated in this list were calculated for a total of eight guests. Throughout the meal, water was served. The main course was accompagnied by red wine and beer.

APERITIF AND APPETISERS

Eclipse · dark rye bread crisps with strawberry butter · chilled cucumber soup





8 malva tea (teabag), 16 tsp. elderberry syrup, 16cl Gin, 8cl Cointreau, 16 mint leaves, 32cl of

Prosecco, ice; 350g dark bread, 2 cloves of garlic, 1 tbsp. olive oil, 80g butter, 1.25 tbsp. honey, 1.25 tbsp. lemon juice, 120g strawberries, pink pepper; 480g plain yoghurt, 90g cucumber, 330g buttermilk, 1.5 cloves of garlic, 6 leaves of mint, a little parsley, 1.5 tbsp. olive oil, salt, white pepper

pour gin, Cointreau and syrup into a shaker; flavour with malva tea; add mint leaves and ice; shake up; fill up with Prosecco

slice bread with 3mm; rub with garlic; brush with oil, sprinkle with salt; cut the bread in pieces and bake it at 180°C in the convection oven for roughly eight minutes

whisk up butter, honey, lemon and season with pepper; strain strawberries through a sieve and mix with butter

peel the cucumber and free it from the seeds; blend it with yoghurt, buttermilk, garlic, mint and parsley; season with salt, pepper and olive oil

STARTER

Wildflower salad in a Parmesan basket, with stinging nettle ravioli and elderberry dressing



wildflowers (app. 100g salad per person): daisies, coltsfoot, cuckoo flower, watercress, rocket and young spinach; 290g parmesan cheese; 75g flour, 2/3 of an egg, 50g stinging nettle, 65g ricotta, second 1/3 of an egg, nutmeg, salt, pepper; 2 tbsp. olive oil, 1 tbsp. walnut oil, 2 tsp. mustard, 2 tsp. honey, 3 tsp. elderberry syrup, 1 tbsp. white balsamic vinegar

make dough withf flour and egg, knead for 10 minutes and let it rest in the fridge for 2 hours; blanch nettles, dry and chop them; press water out of the ricotta; mix ricotta, nettles, parmesan and egg; season with nutmeg, salt and pepper; spread dough and put little heaps of filling on top; put second layer of dough on top and cut out the ravioli; boil in hot, salted water for 10 minutes

melt parmesan chees in the oven at 180°C convection heat (app. 4 minutes) and immediately place them on upside down bowls

whisk mustard, honey, syrup, salt, pepper and vinegar; add oils

MAIN COURSE

pork loin with steamed beans, carrots and pearl barley risotto

(vegetarian: stewed cucumber, beans and carrots, pearl barley risotto)



2 cups of pearl barley, 3 cups of water, 2tbsp. tomato purée, salt, 2 tomatoes, 2 onion, 4 tbsp. olive oil, cress; 1.3kg pork loin, chervil, 4 cloves of garlic, pepper, 1 tbsp. clarified butter; 2.5 cooking cucumbers, 10 carrots, 200g beans, 1 tbsp. butter; 0.5 leek, 0.25 knob celery, cognac, nutmeg, Tabasco, 100ml cream

rub pork loin with chervil, garlic, salt, pepper; roast and warp into tinfoil; bake at 100°C for 45 minutes; proceed in the same manner with the cucumbers

roast celery, 2 carrots, 1 onion and leek; add a little water and cognac; season with salt, pepper, nutmeg, Tabasco and let it reduce; add cream

roast 1 onion, 2 tomatoes, add pearl barley; stir, add water and let it boil for 5 minutes; wrap the pot in a blanket and let it macerate

slice carrots and beans, blanche, add butter and salt

DESSERT

strawberry panacotta with white chocolate mousse and strawberry salsa



770g strawberries, 650ml cream, 130g sugar, vanilla, 5,5 sheets of gelatine; 50g white chocolate, 100ml cream, 100g Greek yoghurt; 6 leaves basil, 6 leaves mint, 1 tsp. confectioner's sugar,

boil cream, sugar, strawberries and vanilla for 10 minutes; blend; add gelatine; pour into cups and let it cool over night

melt the chocolate; half-whisk the cream; blend all

chop strawberries, basil and mint, mix, and season with confectioner's sugar

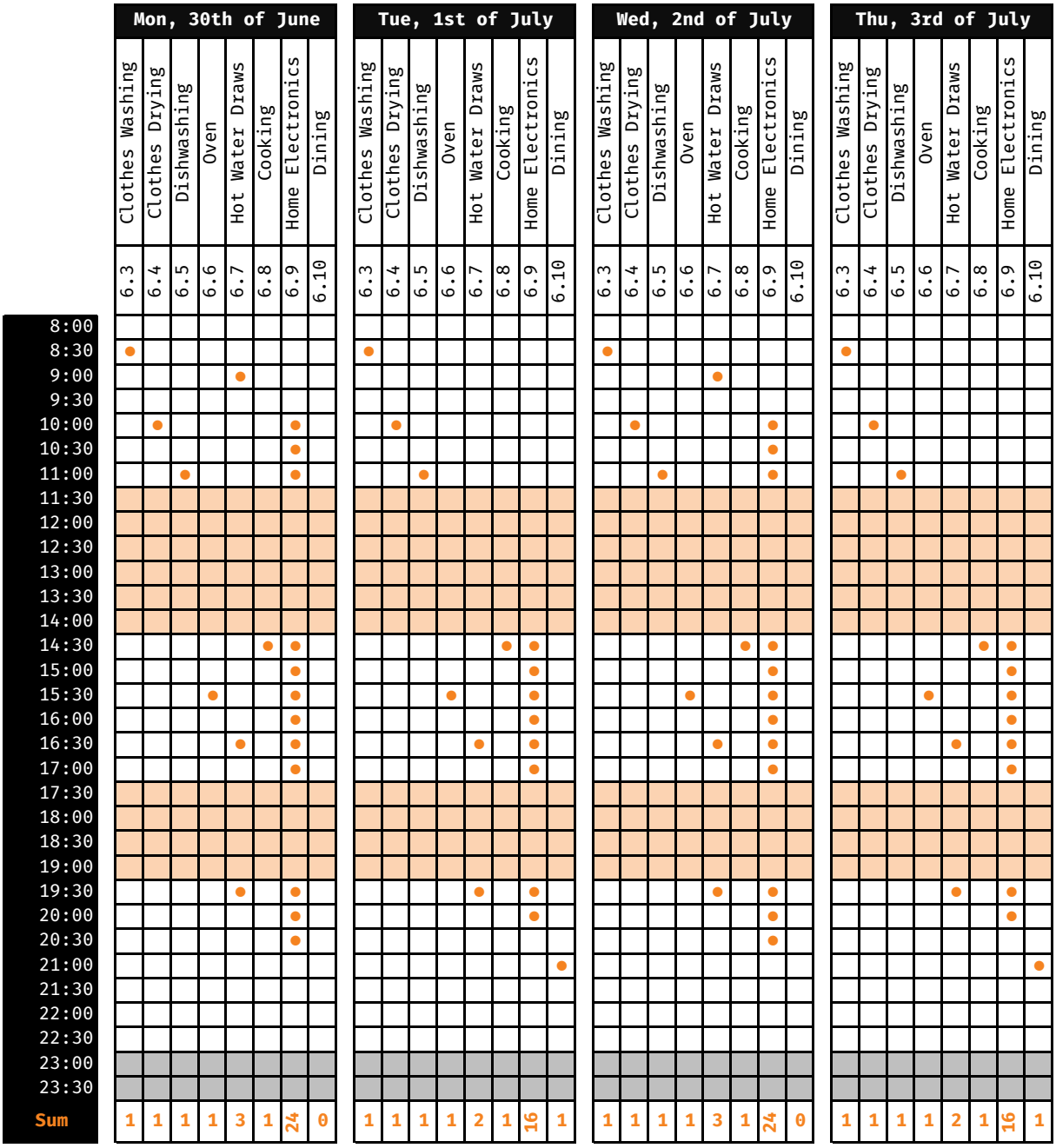
CONTEST WEEKS TASK PLANNING

Housework. Ouuugh.

Metering. Mmmmh.

Cooking. Yum.

All these daily activities will be fun once we perform them in our own house. Taking people on a tour around the house, inviting experts to review our concepts 1:1 — Awesome!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Wed, 2nd of July
Thu, 3rd of July
Clothes Washing
Clothes Drying
Dishwashing
Oven
Hot Water Draws
Cooking
Home Electronics
Dining
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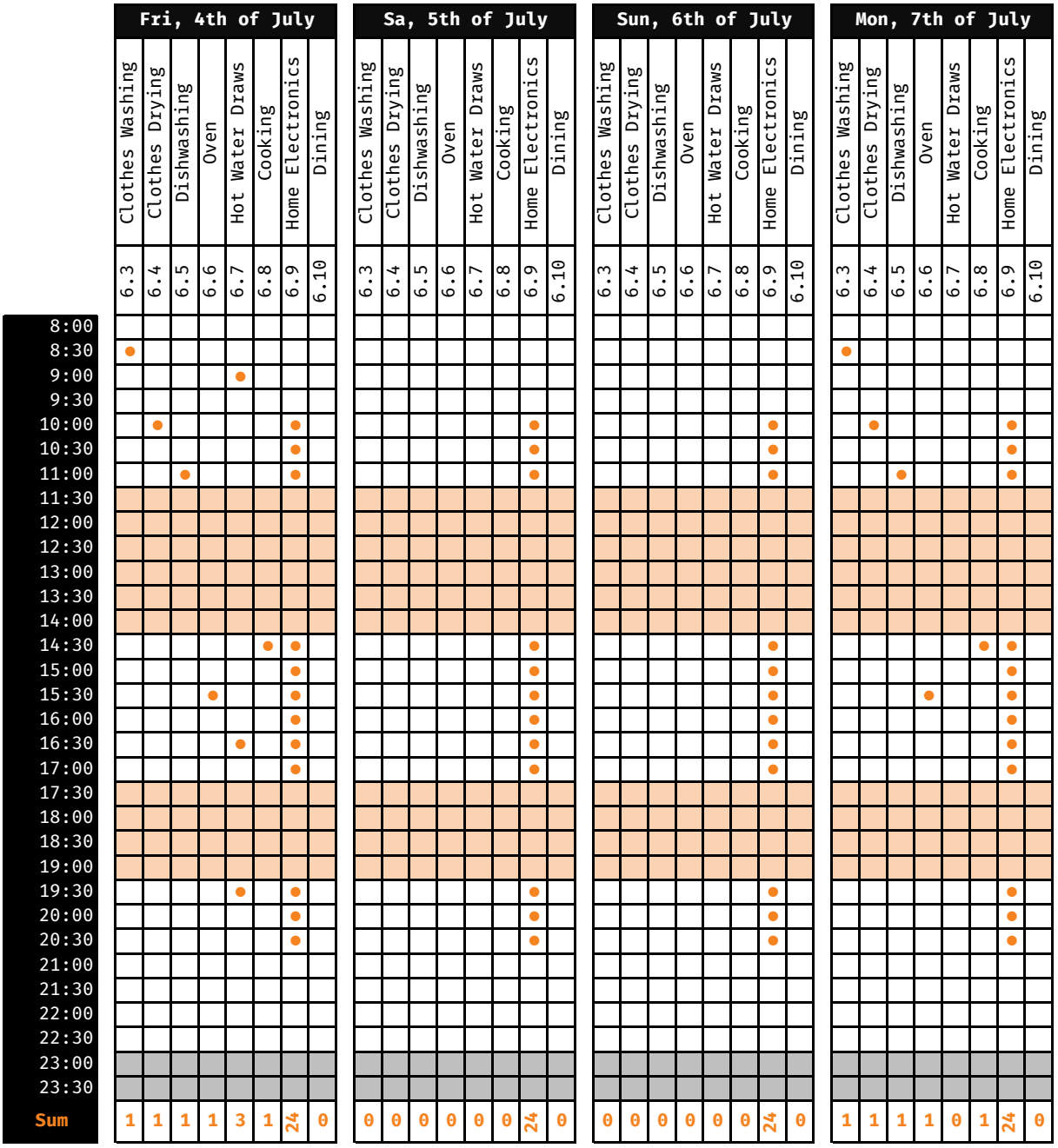
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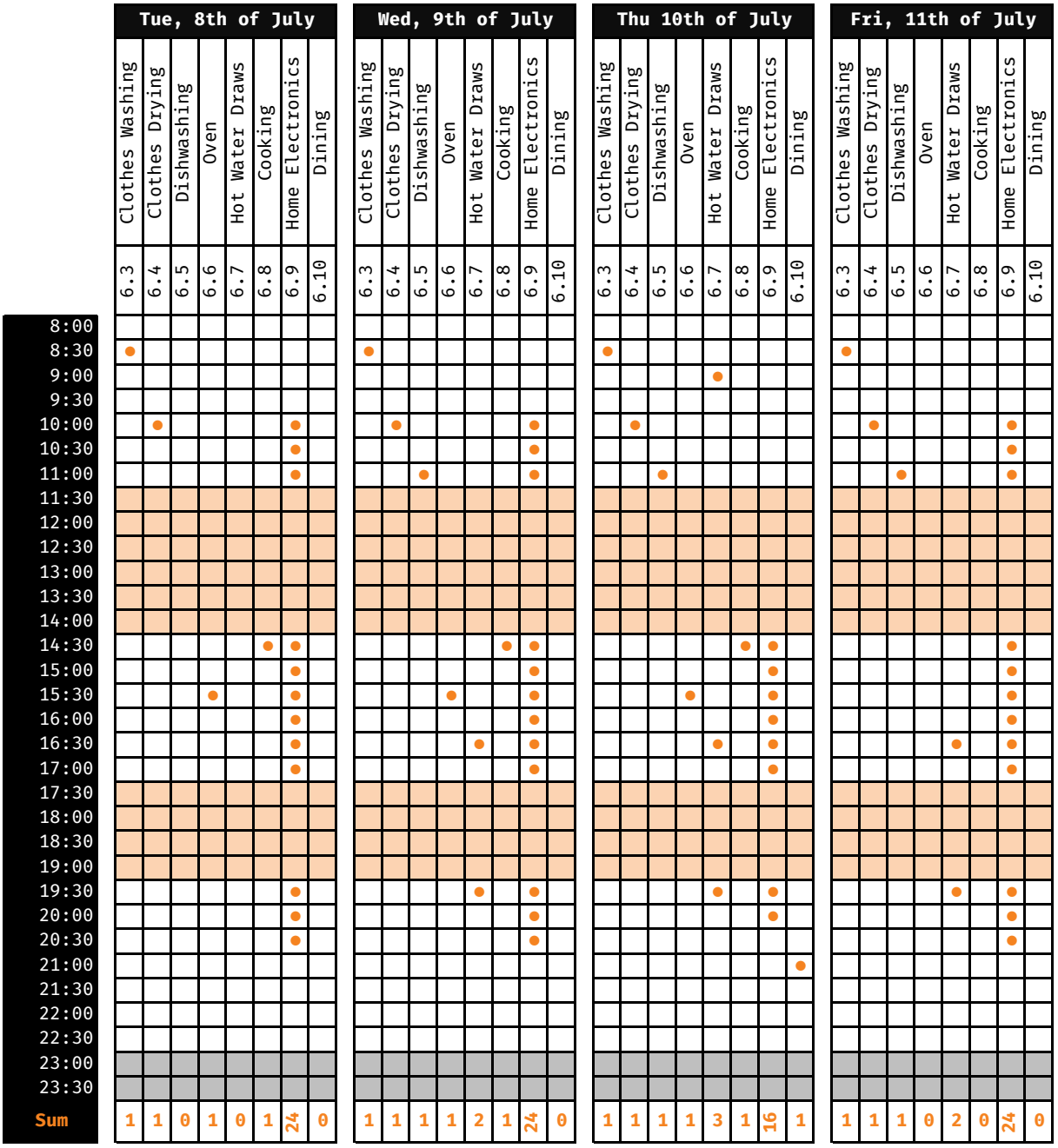
Tue, 8th of July
Wed, 9th of July
Thu 10th of July
Fri, 11th of July
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Clothes Drying
Dishwashing
Oven
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COST
ESTIMATE & FINANCIAL SUMMARY



8.1. FINANCIAL BUDGET AND FUNDRAISING PLAN

Fundraising of the Rooftop project generally builds upon two pillars: private sponsorship and public fundraising. In order to explain the financial stucture of the project a breif explaination on the organisational structure and the financial structure withing the university will be presented.

8.1.1 ORGANISATIONAL STRUCTURE OF ROF/UNIVERSITY

From the universities point of view the most important aspect of the project was the controlling of the project. Therefore the university administration spoke to different German teams that participated in the years beforehand.

It was clear that there were mistakes made in the organisational structure that lead to financial desasters. Namely only one main project manager was selected to be responsible for the orders of the equipment, the cost and schedule planning, tenders, awarding of contracts, invoicing and execution of building work. Also that person was to responsible for the sponsorship. Clearly these tasks can not be done by one person. They need to be distributed among several persons. Also the cost and schedule planning, awarding of contracts and invoicing must be supervised by several people, otherwise it is easy that rules and regulations that apply for all publicly funded institutions are not met.

Therefore the organisational structure of ROF was chosen to be as seen in the following chart.

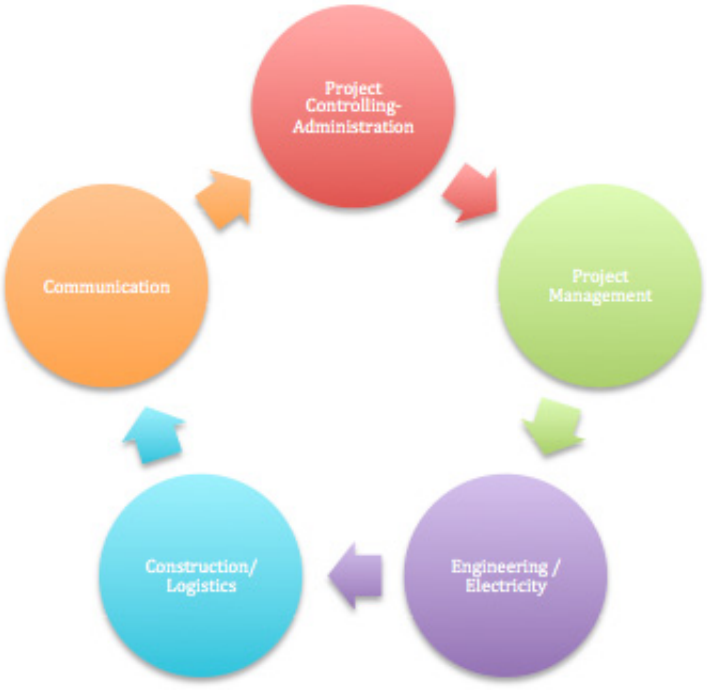

Figure 268: **Organisational strucutre of team ROF**

The organizational structure is divided into 5 parts: Controlling, project management, communication, construction/ Logistics and engineering/ electricity.

It was always important, that within the team each members work is valued and no sub team is put above the others. That is why we always chose a circle for our representation.

This section will focus on the Controlling of the project. It will also touch on the project management and communication and describe the costs of all aspects of the competition but will not go into specifics about the other project parts.

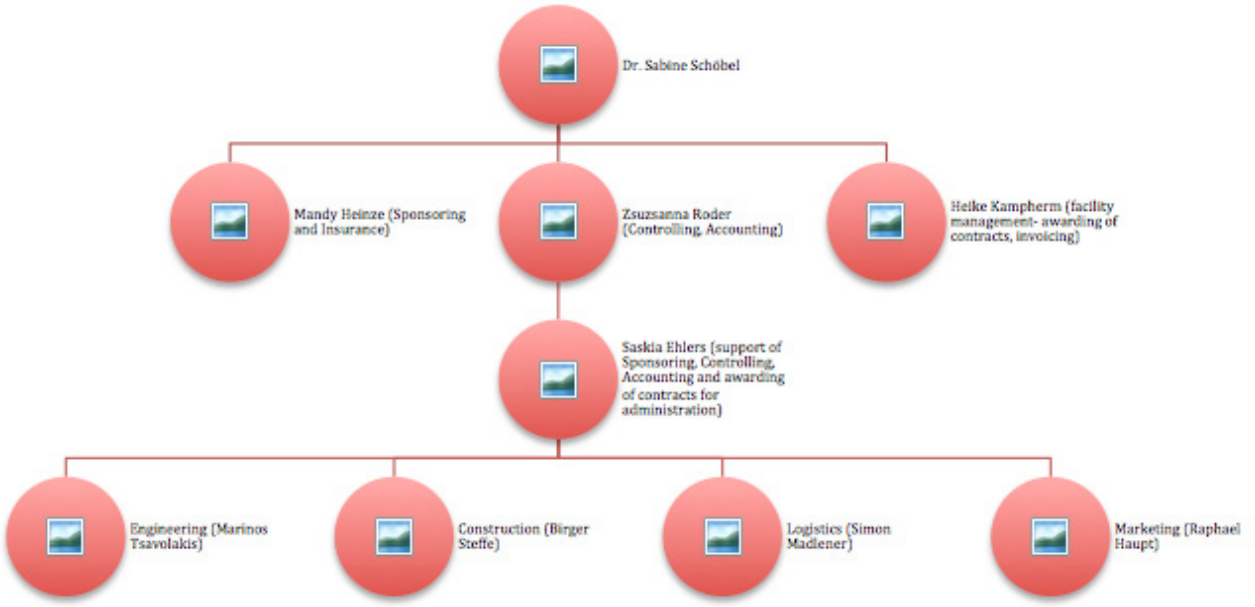

Figure 269: **Controlling structure within University**

The Controlling structure of the project can be seen above. The Controlling is headed by Dr. Sabine Schöbel from the subsidy department of the university. She decided on the overall structure of the controlling together with the president and the head of the finance department. It was decided that two persons – one person in facility management and one person in the financial department would be appointed to work for the project. Zsuzsanna Roder was responsible for the accounting in the project. She registered each transaction from the project account and from which income source which bill should be paid. This was very helpfull because it gave an overall view of how much money was left and of how much money was devoted to which part of the project. Heike Kampherm was responsible for making sure that rules and regulations regarding the awarding of contracts in public instutions were followed. She also checked all the bills of the project. One person from the subsidy department was chosen to advice the team on taxation and sponsorship matters and to take care of insurances for the project. Taxation and sponsorship are very important for German teams because you have to make sure that what you offer sponsors is in the area of passive sponsorship, because otherwise you'd have to pay 40 % in all sponsorship that you receive in taxes later on. – So you can

only keep 60 % of the sponsorship and there are near to no financial resources from which to pay the 40 % because there is technically no funding for paying those types of expenses from the university. It was so very important to only offer passive sponsorship to all sponsors.

A member of team rooftop, Saskia Ehlers, was temporarily employed by the university to assist all three parts important for the Controlling of the project. She had to communicate all the rules to the team , gather and check all the material that needed to be bought and the contracts, that needed to be awarded and have them approved by the university.

The approval process includes the checking of all orders by Saskia Ehlers, the professors who head the project, the facility management and the accounting department. Further more companies are all required to sign a statement that they pay their workers minimum wage or the pay- scale wages for their sector. If the contract is for a large sum, they also have to sign a statement that they oblige the environmental laws and established measures to promote women. All theses documents need to be gathered by Saskia Ehlers or the facility management for each contract.

This long process of approval has advantages and disadvantages.

The advantages are that mistakes are corrected in the process, so that no money is lost through them. It is also good that several people are responsible for the awarding of the contracts so that there is not too much pressure on one person. Also the work is divided between several persons, therefore there is less danger of a burn-out.

The disadvantages are that the building process is slowed down. That delay in building can in hand cause monetary problems as surcharges for express deliveries might have to be paid or companies have to be awarded with contracts hastily as the approval process has slowed the process down to the extend that a milestone has to be completed and there is no time to find other offers. Another problem is that the interested of the team in completing the building fast contradicts the interest of the university of triple- checking every transaction which causes extreme frictions between the team and the university.

8.1.2 SPONSORSHIP

Team ROF was limited in the marketing measures that it could offer, as it was only allowed by the university to apply passive marketing measures. Those include:

- placing the sponsors logo on the website without a link to the sponsors website but with the URL of the sponsors website (all logos in the same height and width and without any special emphasis on any sponsor regardsless of the value of the sponsorship)
- placing the sponsors logo on a sponsors plate in front of the prototype in Versailles during the competition and at the building site of the university
- inviting all sponsors to sponsorship parties to get to know the students, other companies and university staff

- mentioning the sponsors in videos, press releases and dissemination material without any special emphasis on one sponsor

The acquisition of the sponsorship for each part of the project was left to the students responsible for the part. We learned during the acquisition phase that there are effective and ineffective ways of requiring sponsorship.

Lessons learned in the acquisition of sponsorship:

You have to be an expert on your field. The company or person has to get the feeling while talking to you and looking at your plans and also evaluating you as a person, that you are ahead of your game and that you know exactly what you are talking about and what you want.

They have to get the feeling that they are associating with a project that is a winning project and will give them prestige and maybe also chances for economic prosperity in the future.

A great advantage was vitamin B- relations. Namely contacts through family, former employees, employers and friends.

Before contacting sponsors you should do extensive research on what items are the right ones for your project, than you have to look for companies, that can provide those items and have an exact list of what you want. You should also be able to explain, why you want to collaborate with that company and have sponsorship manual and a project description ready to explain what you can offer and what your project is about.

Family contacts:

50.000 Euros in sponsorship was acquired by the family owned business of the engineering team leader. The fact, that they had a successful business for several decades and established firm ties to companies all over Europe was very important. It was also helpful that they could give detailed planning of the building technology and knew exactly which parts were needed.

University contacts:

About 30.000 Euros in sponsorship were acquired through university contacts in the facility management and also the architecture department.

The façade:

The façade was very difficult to realize as it is a quiet new concept to combine mechanical engineering with architecture. The team therefore started searching for companies who had already realized similar projects and would be interested in having the idea of a movable façade combined with solar technology displayed on an international scale.

The team made a fatal mistake in only focusing on one company and only negotiating with that one company. It made a final offer that was far too expensive for our budget and was also non cooperative with the team. You got the impression that they didn't respect the work of the students. Also the company had not done similar projects before and had no special interest in kinetic architecture. It was the absolutely wrong target company and the team got in that mess by following the advice of another company- no familiar with kinetic architecture.

Before approaching companies as an alternative to the unacceptable offer the team in endless discussion, models and calculations exercised different solutions for the drive of the façade, the control system and statics. Therefore the team could while approaching companies make the impression that they knew what specifications the façade had to have and talk about the specific scientific and practical aspects.

Through a long research process and approach of several companies the perfect company, who had already patented a safe system for the façade and was interested and establishing ties with a research and development university was found and gave a high discount in sponsorship for the project. The company was also very cooperative and quick in the delivery.

Confidence:

Our project leader always made the impression on companies that the project was a winning project. Therefore about 80.000 Euros in sponsorship were acquired through what one would call a gift in dealing with people, that luckily our project manager, our engineering team leader and the team responsible for building the kitchen did posses en masse.

Luck:

About 20.000 Euros were acquired through mere luck. It is quiet easy to get large companies with a big budget to sponsor you and sometimes one call or a mail is enough to get a contract. But you have to be careful as some of these companies might expect marketing measures that a public institution cannot offer due to tax restrictions.

Overall the following table shows the costs of the house and the percentage of sponsorship of the building.

The effectiveness of the measures implementation in different parts of the house can be seen in the table costs of building in which the percentage of sponsorship for each part is displayed.

8.1.3 PUBLIC FUNDRAISING

Next to the private sponsorship and the money from CSTB SOLAR, we established a plan to apply for public funding through different research funds. In coopertaion with the Federal "Research and Innovation" Funding Advisory Service and the support of the professors of TU Berlin and UdK Berlin we were able to

identify several programs matching our project. Most importantly, we applied for funding by the Federal Ministry of Economics and Technology (BMWi) together with the teams onTop and team Techhaus. We were granted 400.000 Euros in funding, which will mostly be used for the construction of the house, but also for transport and travel costs and includes an overhead of 48.000 euros for administrative labour costs. The funds were granted within the support program "Energieoptimiertes Bauen" (EnOB) dealing with research for energy- optimized construction. Our project was included in the support programm of the Institute for Architecture and Urban Development of the University of the Arts and will be granted around 3.000 Euros.

SDE 2014 COMPETITION	
Team's Abbreviations	ROF
School's Name	The Berlin University of the Arts
Team's Name	Team Rooftop

Company Name	Collaboration Details	Amount of support	% Total
Institutional Support			
Federal Ministry of Economics and Technology (BMWi)		400.000,00 €	
CSTB SOLAR SAS		100.000,00 €	
institutional support by the TU Berlin and Berlin University of the arts through compensated labour costs for professors, researches and faculty members, that are paid for by the municipality		41.999,02 €	
institutional support by the TU Berlin and University of the Arts through work of students		330.644,97 €	
Funding by the district of Wilmersdorf- Charlottenburg (Aktionsfonds City West)		10.000,00 €	
		872.643,99 €	84%
Industrial Partners & Sponsors			
Albrecht Jung GmbH & Co. KG	lighting switches, electrical outlets, router etc.	3.259,66 €	
Auerhahn	Cutlery Set	577,15 €	
Asta UdK	Financial support	700,00 €	
Augusta Solar	Solarthermal collectors	3.058,30 €	
BeluTec mbH	special project discount for the manufacturing of the facade	31.244,64 €	
Briz GmbH	External labour for heating supply and distribution	1.785,00 €	
Burkhardt Leitner	System for Movable Furniture	2.643,56 €	
Buzon Pedestral International s.a./n.v.	foundation support pillars for terrace	4.685,76 €	
C3 House	materials for kitchen	1.999,68 €	
Catalano	basin and toilet	1.777,86 €	
DGS	Financial support for articles written by students	148,00 €	
Eternit	dry screed panels	5.127,71 €	
Franke	kitchen sink	1.454,81 €	
Geberit	water pipe system, fittings, automatic flush, front wall isntallations	2.356,20 €	
GKI	bath tub	1.500,00 €	
Güde Messer	knifes	369,59 €	
Hansgrohe	bathroom fittings	3.377,30 €	
Hettich	fittings and control system for kitchen furniture	2.078,38 €	
ib-Rec	special discount for batteries	1.023,42 €	
innocent smoothies	drinks for ready-for-Versailles party	1.614,00 €	
Jab- Anstoetz	high end curtains	8.235,99 €	
Kibak & Peter	building automation (software and automatic control technique)	748,95 €	
Lehmorange	PCM material, consulting for cooling system, external labour for instalation	13.574,33 €	
Metallbau Süd GmbH	equipment and labour for the installation of the glas facade	1.489,98 €	
Mechthilde Madlener	physiotherapeutic therapy for team members	471,00 €	
Miele	kitchen applicances and household appliances	12.873,70 €	
Multi-Contact AG	elecric cabling system	1.250,92 €	
NFK Leichtbau	opaque surface for gable wall	2.856,00 €	
Osmo Holz und Colot GmbH und Co. KG	colour and coatings	1.065,40 €	
Ozzio Design	dining table and chairs	1.794,34 €	
PV Partners	connection box	391,51 €	
Rheinmagnet	fixing for pcm cooling walls	255,26 €	
RHEINZINK	gutter and downpipe	1.386,56 €	
Solibro GmbH	84 photovoltaic elements	7.816,00 €	
Stiebel Eltron	carbon sustainable heat pump, solar thermal system and an integrated ventilation system	25.877,74 €	
Thede Witte	special discount for parquet	2.191,27 €	
Uponor	underfloor heating	5.716,94 €	
Valentin Holzhandel	special discount for materials for kitchen	577,00 €	
Valentin Software	licence for Software:PV*SOL Expert set & T*SOL Pro	2.888,32 €	
		162.242,23 €	16%
Other Income Details			
/			
		- €	0%
		1.034.886,22 €	**100 % Total**

Table 46: **Income details**

8.2. COST ESTIMATE AND PROJECT SUMMARY BUDGET

8.2.1 TECHNICAL UNIVERSITY OF BERLIN AND THE BERLIN UNIVERSITY OF THE ARTS

The total value of the project sums up to more than 1 Mio. Euro. The work done by students from Team Rooftop, approximately 23.500 student hours, is worth abouth 330.000 € with an hourly gross wage for student assistants of 14,07 Euro. These costs appear in the A.1 section personnel and the E.2 section As built. They are compensated by an equivalent amount in the income details table as indirect sponsorship through voluntary labour of students. Most students of Team Rooftop work voluntarily without financial rewarding. The costs for student assistant included in the proposal are artificial, except for two position in the administrative field for project controlling. The work is partly integrated in the course program of the UdK Berlin, so the students are able to get credits for their project work. Professors of both universities play a consulting role in the project and do not get extra money. There are no expenses displayed for the professors, because all professors are fully financed by the government. Two professors from the Unviersity of the Arts Berlin and one research associate are offically assigned with the leadership of the project. The hourly wage for a full ordinary professor with his/her own research group and budget is about 40 Euros. With two full professors working on the project 15 hours per month over a period of 24 months that would result in overall costs of 28.800 Euros. It should be said, that most of their work will be in R&D before and during the competition but detailed time distribution will not be included. One research associate will approximately spend 10 hours a month working for the project over a period of 24 months, with an hourly wage of 22 Euros, resulting in 5.280 Euros in costs. Other professors at both universites have no official role in the project but play a consulting role. We estimate that seven professors from various faculties including construction and mechanical engineering technology, building economics, building- and energytechnology, network structures and management will spend 150 hours working on the project resulting in artificial costs of 6000 Euros. Furthermore research associates will help the team with construction management in the building phase. Their help can be evaluated with around 3.300 Euros.

These costs appear in the A.1 section personnel and the E.2 section As built. They are compesated by an equivalent amount in the income details table as indirect sponsorship by the municipality.

ADMINISTRATIVE COSTS

There are four granted positions in the administrative field of the project, costing roughly 50.000 Euros. All granted position are the Controlling of the project and include two granted student assistants. Two positions in the administrative field are two increased part-time positions in the budget department and in the facility management.

DIRECT MATERIAL

The direct material costs make up 390.000 Euros including VAT- a noteworthy section of these costs consist of technologically new materials. The costs for the wooden construction amount to 48.297 Euros. The construction is done by the Knobelsdorffschule, which is a vocational school for building technology and construction work. The exact list of materials needed for the construction can be seen in figure... The prices are list standard prices plus VAT. The coopertation between the two universities and the vocational school prepares both parties for their future professional life. Team Rooftop profits from low costs for the construction as all services done by the teachers and students are provided for free and the school gains access and connections to university students and researchers.

Labour costs

The costs of services make up ca. 250.000 Euros inclung VAT, with 115.000 Euros deferred for the reuse of the building after the competition.

Travel costs

Furthermore, there are travel costs worth 40.000 Euros. This includes support given in kind by the organisation of 22.500 Euros for accomodation and public transport during the competition.

Cost Estimate

Our cost estimate of the construction was based on the one hand on statistical data from the German Baukostenindex (Construction Cost Index) 2013, on the other hand on the experiences of the SolarDecathlon 2010 LivingEquia group from the University of Applied Science for Technology and Economy/ Hochschule für Technik und Wirtschaft and other German participants in the SDE 2010. Furthermore, we were supported by cost planning professionals from the German architects gmp Architekten as well as "Rozynski and Sturm architects" and "Buero Löber for building technology, who took interest in our project and were very helpful in supplying us with cost data from similar projects and revising our estimates throughout the design process. All costs, including the construction costs, can be seen in the price cost proposal form firgures 2, 3 and 4.

Construction Costs of the house

For the detailed analysis for the costs of each part of the house a detailed list of the bought and sponsored items in each category is included in this section and might be referred to for costs for the relevant section. A safety margin of 10 % is added to the total sum at the end. All prices include VAT.

Solar Decathlon Europe 2014 EN FRANCE	SDE 2014 COMPETITION EN FRANCE			
	Team's Abbreviations	ROF		
	School's Name	The Berlin University of the Arts		
	Team's Name	Team Rooftop		
Nº	Name	Description	Budget		% Total
			ex VAT	VAT	on ex VAT
A. DEVELOPMENT PHASE_COST ESTIMATE					
A.1	Personnel				
	Professors & Researchers	840*40	28235,29	5364,71	3%
	Granted Students	22700*14,07	268394,12	50994,88	27%
	Consultants	240*30	6050,00	1150,00	1%
	…				0%
		Personnel	302.679,41 €	57.509,59 €	31%
A.2	Communication				
	Architectural Models	1350	1134,45	215,55	0%
	Videos	1000	840,34	159,66	0%
	Web Page (creation and maintenance)	200	168,07	31,93	0%
	Communication documentation	5000	4201,68	798,32	0%
	Exhibitions	0	0,00	0,00	0%
	Internal Communication	5000	4201,68	798,32	0%
		Communication	10.546,22 €	2.003,78 €	1%
A.3	First Workshop				
	Travel & Transport	2*100	168	32	0%
	Lodging	2*50	83	17	0%
	Expenses Allowance	2*60	100	20	0%
	Miscellaneous Expenses	2*20	33	7	0%
	…				0%
		First Workshop	384,00 €	76,00 €	0%
A.4	Second Workshop				
	Travel & Transport	9*140	907,56	172,44	0%
	Lodging	9*60	453,78	88,94	0%
	Expenses Allowance	9*50	378,15	74,12	0%
	Miscellaneous Expenses	9*20	151,26	29,65	0%
	…				0%
		Second Workshop	1.890,76 €	365,15 €	0%
A.5	Administrative and miscellaneous				
	Consumables and office supplies	1000	840,34	159,66	0%
	Administrative expenses		0,00	0,00	0%
	…				0%
		Administrative and miscellaneous	840,34 €	159,66 €	0%
		Sub-Total_Development Phase Cost Estimate	316.340,72 €	60.114,18 €	32%
B. HOUSE CONSTRUCTION_COST ESTIMATE					
B.1	Direct Materials				
	Raw Materials		350000,00	66500,00	36%
	Purchased Materials & Parts				0%
	Purchased Services		45000,00	8550,00	5%
	Purchased Equipment				0%
	…				0%
		Total Direct Materials	387.254,90 €	75.050,00 €	39%

Table 47: **price cost proposal form page 2**

Solar Decathlon Europe 2014 EN FRANCE	SDE 2014 COMPETITION EN FRANCE			
	Team's Abbreviations	ROF		
	School's Name	The Berlin University of the Arts		
	Team's Name	Team Rooftop		
Nº	Name	Description	Budget		% Total
			ex VAT	VAT	on ex VAT
B.2	Material Overhead				
		0,02*Total Direkt Materials	7.745,10 €	1.501,00 €	1%
	...				0%
		Total Material Overhead	395.000,00 €	76.551,00 €	40%
B.3	Direct Labor				
	Professors & Researchers				0%
	Granted Students	640*14,07	7567,06	1437,74	1%
	Laborers	Estimated Hours * Hourly Rate	7567,06	1437,74	1%
	Administrative	950* 28	22352,94	4247,06	2%
	...				0%
		Total Direct Labor	37.487,06 €	7.122,54 €	4%
B.4	Lower - Tier Subcontractors				
	...				0%
		Total Lower - Tier Subcontractors	0,00 €	0,00 €	0%
B.5	Consultants				
	approval/ planning/ test statistics	20000	16806,72	3193,28	2%
		Total Consultants	16.806,72 €	3.193,28 €	2%
B.6	Other Direct Costs				
	General & Administrative Expenses		0,00	0,00	0%
	Indirect Expenses	1000	840,34	159,66	0%
	Security	2000	1680,67	319,33	0%
	...				0%
		Other Direct Costs	2.521,01 €	478,99 €	0%
		Sub-Total_House Construction Cost Estimate	451.814,79 €		#DIV/0!
C. HOUSE DISASSEMBLY IN ORIGIN AND TRANSPORTATION					
C.1	Disassembly in origin				
	Personnel	500	420,17	79,83	0%
	Material and equipment	1500	1260,50	239,50	0%
	Other Expenses	1900	1596,64	303,36	0%
	....				0%
		Disassembly in origin	3.277,31 €	622,69 €	0%
C.2	House Transportation				
	Transport	30000	25210,08	4789,92	3%
	Transport Insurance (see Insurance Policies)		0,00	0,00	0%
	Other Expenses	2000	1680,67	319,33	0%
	...				0%
		House Transportation	26.890,76 €	5.109,24 €	3%
		Sub-Total_House Disassembly in Origin Cost Estimate	30.168,07 €	5.731,93 €	3%
D. FINAL PHASE IN LE CITE DU SOLEIL:COST ESTIMATE					
D.1	Travels & Costs for Final Phase in Madrid				
	Travel & Transport	30*200	5025,13	974,87	1%
	Lodging	30*667	16730,77	3279,23	2%
	Expenses Allowance	30*200	5016,72	983,28	1%
	Miscellaneous Expenses	30*50	1254,18	245,82	0%
	...				0%
		Total Travels & Costs for Final Phase in Madrid	28.026,80 €	5.483,20 €	3%

Table 48: **Price cost proposal form page 1**

Solar Decathlon Europe 2014 EN FRANCE		SDE 2014 COMPETITION EN FRANCE			
		Team's Abbreviations	ROF		
		School's Name	The Berlin University of the Arts		
		Team's Name	Team Rooftop		
Nº	Name	Description	Budget		% Total
			ex VAT	VAT	on ex VAT
D.2	Assembly and Disassembly Processes				
	Cranes	4000	3361,34	638,66	0%
	Equipment and machinery	3000	2521,01	478,99	0%
	Assembly in Le Cité du Soleil ©	30000	25210,08	4789,92	3%
	Disassembly in Le Cité du Soleil ©	5000	4201,68	798,32	0%
	…				0%
		Total Assembly, Transport, Disassembly Processes	35.294,12 €	6.705,88 €	4%
D.3	Insurance Policies				
	Liability Insurance	800	672,27	127,73	0%
	Transport Insurance	1500	1260,50	239,50	0%
	Accident Insurance	(we are ensured by the university for free)	0,00	0,00	0%
	Medical Insurance	(medical insurance is obligatory in Germany no extra costs)	0,00	0,00	0%
	Exhibition Insurance	1530	1285,71	244,29	
	Assembly Insurance	2400	2016,81	383,19	0%
		Total Insurance Policies	5.235,29 €	994,71 €	1%
		Sub-Total_Final Phase in La Cité du Soleil® Cost Estimate	68.556,21 €	13.183,79 €	7%
E. POST EVENT COST ESTIMATE					
E.1	House Permanent Assembly				
	Personnel		28571,43	5428,57	3%
	Materials		50420,17	9579,83	5%
	Machinery and Equipment		16806,72	3193,28	2%
	…				0%
		Sob-Total House permanent Assembly	95.798,32 €	18.201,68 €	10%
E.2	As built				
	Professors & Researchers	30*40	1008,40	191,60	0%
	Granted Students	800*14,07	9458,82	1797,18	1%
	Consumables and office supplies	1000	840,34	159,66	0%
	Administrative expenses	450*28	10588,24	2011,76	1%
	…				
		As Built	21.895,80 €	4.160,20 €	2%
		Sub-Total_Post Event Cost Estimate	117.694,12 €	22.361,88 €	12%
		Total Price / Cost Estimated	984.573,91 €	101.391,78 €	100 % Total
Please CHECK (X) your status >>>		If you benefit VAT Recovering		-101.391,78 €	
	x	If you don't	101.391,78 €		
		Total Price / Cost Estimated included VAT	1.085.965,69 €	984.573,91 €	

Solar Decathlon Europe 2014 EN FRANCE

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Table 49: **price cost proposal form page 3**

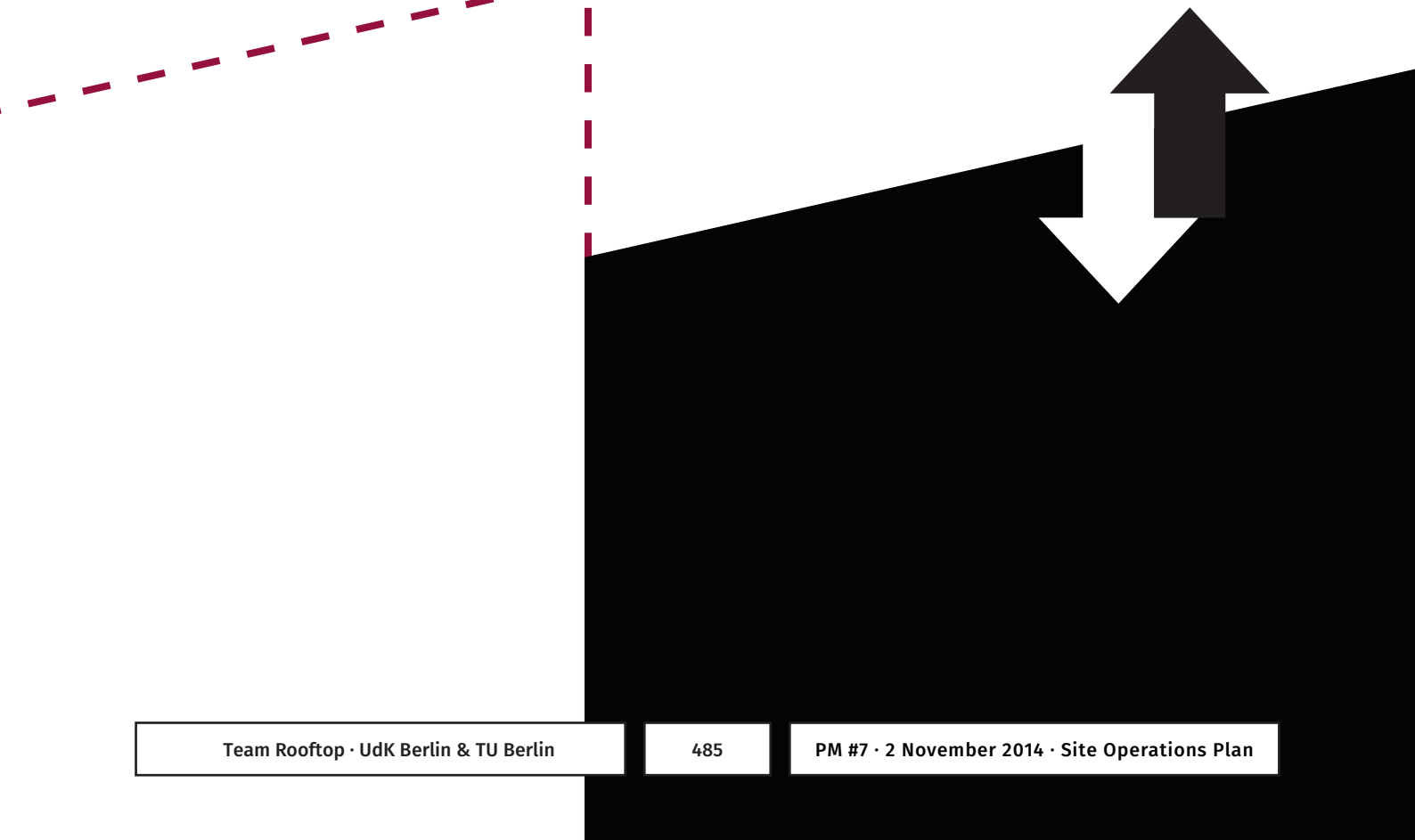
					sponsorship percentage	unnecessary costs
building		overall	448.806,84 €		35,65%	
	construction					
	floor		7.259,05 €		30,19%	0,00%
		parquet	3.937,00 €	Thede & Witte		
		parquet- special discount for project	2.191,27 €	Thede & Witte		
		dry screed	916,00 €	Hornbach Neukölln		
		sound insulation	214,78 €	Bausep		
	terrace		15.289,68 €		30,65%	0,00%
		construction	9.309,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
		railing	1.026,32 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
		wooden benches	268,60 €	Holzpossling		
		support structure for terrace	4.685,76 €	Buzon		
	windows and doors		51.155,39 €		2,91%	0,00%
		sliding glas doors	38.568,48 €	Metallbau Süd GmbH		
		spare glas and assembling tools	1.924,77 €	Metallbau Süd GmbH		
		entrance door	5.959,75 €	Metallbau Süd GmbH		
		inside doors	4.702,39 €	Hans Joachim Grubba		
		personnel costs	1.489,88 €	Metallbau Süd GmbH		
	walls		15.510,00 €		0,00%	0,00%
		longitudinal wall	4.960,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
		gable wall	4.975,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
		fire wall	5.575,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
	other dry construction		5.426,53 €			
			298,82 €	Bäthge Baustoffe GmbH & Co. KG	94,49%	0,00%
		wall covering bathroom and technical room	5.127,71 €	Eternit		
	facade		141.248,17 €		22,12%	7,61%
		materials	95.451,70 €	BeluTec Vertriebsges. mbH		
		research development and personnel costs	31.244,64 €	BeluTec Vertriebsges. mbH		
		lbm	10.751,83 €	LBM Industrieservice GmbH		
		seitl. Isolierung holz fassade	3.494,01 €	M.u.F. Valentin GmbH		
		Verkleidung Fassade	305,99 €	Hellweg		
	roof		11.534,56 €		12,02%	0,00%
		construction	10.148,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
		rain gutter	1.386,56 €	Rheinzink		
	electrics					
	electrics/ PV		45.500,54 €		31,85%	
		mounting of solar modules	2.031,47 €	K2 Systems GmbH		
		cables and fuses	1.250,92 €	Multi Contact		
		batteries	4.330,77 €	ib-rec GmbH		
		special discount for batteries	1.023,42 €	ib-rec GmbH		
		overvoltage protection	328,43 €	ib-rec GmbH		
		inverters	1.344,70 €	Solartechnik Stiens GmbH		
		inverter for heat pump	3.900,00 €	Studer Innotec SA		
		lighting concept	3.807,30 €			
		subcontract Knobelsdorffschule	6.938,30 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
		house automation controlg	5.814,00 €	Burri, Knobelsdorff-Schule Oberstufenzentrum		
		inverter for electricity input	1.071,00 €	Sunways AG		
		connector for inverter	287,00 €	UfE GmbH (wird wahrscheinlich gesponsored)		
		connector for heat pump	772,02 €	Oskar Böttcher GmbH & Co. KG		
		Kanal-CO2-Fühler	384,22 €	S+S Regeltechnik		
		PV- modules	7.816,87 €	Solibro		
		house automation control	748,95 €	Kieback und Peter		
		connectors	391,51 €	PV Partners		
		lighting switches, electrical outlets, router etc.	3.259,66 €	Jung		
	building technology					
	heating etc		41.124,83 €		94,51%	
		heatin/ solar/ ventilation (heat pumpe etc.)	25.877,74 €	Stiebel Eltron		
		underfloor heating	5.716,94 €	Uponor		
		heating	2.259,69 €	Briz Gas-Wasser-Heizung Installations GmbH		
		solar thermal	3.058,30 €	Augusta Solar		
		software for simulations	2.427,16 €	Valentin Software		
		workman services for installation	1.785,00 €	Briz Gas-Wasser-Heizung Installations GmbH		
	sanitary		21.301,09 €		45,62%	
		sanitary	9.591,41 €	Briz Gas-Wasser-Heizung Installations GmbH		
		bathroom fittings	3.377,30 €	Hans Grohe		
		pipes for freshwater and grey water	2.207,09 €	Geberit		
		bathtub	2.356,20 €	GKI Kufstein		
		basin, toilet, accessoiries	1.777,86 €	Catalno it		
		water tanks	1.522,25 €	Osculati		
		replacement of parts	468,98 €	Briz Gas-Wasser-Heizung Installations GmbH		
	cooling		20.011,40 €		69,11%	
		cooling	3.284,40 €	Briz Gas-Wasser-Heizung Installations GmbH		
		fixing for cooling plates in walls	255,26 €	Rheinmagnet		
		phase changing material	13.574,33 €	Lehmorange		
		aluminium brackets for fixing cooling plates	1.066,24 €	BeluTec Vertriebsges. mbH		
			1.831,17 €	Briz Gas-Wasser-Heizung Installations GmbH		
	ventilation		155,00 €		0,00%	
		ventilation	155,00 €	BerlinerLuft. Komponenten- und Systemtechnik GmbH		
	constructed wetland		3.187,08 €		0,00%	
		constructed wetland material	253,25 €			
		finned tubes for heat exchanger	1.011,88 €	Theodor Maier GmbH		
		production of heat exchanger	499,80 €	K&M GmbH		
		pumice stones	1.041,60 €	Lafarge		
		reed	157,30 €	Pépiniére E. Lenoir		
		rubber foil etc.	223,25 €	Geaplan		
	interior					
	interior construction		5.310,77 €		0,00%	
		multiplex boards	714,46 €			
		covering of the core module	4.596,31 €	Klöpferholz GmbH & Co. KG		

Table 50: **costs of building page 1**

furniture		15.874,27 €		27,96%	63,00%
	rails for movable furniture	475,00 €	Attas		
	materials for funriture	961,37 €			
	lending of movable furniture and design	2.643,56 €	Burkhardt Leitner		
	dining table and 4 charis	1.794,34 €	Ozzio Design		
	lost furniture from Burkhardt Leitner	10.000,00 €	Burkhardt Leitner		
curtains		9.772,23 €		84,28%	
	aluminium rails	642,60 €	Lars Leppin GmbH		
	production of curtains	893,64 €	Adular		
	high end fabrics for curtains	8.235,99 €	Jab Anstoetz		
kitchen		23.749,51 €		95,94%	
	materials for kitchen	749,85 €			
	aluminium matt	213,21 €	M.u.F. Valentin GmbH		
	all household applicances and accessoiries	12.873,70 €	Miele		
	planning and coordination of kitchen building	2.856,00 €	NFK Leichtbau		
	ecological materials for kitchen	1.999,68 €	C3 House gmbh		
	fittings for kitchen furniture	2.078,38 €	Hettich		
	high end kitchen sink	1.454,18 €	Fanke		
	special discount for project	577,77 €	Valtine Holzhandel		
	cutlery set	577,15 €	Auerhahn		
	knife set	369,59 €	Güde Messer		
incidental building costs		15.396,74 €		9,98%	12,99%
	construction site	1.500,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
	addition to building	1.510,00 €	Knobelsdorff-Schule Oberstufenzentrum Bautechnik I		
	tools	4.343,33 €			
	construction markets, small purchases	6.507,01 €			
	wood teak oil	1.065,40 €	Osmo		
	physiotherpeutic services for team members	471,00 €	Mechthilde Madlener		

Figure 270: **Costs of building page 2**

SITE OPERATIONS PLAN



9.1. GENERAL DATA

9.1.1 GOALS

There are four goals in our planning:

- time — set realistic dates, stay in set time frame.
- quality — assure that everything is built exactly according to plans.
- costs — keep transportation and assembly costs as budgeted
- motivation — awesome and happy people are the biggest contribution to our project

All are closely related. For instance, if Philippe gets up with a smile — or smiles after we served him coffee — he is going to be more attentive to the quality of work being done by his group, will work faster and not strain our budget.

9.1.2 PROJECT DATA

We have structured our building project into three distinct parts.

- H = House — this is what makes our house stand, you could stay in there and survive like a Neanderthaler
- I = Installations — make our house really nice to live in; includes appliances, electrical and HVAC installations: you survive like a homo sapiens comfortiens of the 21st century
- S = Surroundings — everything embedding our house in its urban character in Cité du Soleil

These parts in turn have multiple elements.

There is a letter signage system indicating each direction on the building site, W for west, N for north, E for east, S for south (see lot drawings SO-10x). There are posted signs on each side of the building site with the respective letter. Each piece is equipped with a small sticker of that letter on its respective side. I.e. a pillar has a 'W' on its western side, and a 'N' on its northern side.

For a transportation system we use a colour signage system. We assign a colour to each truck, and put stickers for that colour on every item belonging into that truck. I.e. The footings belong into the first truck, and have an orange sticker.

This helps us to

- quickly recognize parts during transport and assembly

- communicate clearly
- keep track of where we are in the building process

9.1.3 SITE OPERATIONS COORDINATORS

We comply with the shift times imposed by the Solar Decathlon Organisation, i.e. taking

- the first shift from 7 A.M. to 3 P.M.
- the second shift from 3 P.M. to 11 P.M.
- the night shift from 11 P.M. to 7 A.M.

shift	team	name	phone number	mail address
07-15	1	Philippe Ullbrich	+49 157 73919305	pullbrich@teamrooftop.de
15-23	2	Simon Madlener	+49 152 03807807	smadlener@teamrooftop.de
23-07	3	Alessandro Jänicke	+49 176 70744658	ajaenicke@teamrooftop.de

Deadline for Wind-and-water tight	25 June 2014
Deadline for electrical connection to village grid	25 June 2014
Deadline for house delivery	25 June 2014

9.2. LOGISTIC OUTSIDE OF LA CITÉ DU SOLEIL

9.2.1 TRUCKS' ROUTE

Our assembly location in Berlin is where all parts are going to collected prior to transport. From there we will work with a German logistics company to bring our house to Paris. The following is a selection of routes from Berlin to Paris. They all take ten to eleven hours of driving for a normal car (according to Apple Maps) — which means roughly thirteen hours of driving for truck, plus stops, local traffic in Berlin and Paris/Versailles and unforeseen events. It will be safe to calculate two days of transit after trucks depart at our location (see Figure 269) to arrive in the truck waiting line de la Cité du Soleil.

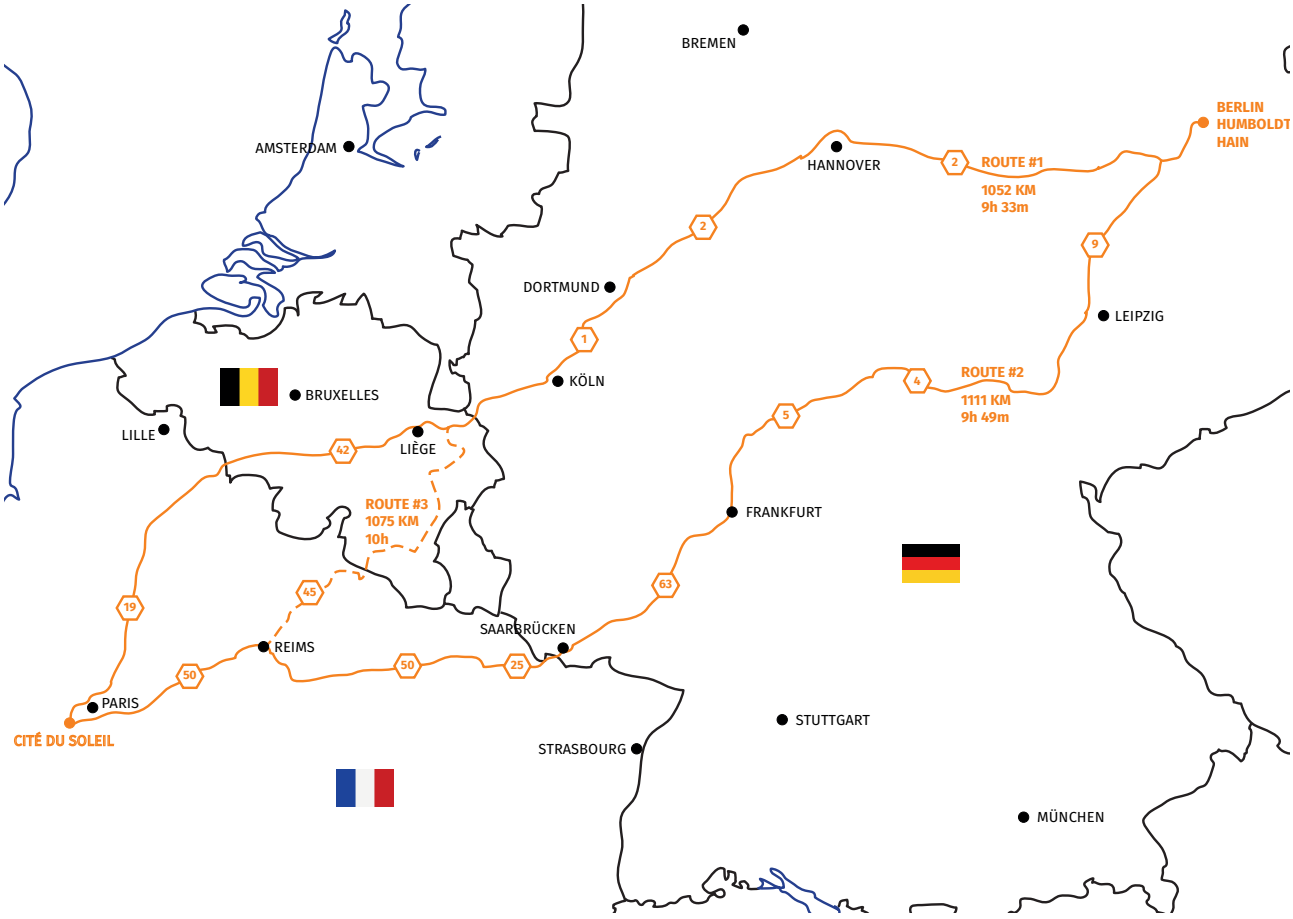


Figure 271: **Truck route from Berlin to Paris**

Our assembly location in Berlin is one of the biggest halls in Berlin and part of the Civil Engineering Department of Technische Universität. We have one area for construction measuring 18 by 11 meters and another for storage that is just as large, but may be needed by others periodically. The time frame to build our house

is not included in this report as there seems to be no proper place for it. We will have built the house and installations (excluding surroundings) by mid-may, test it, disassemble it, put it on the trucks and come to la Cité du Soleil.



Figure 272: **Perspective of assembly location in Berlin.**

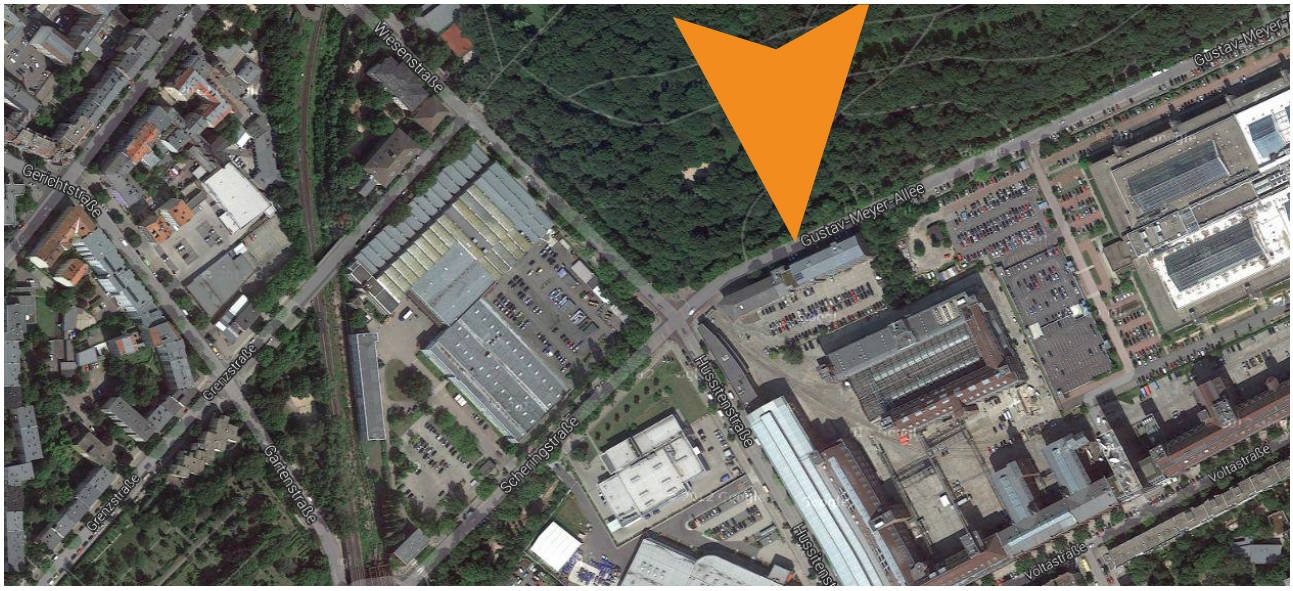


Figure 273: **Map of assembly location in Berlin — in orange is the perspective of the above figure.**

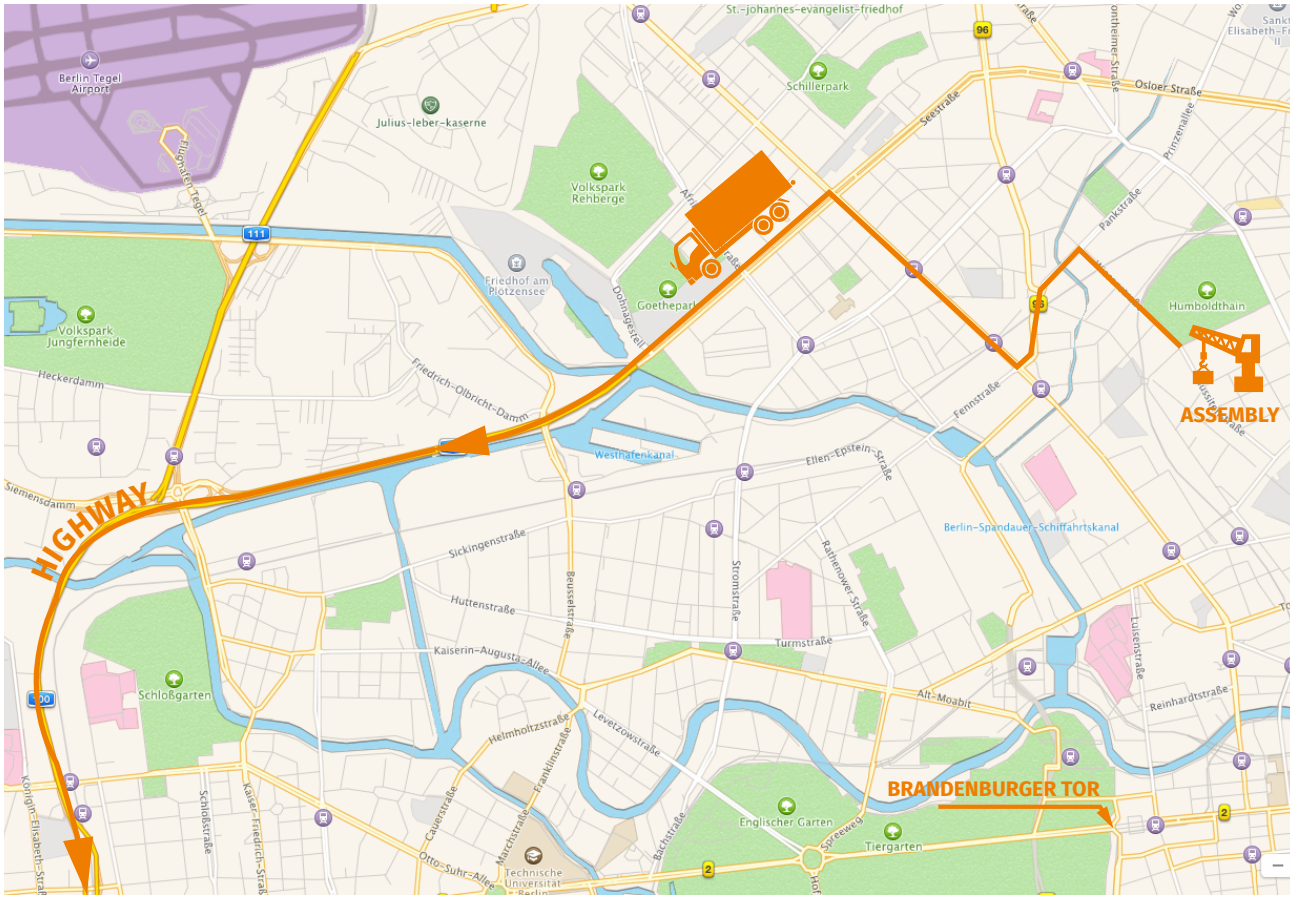


Figure 274: **Logistics in Berlin.**

The location in Berlin is ideal: From assembly to where the highway starts (tip of the truck in illustration) is a distance of only 5km on main roads that usually aren't congested.

9.2.2 TRUCKS' SPECIFICATIONS AND SHIPMENTS

This information is confidential and is not published in Deliverable #7.

9.3. LOGISTIC IN LA CITÉ DU SOLEIL

This information is confidential and is not published in Deliverable #7.

9.3.1 INFRASTRUCTURES

This information is confidential and is not published in Deliverable #7.

9.3.2 CONSTRUCTION WORKING TEAMS

This information is confidential and is not published in Deliverable #7.

9.3.3 PHASES DESCRIPTION

This information is confidential and is not published in Deliverable #7.

9.3.4 WASTE MANAGEMENT

This information is confidential and is not published in Deliverable #7.

9.4. ASSEMBLY/DISASSEMBLY SCHEDULES

This information is confidential and is not published in Deliverable #7.

9.5. EQUIPMENT REQUIREMENT CHART

This information is confidential and is not published in Deliverable #7.

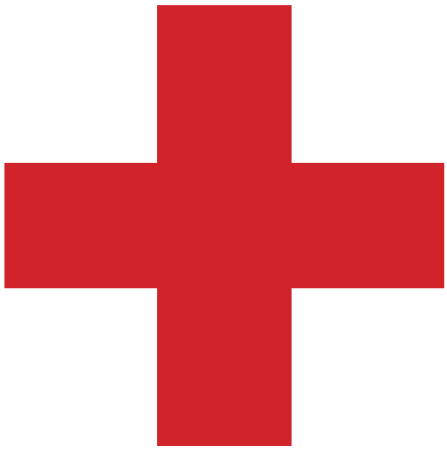
9.6. STORAGE AREA CHART

This information is confidential and is not published in Deliverable #7.

9.7. SITE OPERATIONS CHART

This information is confidential and is not published in Deliverable #7.

HEALTH



SAFETY

Safety first! In this section we describe our risk assessments, safety measures and fire regulations.

10.1. HEALTH AND SAFETY CHECKLIST

Legal Contents	Location in the Report or in Drawings
Name and adress of SDE 2014, HS Coordinator, Prevention authorities, Team	HS Report – (see section 10.3)
Number of Workers	HS Report – (see section 10.3) / (see section 10.6.3)
Contact information of the Site Operations Co-ordinator	HS Report – (see section 10.3)
Description of works	HS Report – (see section 10.5)
First aid procedure	HS Report – sections (see section 10.14.1) , (see section 10.14.3) , (see section 10.14.4) „Appendix 2: Emergency Evacuation Plans“
Name and number of first aid certificated worker	HS Report – section (see section 10.14.1) .
Description ofthe Team's first aid kit	HS Report – (see section 10.14.2)
Description of hygiene conditions (toilet, changing room, restroom …)	HS Report – (see section 10.10)
Detailed description of operating modes	Site Operations Plan
Risk assessment – risks generated by other	HS Report – (see section 10.5) „Appendix 1 – Risk Assessment Charts“
Ris assessment – risks generated by environment	
Risk assessment – risks generated on other	
Risk assessment – self generated risks	
Procedures to adapt collective protection	HS Report – (see section 10.10)

10.2. PRECEDENTS AND AIM

The most important aim, also disclaimed by the "Arbeitsschutzgesetz" (similar to "labour protection act") in Germany, is to avoid as many risks for life living and health hazards as possible or, if inevitably, to keep those to a minimum by taking appropriate measures. Therefore, possible sources of danger, have to be fought.

Hence, in order to achieve these requirements, during every construction planning the state of art, occupational medicine and hygiene have to be considered and all technical equipment and measures, the organization of the work and other working conditions have to be linked properly.

These aims are also mentioned in "Richtlinie 89/391/EWG des Rates über die Durchführung von Maßnahmen zur Verbesserung der Sicherheit und des Gesundheitsschutzes der Arbeitnehmer bei der Arbeit" (similar to "guideline 89/391/EWC on the introduction of measures to improve the safety and health of workers included in the work") of the European Council. Fundamental objectives of this directive are suggestions for improvement of safety in the workplace through appropriate measures, general arrangements to prevent work-related hazards and the elimination of risk- and accident factors.

For ensuring the protection of all Rooftop team members, supporting personnel, visitors and inspectors during construction, transport and dismounting the Rooftop House, a project Health and Safety Plan (HS-Plan) is required.

According to ArbSchG, at a minimum, the HS plan includes information relating to all working processes on site, including locations and time schedules. It lists all relevant, across the trades appearing dangers and defines measures for avoidance or decrease of those, considering all relevant provisions for labor protection.

The possible hazards during all phases have to be considered on the basis of all available information regarding physical and chemical risks as known or suspected for the duration of the project. However, not all possible dangerous situations can be avoided in advance, which creates the aim to reduce the probability of occupational injury.

All assignments made in this HS-Plan have to be abided by all engaged personnel during all tasks associated with the phases of transport, assembly and disassembly.

Furthermore, to enable review in these assignments and to present the minimum security standard of this project to visitors, a copy of the HS Plan including the HS Drawings will be provided on site during all construction phases.

10.3. GENERAL DATA OF THE PROJECT

- house builder: Team Rooftop Berlin (TU Berlin, UdK Berlin)
- footprint: 140m²
- volume: 202,5m³
- assembly phase duration: 10 days
- disassembly phase duration: 5 days
- number of workers: 36 people
- Contact information of the site operation coordinator: Simon Madlener, simon.madlener@gmail.com, +49 152 03807807
- Contact information of the health& safety coordinator: Katharina Haucke, k.haucke@mailbox.tu-berlin.de, +49 173 6308989
- adress La Cité du Soleil - SDE 2014 France: Chantier CSTB SOLAR DECATHLON, Domaine du château de Versailles, Allée des Matelots Versailles
- prevention authorities [general coordination plan]:

Stakeholders	Addresses	Telephone	Fax	Name of manager
SDE 2014	cours Louis Lumière, 94300 Vincennes - France	00.33.(0)1.40. 50.29.34	00.33. (0)1.40. 50.29 10	M. MAT jerome.mat@solardecathlon2014.fr
BUREAU VERITAS	17A, avenue Robert Schuman, 13235 Marseille Cedex 2	00.33.(0)4.96. 17.13.50	00.33.(0)4. 91.56.18.73	C. PEYRONEL christophe.peyronel@fr.bureau veritas.com
BUREAU VERITAS	Immeuble Le Florestan 2 boulevard Vauban	00.33(0)1.39. 44.69.57	0033.(0)1.30. 43.34.57	B. IANNELLI bruno.ianelli@fr.bureau-veritas.com
CARSAT	9 rue Porte de Buc 78035 Versailles Cedex 20	0033.(0)1.39. 53.41.41	00.33.(0)139. 51.06.24	M. TACCOEN
FRENCH LABOUR INSPECTION (DIRECCTE)	La Diagonale Building, 34, avenue du Centre, 78 182 Saint Quentin-en-Yvelines, Cedex 20	00.33.(0)1.61. 37.10.00	00.33. (0)1.61. 37.10.01	dd-78.direction@direccte.gouv.fr
OPPBTP	1 rue des Mazières Clos de l'Agora 91000 Evry	00.33.(0)1.71. 63.70.00	00.33.(0)1.71. 63.70.01	

10.4. HEALTH AND SAFETY PLAN OBJECTIVES

All necessary measures related to occupational safety have to be taken to improve health and safety of all project members and their effectiveness has to be verified. An appropriate organization of the measures has to be guaranteed, the necessary resources have to be provided and the implementation and feasibility of cooperation duties by the project members have to be ensured. (§3 ArbSchG)

The highest priority is the insurance of the safety of all persons involved in the transport, construction and dismounting of the Rooftop House.

Therefore, three objectives can be perceived:

- planning operations on side considering possible hazards and eliminate these as far as practicable by preventive measures
- minimizing accidents or diseases caused by operations on site
- providing and maintaining a safe work environment

10.5. SITE CONDITIONS

To improve the safety and health of workers on construction sites the instructions of the guideline "Baustellenverordnung" can be used. Before start of construction a health and safety plan has to be worked out, which includes work protection measures and provisions to prevent accidents at dangerous works for the respective site as follows.

All possible risks for health and safety for all team members on site as well as the impacts on other teams in close proximity to the construction site have to be identified.

The risk assessment includes four steps:

- risk analysis
- risk investigation
- definition of health and safety protection measures, check of effectiveness
- documentation of ideas and measures

The results of all stages have to be documented if more than ten employees are engaged.
(§5 ArbSchG)

Three types of risks have to be considered:

- workspace-related: complete elements
- in terms of activities: type of the work process
- person-related: assessment of employees

In particular, risks arise during:

- design, construction of workplace/space
- physical, chemical, biological impacts
- design, selection, usage, handling work equipment (materials, machinery, equipment, facilities)
- labor, production methods, procedures, working hours; interaction of all
- insufficient qualification / training d employees
- mental stress at work

Overall, this results in the collection of all works and situations on site, which are connected with a danger potential. (§6 ArbSchG)

Consequently, as the Rooftop House will be executed next to other project sites, the interference with other teams is inevitable. Relating to health and safety requirements, the concerned teams should cooperate to improve all individually taken measures by each project team. Information as well as measures should be synchronized. (§8 ArbSchG)

10.5.1 CONSTRUCTIVE PROCESS

DESCRIPTION

The likely scope of work will include the assembly, maintenance and disassembly of the Rooftop Unit. Team Rooftop personnel will conduct an oversight role for all the activities and will perform the actual sampling. For detailed phases of the construction process see the Site Operation Plan and the Construction Plans.

POSSIBLE RISKS

During the constructive process a variety of risks can be identified. Since the constructive process is described more in detail in the sections below, please refer to these sections.

However, some risks concern all parts of the construction:

- dangers created by inadequate lighting
- not heard warnings/ communication difficulties to other team members or teams

PREVENTION OF POSSIBLE RISKS

As well as the description of possible risks, the prevention of these risks is described in the respective section that goes more in detail to the specific item.

The risks mentioned before can be prevented by:

- provide adequate lighting at every time
- Measures for improvement of communication and warnings will be taken, such as predefined signals and signs and amplifiers (e.g. megaphones).

10.5.2 TYPE AND CHARACTERISTICS OF THE MATERIALS AND ELEMENTS

DESCRIPTION

The used materials for out prototype are mainly timber, glass panes, metal sheets and components, plastic and rubber. Technical and electronic devices form part of the prototype as well. Therefore, all used building and packing materials provide fire loads.

POSSIBLE RISKS

- timber: injury by wood splinters or intensive collision with timber
- glass: cutting with broken glass parts or sharp edges, injury by intensive collision
- metal: cutting at sharp edges or burrs, injury by intensive collision
- plastic/rubber: injury by intensive collision
- loam: inhalation of loam dust, injury by intensive collision
- devices: electric shock, injury by intensive collision
- batteries: cauterization or intoxication with lead-acid, injury by intensive collision
- all building materials, packing materials: fire spread in case of contact with source of ignition

PREVENTION OF POSSIBLE RISKS

Basically, the usage of protective working clothes (safety gloves, shoes, caskets etc.), is mandatory. As shown with signposting, when applicable, safety glasses and breathing protections have to be used.

The working rules and schedules have to be followed strictly to avoid unwanted collision with heavy material pieces.

Additionally, all used building parts and materials have to be stored safely. Packing and waste materials have to be removed daily and stored in a sufficient distance to the building. Finally, around the fire hazardous works a fire extinguisher and fireguards have to be provided.

10.5.3 SITE DESCRIPTION

DESCRIPTION

- location: Garden of Versailles, Versailles, France
- site divided in 20 construction lots
- size per construction lot: 20 m x 20 m (400 m²)
- lot: Grass area, possibly uneven ground
- lot: Ground level differences of up to 50 cm
- lot: No natural shadowing elements

POSSIBLE RISKS

- location: terrorist attacks, entrance of unauthorized people
- construction site: collision of transformational or constructive vehicles (trucks, cranes, suppliers etc.)
- lot: entrance of unauthorized people (stealing, increased risk of injury, decrease of concentration of workers, increased risk of arson, manipulation of building parts)
- lot: stumbling upon ground unevenness, heat stroke

PREVENTION OF POSSIBLE RISKS

Measurements for the prevention of risks at the location have to be taken by the French Government and Municipal authorities as well as the SDE organization.

At the construction site, it is the site operation managers duty to obey instructions of overall (truck schedules, traffic rules, etc.). Additionally, trucks and other vehicles well be accompanied by two pedestrians.

The lot will be marked off by barrier lines and dangerous unevenness of the ground will be assigned by signal barriers. Those steps will be observed by the Health and Safety Coordinator and Officers.

10.5.4 CLIMATE DESCRIPTION

DESCRIPTION

- Versailles, France (48° 48m 19s N, 2° 7m 49s E)
- oceanic climate zone, elevation 135 m
- daytime is from 06:00 h in the morning to 20:00 h in the evening, resulting in duration of solar irradiation of
- during competition phase, the temperature ranges from 12°C at night to more than 25°C at daytime.
- The peak of ambient temperature is around 16:00h, whereas the lowest temperature occurs at 06:00 in the morning.
- The wind speed in Versailles ranges from 1m/s to 6m/s in June and July.

POSSIBLE RISKS

- direct human hazards: sun burns, intensive glare, dehydration
- because of sudden/ extreme rainfall: slipperiness of underground
- because of flooding after extreme rainfall because of dry earth: slipperiness of underground
- because of summer storms/ sudden gusts of wind: persons falling off heights, swinging building parts/ materials held by cranes, falling parts of scaffolding, material, building parts

PREVENTION OF POSSIBLE RISKS

Individual measures are the wearing of appropriate, protective clothes and especially resistant, non-slipping footwear. If sunny, sun glasses, the application of sun screen and the provision of artificial shadow (teams pavilion) is required. At any weather condition, a sufficient amount of drinkable water has to be provided. The Health and Safety Coordinator and/or Officers have to observe and confirm the compliance to these requirements before every shift.

To avoid swinging parts or materials, if very windy, cranes or similar machinery must not be used. However, every task only may be executed using work equipment suitable to the weather conditions. Emergency roofs and awning to protect the building as well as provisional and sufficient fixed cover for devices and materials have to be established. Also, timely adjustment of the construction operations, secure anchoring of the scaffolding on the building, early closing of openings in the roof or of the façade must be possible.

Therefore, the weather forecast will be continuously observed by the Health & Safety Coordinator and the Project Manager during assembly and disassembly phases for analysing and making appropriate decisions. Decisions have to be taken early enough to limit damage, even if this includes stopping the work for a longer period.

10.5.5 ACCESS AND PATHS AND VEHICLES

Summarizing the routes, the only possible routes are the official ways of the SDE 2014 site, which are drawn in the Site Plan.

DESCRIPTION

Due to the restricted width of the access route, only one vehicle can access the site at a time.

The access and exit gates are separated locally to the north and south side of the site.

Trucks have predefined routes to circulate (see Route Plan) and must not intersect e.g. the radius of effect of the cranes or the parking lots of the trucks. Parking lots are locally separated from the construction site.

POSSIBLE RISKS

- Collision of trucks during manoeuvres
- Collision of truck with person on truck lane
- Collision of released, parked truck with other vehicle or person
- Person falling down off truck because of using inadequate seat

PREVENTION OF POSSIBLE RISKS

Vehicles only may be used by workers, who obeyed instructions on the safe operation of the vehicle by appropriate personnel, as follows.

There will be strict observation and anticipatory planning of the movement of vehicles by SDE site operation manager, team site operation manager, truck drivers and crane personnel.

Related and Parked vehicles have to be protected against undesired release or movements.

Riding vehicles by team members is only permitted on specific and suitable places on the vehicle.

10.5.6 DETERMINING FACTORS FOR THE HOUSE PLACING

The main determining factors for the house placing are: the used materials, site and weather conditions as well as the accessibility for vehicles.

Therefore, the determining factors for the house placing have already been described in previous sections (4.2 to 4.5).

10.5.7 OVERLAPS WITH THE AFFECTED SERVICES AND OTHER CIRCUMSTANCES OR ACTIVITIES OF THE ENVIRONMENT

All overlaps can be seen in the Site Operations Plan, Construction drawings and the risk assessment charts („Appendix 1 – Risk Assessment Charts“), which show the assembly schedule.

DESCRIPTION

- Co-activity/ overlaps of construction steps in can be seen in the Site Operations Plan.
- overlaps with affected services: transportation enterprise staff, crane operator
- overlaps with other construction threads: approx. 19 other construction teams
- Work done over other work at heights
- Work on slatted flooring (or equivalent)
- Work which pollutes
- Shared use of materials

POSSIBLE RISKS

- collision with other workers, material, devices, tools, constructive elements, falling elements, risk of material damage due to collision
- collision with heavy machinery, third party workers
- collision with workers or heavy machinery from other teams or other team’s subcontractors
- falling of materials, devices tools, constructive elements during work at heights, slatted flooring
- creating health hazardous working area of own team and other workers via

generating pollution

- brasion of tools to non-conformity to the rules (shared tools)
- occupational diseases

PREVENTION OF POSSIBLE RISKS

The best way to prevent those risk is the carful organization by the Site Operation Mangager and a close observation by the Health and Safety Manager. Also every worker hast to abide the rules set up for safe work to guarantee the effectiveness of all taken measures. Furthermore, a proper communication with third party workers and workers of other teams or other team's subcontractors is essential for a safe construction process of all teams.

In detail this means:

- avoiding work done over top of other work; if not avoidable: necessary protection measures have to be taken to protect the personnel working below; approved measures (approval by Security Coordinator): collective protective decking, awnings
- before performing lifting operations/ work at height: implementation of measures to prohibit the circulation of personnel at the base of the work areas: signposting, barriers
- work via task superposition on industrial floor gratings is prohibited, exception: adapted group protections to protect personnel working underneath, esp. from through grating falling objects
- awnings, decking, nets: installed of project supervisor (phases 1, 4) and by TEAM (phases 2, 3) when work over and at base of access to buildings/ placec characterized by horizontal movement
- isolation of work generating noise pollution, hazardous vapor fumes, dust; if not possible: implementation of measures to protect others by polluter; group protection have to be given preference to individual protective devices
- examples of avoiding pollution: utilization of sound proof materials, watering work areas/ materials to be treated, ventilation of work and storage areas (mechanical extraction, filtration before any discharge, individual oxygen measurement device, breathable air etc.)
- avoidance of equipment with heat engines in areas lacking sufficient ventilation, also consideration of working after usual working hours: monitoring to plan during phases 1,4 (Project Supervisor) and 2,3 (Project Owner)
- if equipment is available to other teams/ company: equipment must be in good condition and comply with regulations, the proper usage must be supervised, fit-gap analysis regarding means and end result; approval from team/

company necessary before provision

- suction, ventilation of premises with outside air is the responsibility of the stakeholder
- selected procedures, products and tools should not cause any nuisances such as noise, vibrations, dust, toxic gases; if not avoidable: usage of materials which reduce such pollutions at source
- elated companies: provision of HS plan in advance with detailed execution of works planning incl. provisions implemented to address the risks involved
- co-activity is not permitted if different construction companies execute work which presents a specific risk (levelling, foundations, application of toxic or flammable substances, etc.)
- detailed planning of shift work, staggered operations, other work coordination by Project Subervisor (phases 1,4) and Teams (phases 2,3) to prevent risk of task interfering; HS Coordinator has to approve the provisions adopted
- main VRDs including underground networks should be undertaken as soon as possible to reduce the risk of co-operations during the assembly of facilities

10.5.8 PLANNED ACTIVITIES

DESCRIPTION

The shift plan for the construction of the unit including number of workers and hours of work can be seen in the Site Operations Plan. A detailed description of the shift system is included in the Site Operation Plan.

POSSIBLE RISKS

- lack of rest times (to long working shifts)
- overlaps of work, that increase health and safety risks if overlapping (e.g. placing roof covering and simultaneously start installing PV modules)
- too tight schedule: incorrect/ sloppy execution of tasks because of time pressure

PREVENTION OF POSSIBLE RISKS

The Shift Plan has to be planned accurately by the Site Operation Manager and checked by qualified personnel to avoid unwanted overlaps.

The considered hours of work and rest times can be seen in section 10 below.

TRADES WHOSE INTERVENTION IS AFFECTED BY THE RISKS PREVENTION

As far as can be foreseen now, no planned measures of risk prevention does affect the intervention of any trade.

10.5.9 AUXILIARY RESOURCES PLANNED FOR THE CONSTRUCTION

DESCRIPTION

All provided machinery and work equipment has to be suitable for the site conditions and ensure health and safety protection when used as directed. The taken measures for the insurance of the protection have to meet the requirements made in the risk assessment. Additionally, these have to correspond to current state of technology and to adapt the ergonomic correlations (esp. posture) between workspace, equipment, organization, operation and tasks. (§3 BetrSichV)

Following auxiliary resources will be used:

- Rotating machines: Mitre saw, circular saws, chainsaw, fret saws, drill machines, power screwdrivers
- Further tools: Saws, screwdrivers, hammers, other carpentry tools, pincers

POSSIBLE RISKS

- Rotating machines: Injury by cutting, direct contact with rotating components, danger of long items (hair, scarves, necklaces, wristbands, lanyards, etc.) getting into rotating components.
- injury due to incorrect use (e.g. damage to hand wrist due to unexpected torque of power screwdriver)
- fire spread because of overloading of machines and cable drums: damage to cables by external thermal or mechanical influences

PREVENTION OF POSSIBLE RISKS

If work equipment with high hazard potential has to be used, those only may be used by authorized persons (§8 BetrSichV). Every worker, operating with high hazard potential machinery, will be instructed according to the requirements made in §14 ArbSchG.

Therefore, following measures, also in accordance with §81 BetrVG, will be taken:

- All team members will be informed about the risks concerned
- The operating instructions about the used equipment will be provided. These contain at least: information on operating conditions, foreseeable malfunctions, existing experiences on the usage
- Every worker of the team will provide a certificate for rotating machinery.
- The correct and safe use will be observed by the Health and Safety Manager and the Site Operation Manager.
- Every team member will provide a signed certificate of being aware of the risks resulting from the usage of the tools applicable and of being taught how to use the tools correctly.
- Only tools, providing CE certification will be used during assembly and disassembly (already bought and tested in Germany). Checks will be made before the first usage and repeated regularly.
- For a proper operation of the electrical equipment it has to be maintained and tested regularly. This includes a visual inspection by the workers before using.
- The equipment must be put away after completing the work.

10.5.10 CONSTRUCTION SITE INSTALLATION

DESCRIPTION

- No ventilation outlets or other obstacles from the tunnel underneath have to be taken into account.
- Electric connection box, telecommunication connection box

POSSIBLE RISKS

- stumbling upon connection boxes
- electric shock

PREVENTION OF POSSIBLE RISKS

- Erection of signal barrier
- work on these boxes only by authorized personnel

10.5.11 CHARACTERISTICS TABLE FOR THE STOCKS

Because of the planned modularity of all building parts, only minor amounts of material have to be stored. Therefore, two stock grounds will be sufficient.

characteristics table for the stocks	
stock ground	**Size in m²**
main stock ground	95
temporal ground for waste and package material	20

10.6. ACTIVITIES FOR RISKS PREVENTION

10.6.1 DETERMINATION OF WORK EFFECTIVE TIMING

„Site Operations Report“ on page 485

10.6.2 OVERLAPS AND INCOMPATIBILITIES IN THE CONSTRUCTION

„10.5.7 Overlaps with the affected services and other circumstances or activities of the environment“ on page 512

10.6.3 NUMBER OF WORKERS TAKING PART IN THE CONSTRUCTION

- Construction Calculation: 3
- Construction: 36
- External Logistic Supervisors: 2

10.7. CONTRACTING PLANNED

The crane company is chosen by the SDE Organization. Other in contracting involved companies such as logistic companies can be seen in the Site Operations Plan.

10.8. CRITICAL WORK PHASES FOR RISKS PREVENTION

Work phases for risks prevention are especially:

- transport of pre-build house modules
- application of wall, roof and floor modules
- assembling of glass façade elements

- assembling and connection of PV and solar thermal modules
- installation of electric connections
- piping installations (plumbing system, floor heating)

10.9. RISKS IDENTIFICATION AND EFFICACY EVALUATION OF THE ADOPTED PROTECTIONS

10.9.1 LOCATION AND IDENTIFICATION OF AREAS INVOLVING SPECIAL RISKS

- see Construction Drawings

10.9.2 RISKS IDENTIFICATION AND EFFICIENCY EVALUATION OF THE ADOPTED PROTECTIONS

- see risk assessment charts in „Appendix 1 – Risk Assessment Charts“

10.10. COLLECTIVE PROTECTIONS TO USE

Several measures as prevention from general risks have to be taken:

- beforehand preparatory training of all workers in Berlin (operating machines, instructions about team work, parallel tasks, general safety aspects)
- first aid courses/ basics for all involved workers (show possible risks, guidelines on behavior in cases of emergencies)
- to reduce misuse: instruction manuals on site for all tools used
- detailed plan of assembly, disassembly (who, when, where, with which tool)
- medical examination evaluation (physical fitness, aptitude) of every worker
- the Project Supervisor and the Rooftop team are responsible for providing, implementing and maintaining group protection up to its final disassembly or up to the end of construction.

- the Health and Safety Coordinator instructs and observes the workers
- every group protection implemented by the Rooftop team on the construction site must be described in detail (see health and safety drawings)
- Sub-contractors can implement groupprotection in agreement with and under the responsibility of the Project Supervisor and the Rooftop team
- safety devices (scaffolding, nets, barriers, etc.) or group protection shared with other groups, can only be moved or changed by those who originally installed them

Group protection must be designed and constructed to meet the following general principles:

- always be implemented prior to the beginning of any risk
- be adapted and sufficient to allow the completion of various works safely

Group protection can only be take off in the following situations:

- elimination of the risk related to the advancement of work
- definitive group protection of the overall work is in place and is sufficient for the remaining work (see health and safety drawings, which group protection is needed in each work phase)

To support a save building site the used scaffolding has to be checked and certified. Only scaffolding offered by the SDE supporting companies will be used. (see Site Operations Plan)

Additionally, to avoid hygienic risks, before starting to work all team members will be instructed on the locations of the nearest sanitary rooms, changing rooms and the rest rooms.

The restrooms, showers, wash basins, cloakroom on the construction site premises are shared by all stakeholders. The set-up maintained of porta-potties will be coordinated by the Project Supervisor. Those will be provided for use by personnel in the construction site area close to the construction. The specific position is in progress for all work phases [see general coordination plan].

10.11. INDIVIDUAL PROTECTION RESOURCES TO USE

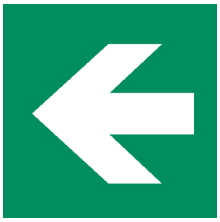
To provide harms from chemical or physical hazards all workers on site have to wear personal protective equipment (PPE). The PPE provides an isolation against those dangers occurring during the work on site.

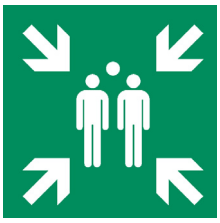
At a minimum the PPE includes safety boots with ankle supports, leather gloves, a hard hat, in some cases (e.g. metal work) safety glasses, a long sleeves shirt, long trousers and a reflective jacket. Especially the hard hats have to be worn all times. Exeption of this are authorized areas (offices; rest, break, locker rooms; changing rooms, showers).

10.11.1 SIGNPOSTING OF THE LABOUR RISKS

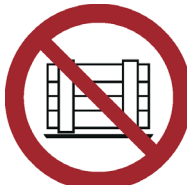
As additional prevention all positions of possible labour risks have to be signed according to [Bgi 2008, p.32–37]. In detail, the labeling for health and security protection includes labeling of emergency and escape ways, emergency exits as well as the remaining operational environment. The signs have to be visible and placed as close as possible to the area in question.

sign	meaning	location
	M 003: utilization of ear protection	HS drawings
	M 004: utilization of eye protection	HS drawings
	M 008: utilization of foot protection	HS drawings
	M 009: utilization gloves, sort depending on task choice to be made by site leader	HS drawings

	M 014: utilization of a hard hat	HS drawings
	M 015: utilization of a security jacket	HS drawings
	E 001, E 002: emergency exit	next to emergency exits
		
	E 001, E 002: shows direction of emergency exit, first aid establishments, emergency routes	next to emergency exit signs
		
	E 003: first aid labeling of medical rooms, first aid bags/ boxes	next to location of first aid bag (core module)

	E 004: emergency telephone shows place of emergency telephone	next to location of emergency telephone (core module)
	E007: shows collecting point	next to the collecting point on site
	E 009: shows office of a doctor	in fire safety plan
	W 007: warning – falling hazard	HS drawings, next to storage ares
	W 008: warning – falling hazard	on high working places; next to terrace
	W 011: warning – slipping hazard	HS drawings
	W 012: warning – dangerous electrical tension	during PV construction phase near the roof (scaffolding)
	W 014: warning – industrial trucks	site entrance

	W 015: warning – pending loads	site entrance
	W 017: warning – hot surfaces	next to movable façade modules (hot PV surfaces)
	W 019: warning - crushing hazard	HS drawings
	W 026: warning – risks batteries	inside of door of machine room
	F 001: shows position of fire extinguisher	next to fire extinguishers (core module, stairwell)
	F 004: shows position of fire fighting equipment	next to location of fire fighting equipment (core module)
	F 005: shows position of fire detector	next to emergency stop button = fire detector (stairwell/ machine room)
	F 006: shows position of fire alarm telephone	next to emergency telephone = fire alarm telephone (core module)
	P 002: smoking prohibited	site entrance

	P 003: prohibition of all sources of ignition (incl. welding flames, grinding sparks)	site entrance
	P 010: contact prohibited	next to sensitive systems (electrical systems)
	P 011: arcing with water not allowed	ceiling
	P 013: cellular radio prohibited	site entrance if necessary (installation of regulating system)
	P 022: eating, drinking prohibited	site entrance
	P 023: placing/ storing prohibited	next to prototype
	P 024: entering of the area prohibited	during sensible construction phases

10.12. SAFE WORKING PROCEDURES OF EVERY EMPLOYER

As mentioned before, to guarantee health and safety, all Rooftop team members must follow all measures and rules given in this HS-Plan.

To guarantee the effectiveness of all taken measures all Rooftop team members must attend to his/ her own health and safety. Additionally, all consequences on other people related to own activities and works must be considered by each team member. Machinery and protective equipment have to be executively used for the individual intended usage and in an adequate way. Finally, all noticed risks, dangers and damages have to be notified to the site supervision, in this case the project manager. (ArbSchG)

An additional factor for health and safety of every team member is the compliance to appropriate working and rest phases on working days. According to ArbZeitG parts one and two, the working time a working day consists of 8 hours at a maximum per day. This relates to a reference period of six months or 24 weeks. If this requirement can be met for the entire period, exceeding working phases of at a maximum 10 hours are allowed. However, employees must not work more than six hours without a break. Following break times have to be considered:

working time	breaktime (minimum)
h	**min**
6-9	30
<9	45
separable in parts of 15min each	

Between each shift, every team member must have the possibility to take continuously rest for 11 hours at a minimum.

10.13. MACHINERY AND AUXILIARY RESOURCES

If given by the manufacturers the manuals of all machines and auxiliary resources on how to work safe on procedures involving those, will be provided.

The data sheets of the convector fluid for the solar thermal design can be seen in appendix 4 of the HS plan.

10.14. PLANNED MEASURES IN CASE OF ACCIDENT

10.14.1 FIRST AID

Firstly, a first aid centre will be provided by the Project Owner with the start of the prototype buildi-up. Secondly, the Project Supervisor / Project Owner hast to outfit the construction site with a permanent means of communication, specifically from offices which will allow personnel to call for outside emergency services in case of accident, fire or a pollution incident. [General Coordination Plan]

To guarantee fast help in cases of emergency, first aid equipment will be placed on site. At a minimum a first aid provision consists of a first aids bag, a full-edged first aider, a survival blanket and information about first aid arrangements for not trained persons to enable them to help anyway.

During construction phases, at least one first aider per subteam will be present, in total two first aiders per shift. Each team member concerned, in total eight members at a minimum, will complete a course on occupational first aid until at least may 2014. The latest refresh for team members, who already completed such a course, must not date back more than one year. Every first aider will be easily identifiable by a badge on the helmet. The list of all first aiders will be displayed in the staff work offices. The following taem members have completed the course (certificates (see section 10.27) appendix 6):

- Katharina Haucke
- Arno Reimann
- Lucas Westermann
- Altunay Koc
- Christian Wengert
- Saskia Ehlers
- Birger Steffe
- Jenny Loebel

In cases of emergency or accidents, the instruction on the emergency evacuation plans has to be followed (see section 10.23.1) . These plans will be provided in the living room and the sleeping room. During construction, every worker will cary a copy of the emergency evacuation plan for the construction phases with him/her (see section 10.23.3) . Furthermore, the emergency evacuation plans will show the shortest way to the medical centre of the SDE site.

In addition to the emergency evacuatin plans, every team member has to note and follow the instructions of the "General Instructions in Case of an Accident" and of the "General Instruction in Case of Fire" provided by

SDE Organization in the General Coordination Plan (see appendices 3 and 4).

An emergency telephone and a list with all emergency phone numbers (fire departement, ambluance, police, SDE contacts) will be placed inside, marked by the related sign, to enable every person in the house to call help in cases of emergency. The most important phone numbers are:

- Call from a land line Dial: 18
- Call from a mobile phone Dial: 112

In case of a serious accident the following instancec have to be called immediately:

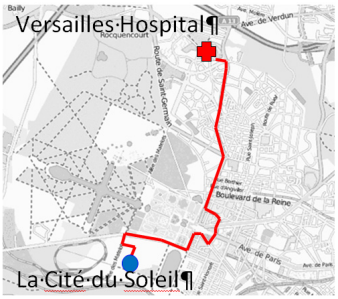
- The HSE coordinator
- The representative of the Project Owner
- The Project Supervisor
- The SPS Coordinator

Also the following entities have to be informed quickly: French Labour Inspection, PPBBPW, RPFWH.

For each call, someone must be designated to proceed to the meeting first aiders point

and wait for the firemen and then lead them to the place of accident.

The nearest hospital is the Versailles Hospital (177, rue de Versailles; 78157 LE CHESNAY):



To avoid repetition of accidents or occuring of accidents caused by known risks, all accidents, incidents, near accidents and dangerous situations have to be analysed and described. This must lead to safety measures to avoid any further similar accidents or situations.

10.14.2 FIRST AID KIT

The first aids bags has to be placed in an easy accessible way and near to all places of greater working risks. Furthermore the location of the bags shall protect against humidity, particles and high temperatures. There has to be an adequate amount of bags, which have to be actualized and restocked in time. [BT-INFOBLATT 2011]

On building sites, according to DIN 13157, one first aids bag of size C has to be placed in case of maximum 10 possibly insured persons. Furthermore, for each, 11 to 50 and every additional 50 insured persons, one bag of size E has do be added [DIN 13169].

DIN 13157 and DIN 13169 define the content of first-aid bags as follows:

nr	notation	DIN 13157	DIN 13169
1	wrapped sterile plasters (55cm × 2,5cm)	1	2
2	dressing (10cm × 6cm), w wrapped dustproof	8	16
3	fingertip dressing, wrapped dustproof	4	8
4	finger dressing (12cm × 12cm) wrapped dustproof	4	8
5	precut plasters (min. size 1,9cm × 7,2cm) wrapped dustproof	4	8
6	precut plasters (1,9cm × 7,2cm) wrapped dustproof	8	16
7	first aids dressing (300cm × 6cm) with compress (6cm × 8cm), wrapped sterile	1	2
8	first aids dressing (400cm × 8cm) with compress (12cm × 8cm), wrapped sterile	3	6
9	first aids dressing (400cm × 10cm) with compress (12cm × 10cm), wrapped sterile	1	2
10	sterile gauze	1	2
11	compress (10cm × 10cm), max. 2 in one sterile package	5	12
12	eye compress (5cm × 7cm), weight 1,5g/piece, separate sterile packages	2	4
13	cooling compress (min. 200cm²) without pre-cooling	1	2
14	rescue blanket (min. 210cm × 160cm), min. film thickness 12 , permanent metalized polyester film or material of similar properties (reflection, stability of temperature), seamless, evaporated with aluminum, backside coloured, wrapped dustproof	1	2
15	elastic bandage (400cm × 6cm), wrapped separately, dustproof	2	4
16	elastic bandage (400cm × 8cm), wrapped separately, dustproof	2	4
17	triangular shawl (96cm × 96cm × 136cm), wrapped separately, dustproof	2	4
18	first aids scissors (min. 18cm length), bent, stainless	1	1
19	non-woven fabric shawl (min. 20cm × 30cm), mass per area min. 15g/m²	5	10
20	foil bag (min. 30cm × 40cm) min. film thickness 45 , lockable, consisting of polyethylene	2	4
21	disposable gloves, seamless, large, wrapped dustproof	4	8

22	first aids brochure consisting at a minimum of "Instructions of First Aid"	1	1
23	contents	1	1

10.14.3 PREVENTIVE MEDICINES

The protection against solar radiation must not be underestimated. As preventive measures following requirements have to be met by every team member on site:

- wearing sun glasses made of safety glass when working outdoor (daylight hours)
- using sun block with minimum solar protection factor 20

One liter of sterile water or normal saline (0,9%) in sealed, disposable containers will be provided, if the tap water is not yet available for eye irrigation. If once unsealed or the expiry date is exceeded the containers must not be (re)used.

Generally, giving oral medicines does not belong to first-aid measures. Only exceptions is the utilization of aspirin in cases of suspected heart attacks in accordance with currently accepted first-aid practice. Tablets and medicines must not be kept inside first-aid bags.

10.14.4 ACCIDENT VICTIMS EVACUATION

First of all, necessary emergency procedures take priority over the requirements of this document. If such procedures have to be performed, e.g. in cases of injury or accidents, the measures have to be taken immediately. The phone number called for emergency response in Paris is 112.

In addition, the Site Operations Coordinator, the Site Safety Officer and the Health and Safety Coordinator must be notified without delay. They will investigate the site conditions to evaluate and determine the cause of the incident, and the precautions that will be implemented to prevent a reoccurrence.

If an emergency occurs, such as fire, accident, medical emergencies or other hazards, the personnel will be directed to evacuate the building, leading to a safe refuge location, to support necessary emergency procedures. The evacuation will only be determined if the risk is controlled and the building officially reopened for further working processes.

Additionally, the site personnel has to beware that their work does not obstruct emergency exits and that their working areas have to be neat, clean and safe. In cases of transportation of persons to a hospital or doctor, a copy of this document has to accompany them.

10.15. RISKS IDENTIFICATION FOR POSSIBLE LATER WORKS – DESCRIPTION AND PREVENTION

The thermal envelope and the building equipment and appliances must be regularly checked for proper function. Because the maintenance work associated potential risks must be taken protective measures.

- All electrical systems and building technology demand the conduct of maintenance. The risk of an electric shock, material or device damage can be minimized by the requirement of the employment of authorized personnel only.
- The solar systems as well as all architectural elements have to be cleaned and conducted several times during the competition. Therefore results a risk of falling because of slippery surfaces which can be prevented by signposting appropriately.
- The reconstruction has to fulfil carefully to minimize the risk of damage of the outer building envelope so that no water can penetrate into insulation. Authorized personnel should perform the reconstruction.
- Windows: Security relevant fitting parts should be regularly checked for tightness and check for wear. Depending on requirements, the fixing screws should be tightened or replaced. In addition, perform the following maintenance annually:
- All moving parts and all locking points of the tilt and turn window must be greased. Cleaning and maintenance equipment must be coordinated with the window material, Damage of material or persons can be reduced by leaving the maintenance to skilled persons.
- Decentralised ventilation system: regular and proper maintenance. Once a year the filters of the supply and exhaust air should be replaced and grids of the air inlet and outlet should be cleaned. The heat exchanger has to be cleaned every 5 years and the ventilation duct system every 10 years because of hygienic reasons. The maintenance and cleaning should carry out by trained personnel to reduce the risk of material damage or of injury to persons.
- Heating system: Maintenance of the heat pump by trained personnel annually, checking the operation of all mechanical parts, checking the fluid circuit for leaks. The maintenance minimizes the risk of major damage and prolongs the lifetime of the heat pump.
- Underfloor heating: After setting up the implementation of a hydraulic balancing should be done. After 10 years of service the pipes have to be flushed to remove disposals and the functional review of the distribution, valves and

pumps should be executed. Material or personal damage can be minimized by the requirement of the employment of authorized personnel only.

10.16. USEFUL PLANS AND INFORMATION FOR LATER WORKS

The plans

- BA-011
- IN-051
- ST-401
- PL-001, PL-002, PL-011, PL-021, PL-101
- ME-021, ME-031, ME-041, ME-101, ME-102, ME-103, ME-201, ME-221, ME-222
- EL-001, EL-201, EL-301, EL-501, EL-601
- PV-001, PV-011, PV-012, PV-013, PV-021, PV-031
- BAS-001, BAS-101, BAS-201

provide the base of the operation and maintenance of the Rooftop House. All user manuals, installation manuals and additional information provided by the manufacturers will be placed inside the core module.

In detail this includes the information provision of:

- heat pump
- storage tank
- electrical systems: circuirity, fuses, PV modules, solar thermal
- sanitary systems: circulation
- folding façade
- flass façade
- kitchen equipment: oven, dishwasher, freezer, fridge
- fire extinguisher, CO2 extinguisher, smoke detectors

As the maintenance of the technical systems has to be executed in different intervals, the following table shows the periods, that have to be met.

equipment	manufacturer	maintenance interval	endurance/ exchange time after
heat pump, storage tank	Stiebel Eltron	anual (incl. compression test)	ca. 20-25 years
underfloor heating and supporting machinery	Uponor	anual (incl. process and control systems)	ca. 20 years
PCM and supporting machinery	Lehmorange	anual (incl. process and control systems)	-

PV modules and supporting machinery	augusta solar	anual or if polluted heavily	ca. 20-30 years
soler thermal and supporting machinery	augusta solar	anual or if polluted heavily	ca. 20-30 years
circulation and supporting machinery	Geberit	anual	5-10 years (circulation pump)
oven	Miele	no requirements because (residental building)	15 years
dishwasher	Miele	no requirements because (residental building)	15 years
freezer	Miele	no requirements because (residental building)	10 years
fridge	Miele	no requirements because (residental building)	10 years
fire extinguisher	e.g. Jockel/ Gloria	every 10 years (compression test)	20 years
CO2 extinguisher	e.g. Gloria/ Hildebrandt	every 10 years (compression test)	25 years
smoke detector	e.g. Siterwell/ Abus/ Bavaria	anual, battery change if necessary	8 years (acc. to DIN EN 14675)
folding façade		anual	ca. 25 years
glass façade	Schüco	anual	50 years

10.17. ADOPTED SYSTEM FOR THE LEVEL OF HEALTH AND SAFETY CONTROL DURING WORKS

As supervision of the building site the health and safety organizations tasks will be parted to the responsibility of several persons:

The overall authority and responsibility is taken by the *Project Manager* (PM) for all site operations, including safety. He will provide the site supervisor with work plans, staff and budgetary resources.

Due to the provided work plans the *Site Operations Coordinator* is responsible for direct work instructions. PM and Site Operations Coordinators tasks can be conducted by the same person on site.

Observing the teams' site activities the *Site Safety Officer* supervises on site.

The Health and Safety Plan is enforced by the *Health and Safety Coordinator* (HS Coordinator) on purpose to take charge of first aids arrangements. His/ Her responsibilities include actualizing the first aids equipment and facilities as well as calling required emergency services. Additionally, providing emergency cover can extend this tasks. At a minimum four persons will support the HS Coordinator.

The appointed HS Coordinator of Team Rooftop is Katharina Haucke (contact data see section 10.2). As supporting Health and Safety Officers following persons have been chosen:

- Claudia Wengierek
- Arno Reimann
- Simon Madlener
- Jonas Eimermacher
- Felix Gabler

The German law extends this requirements. According to UVV BGV A1, if more than 20 employees are working on the workspace, at a minimum 10% of all attendees have to be first aider. Therefore, the supporting team of the HSC will be additionally educated to first aiders by an authorized physician.

To meet the special requirements of fire protection the Fire Watch Captain is responsible for the safety regarding fire emergencies and risks.

All persons in charge have to meet the requirements of the HS-Plan.

10.17.1 HEALTH AND SAFETY COORDINATOR

The Project Manager has to appoint the Health and Safety Coordinator. According to §4 ArbSchG, the tasks of the HS Coordinator have to meet these requirements and extend to planning to inclusively the execution

of the building project.

During the planning phase, this relates to the creation of the HS-plan.

During the construction phase, the HS Coordinator has to supervise the orderly execution of the working processes. Whenever significant changes in the process or the choice of method and equipment was made, the HS plan needs to be adjusted. All information relating to health and safety on site have to be provided in an understandable and accessible way to each team member. A copy of the relevant documents must be deposited on site. Finally, All proposed measures must be coordinated and presented in a combined and optimized way (HS Plan).

Furthermore, all necessary information for operation, maintenance and repair have to be provided. Therefore, documents for subsequent later works at the building or structure will be created. Firstly, these are prerequisites to secure health and safety protection during operation. Secondly, this documents list all areas, which have to be inspected, maintained and repaired, including the definition of appropriate methods or measures and time intervals.

10.18. FORMATION AND INFORMATION ABOUT HEALTH AND SAFETY

All workers of the team will provide the following documents:

- copy of passport
- statement/ document about blood group, tetanus vaccine, information about allergies, important regular medication and other medical specialties (see HS Specific Terms and Conditions Document - medical examination)
- approval of having read and understood the HS-Plan (see HS Specific Terms and Conditions Document)
- declaration of passing specific medical examination for the individual working place and of passing education for working safely on construction site (see HS Specific Terms and Conditions Document)
- certificate for operational safety of rotating machinery
- first aid course certificate (e.g. drivers license, copy of course certificate)

During the assembly and disassembly phases, a documentation will be established and maintained that will record, at a minimum, the following information:

- personnel on site
- personnel's arrival
- personnel's departure
- personnel's working place on site

Incidents will be reported in writing by the Health & Safety Coordinator or appointed persons.

10.19. EMERGENCY EVACUATION PLAN DURING THE ASSEMBLY AND DISASSEMBLY PERIODS

- see appendix 2 (10.22.3)

10.20. FIRE SAFETY

10.20.1 REQUIREMENTS

As the later use of the Rooftop House will be in Berlin, the requirements of fire safety have to meet German Standards, which include the European requirements. The following building codes and norms have to be considered:

- BauOBln: Bauordnung Berlin (Building Code Berlin)
- LAR (guidline for wiring systems)
- LüAR (guidline for ventilation systems)
- " Richtlinie über Flächen für die Feuerwehr" (guidline for areas of fire service)
- DIN 4066: indicating labels for fire service
- DIN 4102: reaction to fire of building materials and modules
- DIN EN ISO 7010: graphic symbols - safety colours and safety signs
- DIN ISO 23601: safety signs - emergency and evacuation plans
- DIN 14 096: fire protection code
- DIN 18 065: stairs inside buildings
- DIN EN 3: portable fire extinguishers
- DIn EN 62305-3, DVE 0185-305-3: lightning protectino systems

BUILDING CHARACTER AND OCCUPANCY

In Versailles the Rooftop House will be build freestanding, surrounded by, at a minimum of 5m distance, the buildings of other teams. Considering the planned rebuild in Berlin as replacement of an existing roof and referring to the BauOB, the Rooftop House can be assigned to building class 5, which means in detail, that following requirements are fulfiled:

- building hight (from ground to top of the last floor of the highest habitable rooms) >13m
- building hight < 22m
- building used as residental building

Because of the small size of the building (<75m²), the whole building can be defined as one fire zone. Therefore, no further seperation of fire zones inside the building is needed.

10.20.2 STRUCTURAL FIRE PROTECTION

COMPARTMENT WALL

According to §30 (3) BlnO, a fire resisting wall will be needed as building closure against other residental buildings. Therefore, models of compartment walls on both sides of the building will be constructed on site in Versailles. More details, see architectural drawings, such as the footprint.

In Berlin, the compartment walls have to be constructed flame resistant even with additional mechanical loads and have to consist of noncumbustable materials (class: (R)EI 90-M). Further constructural requirments have to be planned individually for the existing building and in accordance with the building owner as well as an authorized expert on fire protection.

SEPARATING WALLS & OPENINGS

There will be ohnly one seperating wall in the Rooftop House: the wall to the stairwell. Because the building will be an attic floor with no possible habitable rooms above, the separating walls only have to meet the requirment to be fire-retardant, which means (R)EI 30. (§29(3) BauOBln)

Additionally the opening inside the separating wall, the door to the stairwell, must not decrease the fire resistant of the separating wall. The door has to be fire-retardant, sealed and selfclosing. (§29(4) BauOBln)

ESCAPE ROUTES

A necessary floor is not needed, because the Rooftop House is a residental building of less than 200m². (§36(1) BauOBln)

The necessary staircase in the existing building in Berlin can be assumed as compatable to the BauOBln. In Versailles, the staircase will be modeled exemplarily.

As First Escape Route, the necessary staircase will be used. In Versailles, this route also will be chosen. According to §35(2) BauOBln, the path from the most disadvantageous location inside the house, must not be longer than 35m. This requirement can be met from every location of the building. More details, especially the route and the signposting of the escape routes, can be seen in the Emergency Evacuation Plans (see section 10.23) , which will be provided in the living room and in the sleeping room.

In Berlin a Second Escape Rout will be necessary. This route will be realized using live-saving equipment of the fire department, such as aerial rescue vehicle or aerial ladders. Additionally, the firefighter accessibility and passage must be guaranteed. Therefore, the existing building has to be chosen in accordance to the requirements of BauOBln.

LOAD AND SUPPORTING WALLS AND BEAMS

The bearing structure dos not have to meet special requirements, because the Rooftop House is planned as

attic floor with no possible habitable rooms above (§27 BauOBln). In accordance with SDE rules 51.3, the bearing structure meets REI 30 requirements. More details see section 5.3.1 in PM.

EXTERIOR WALLS

Nonbearing exterior walls have to consist of at a minimum normally inflammable materials, if these walls provide a fire restistance of at a minimum 30min (§§27,28 (2) BauOBln). According to DIN 4102-4, the planned construction of the solid walls (= exterior walls) provide this fire resistance.

COVERING

If a hard covering is used as a protection against flying sparks and heat radiation, which is achieved by the choice of the trapezoidal sheet (steel), no other for the Rooftop House relevant requirements have to be met (§32 (1) BlnO).

CEILING

The ceiling dos not have to meet special requirements, because the Rooftop House is planned as attic floor with no possible habitable rooms above (§32 (1),(2) BauOBln). In accordance with SDE rules 51.3, the bearing structure meets REI 30 requirements. More details see section 5.3.1 in PM.

In contrast, the floor, wich is the ceiling to the story below, has to provide noncombustable materials and a fire resistance of 90 min. Hence, the building, on which the Rooftop House could be build, is yet unknown. Because of this, it can be assumed, that a belated improvement of the fire resistance by providing an EI90 ceiling, will be constructed before installing the Rooftop House. The SDE requirement of 30 min fire resistance can be met. See more details in section 5.3.2 PM.

INSTALLATIONS

There are no for the rooftoop house relevant requirements in BauOBln relating to the materials of ventilation ducts, plumbing pipes and cable ducts as well as insulation of those systems, because the Rooftop House is a residental building.

Nevertheless, the wiring, piping and line routes. are regulated. Ventilation ducts may not be led to exaust systems, but directly to the outer air. Pipes may only be led throug necessary staircases, escape routes and the exit if the usage of the escape route is secured long enough for rescue.

The systems for lightning protection and the protection of the PV system are linked. The PV inverter can be separated from the grid and the batteries by a contactor by manually actuating the emergency stop. According to SDE rule 51.7 , all DC cables, which connect the PV systems with the inverters, will be installed inside fire prevention drains, E30 I90.

ADDITIONAL FIRE PROTECTION SYSTEMS

Th BauOBln does not instruct to take active fire protection measures inside residential buildings of sizes as of the Rooftop House. Nevertheless, it advises insistently to install fire protection systems. Therefore, and according to the SDE rules, additional fire protection systems will be installed.

According to SDE rules 51.3 (3), three smoke detectors will be installed: at the ceiling of the living room, the sleeping room and the technical room.

Two fire extinguishers will be placed, one inside the house (core module) and one outside (terrace, at wall of staircase). A CO2 extinguisher will be placed next to the technical unit, in detail next to one the doors to the technical room. Additionally, an emergency phone and a fire blanket will be mounted in the living room. All fire fighting equipment will be transported by the first truck to the site.

In Berlin, the allocation of the water for fire fighting have to be considered according to BauOBln too. Because the Rooftop House will be installed on an existing building, it can be assuemd that an access to water for fire fighting is already existing.

All planned fire protection system, exept the smoke detectors, are drawn in the Emergency Evacuation Plans (see appendix 2 of HS Plan).

10.20.3 ORGANISATIONAL FIRE PROTECTION

The prerequisites for a safe operation of the house are created by the construction and installations, if executed correctly. The Fire Watch Captain therefore thas to supervise the correct execution of the planned fire safety measures.

At all times and all places on the construction site and later on the Rooftop House area smoking and open fires are prohibited. Signposting and instructions by the team members will implement this adjustment.

To additionally guarantee a safe and smooth operation, the members of Team Rooftop will be instructed on the right behavior in cases of fire emergencies. Two versions of the Emergency Evaluation Plan will be placed on respectively one wall in the living and in the sleeping room, so that visitors can be instructed correctly.

10.21. SPECIFIC TERMS AND CONDITIONS DOCUMENT

10.21.1 RISK AVOIDANCE

Each member of Team Rooftop declares the aim to avoiding or minimizing risks arising during work processes as well as doing as much as possible to achieve this aim.

See also document10.21.5 "Terms and Conditions of the Safety Plans" below.

10.21.2 HEALTH AND SAFETY DEMANDS

Each member of Team Rooftop agrees with the contents of the HS plan and declares compliance with the measurements and behavioral codes for the construction phases in Versailles, aiming at minimizing the risks caused by work process on site as well as on the approach and departure paths.

See also document 7 "Terms and Conditions of the Safety Plans" below.

10.21.3 SPECIFICATION OF COLLECTIVE PROTECTIONS

The collective protections include all sign posting, bordering and scaffolding used on site. For more details relating to position and execution see Health and Safety Drawings.

All signs are produced as plastic fabrics and will be assembled using screws.

The site will be bordered using a barrier tape, which will be fixed on wooden or metal bars.

The scaffolding used (for more technical details see Site Operations Plan) will be placed on the long side of the rooftop house. On the roof barriers will be installed to prevent the workers from passing out of the area protected by the scaffolding. The scaffolding applies to the standards of EN 384 to 363.

10.21.4 SPECIFICATION OF INDIVIDUAL PROTECTIONS

The individual protections include safety shoes, glasses, helmets as well as, if necessary, gloves protective respirators and earmuffs. All used products apply to the standards of

- EN 140, EN 149, EN 166
- EN 352, EN 369, EN 388, EN 397 and
- EN 420

10.21.5 MEDICAL EXAMINATION, LEGAL AGE

All team members (see table below) will have passed the medical examination until the 10th of June, which declares that all members are capable of execution their work on site. Furthermore, all members are of legal age (see column 2).

Team Member (last name, first name)	Date of Birth (day.month.year)
Caldera, Upeksha	13.08.1988
Ehlers, Saskia	
Eimermacher, Jonas	26.09.1984
Fetten, Sophie	
Fritsch-Seerhausen, Bertram Freiherr von	07.10.1986
Gabler, Felix	30.10.1987
Gaetani, Isabella	18.05.1988
Graf, Frieder	
Gülle, Kim	18.04.1991
Haucke, Katharina	22.12.1989
Haupt Raphael	19.12.1991
Hempel, Philipp	20.08.1987
Jänicke, Alessandro	02.06.1986
Jendges, Rebecca	
JulianEric, Christian	29.04.1990
Kafemann, Pit	25.01.1987
Kaippallil, Ben	
Kamlah, Nils	29.03.1993
Koc, Altunay	16.05.1989
Loebel, Jenny	22.06.1988
Madlener, Simon	25.07.1992
Makris, Ruben	
Maysuk, Anna	
Mühlbacher, Stefanie	
Reimann, Arno	01.09.1989
Sadri, Hamed	13.04.1983
Steffe, Birger	15.05.1989
Teubner, Janine	15.05.1988
Tsavolakis, Marinos	29.02.1988
Ullbrich, Philippe	05.06.1987
Wengert, Christian	04.04.1990
Wengierek, Claudia	06.03.1989
Westermann, Lucas	11.09.1991
Zimmermann, Luise von	

Copies of the certificates can be (see 10.28) appendix 7.

10.21.6 SPECIFIC TRAINING

The following team members (see table below) have received the specific training to assemble and disassemble the house:

Team Member (last name, first name)	Type of license
Fritsch-Seerhausen, Bertram Freiherr von	drivers license for pallet transporter, drivers license for indoor cranes
Gabler, Felix	drivers license for pallet transporter, drivers license for indoor cranes
Madlener, Simon	drivers license for indoor cranes

10.22. APPENDIX 1 – RISK ASSESSMENT CHARTS

LEGEND

P	probability	
A	frequent	≥ once per month
B	occational	≥ once per year; ≤ once per month
C	rare	≥ once per 5 year; ≤ per year
D	improbable	≥ once per 20 year; ≤ per 5 years
E	nearly impossible	≥ once per 100 year; ≤ per 20 years
M	measure of damages	
I	very high	death
II	high	severe permanent health damage
III	medium	slight permanent health damage
IV	small	curable health damage without absence from work
V	minor	curable health damage with absence from work
	Determined Precaution	
CP	collective protection measure	
PI	individual protection measure	
PP	preventive procedures	
S	signposting	

	V	IV	III	II	I
A					
B					
C					
D					
E					

Z	zone
1	great rist
2	medium risk
3	high risk

Short Cut	Description
a	assembly
c	competition
d	disassembly
B	Berlin
V	Versailles

10.22.1 IDENTIFICATION OF RISKS AND EVALUATION OF THE EFFICIENCY OF THE ADOPTED PROTECTIONS

Phase: assembly/ disassembly Work Process: transport (a+e; V, B) Working equipment used: transportation vehicles															
risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	2	-
Fall of persons at the same level	falling	IV	E	3					IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3					IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3					IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3					IV	E	3	-
Stepping on objects	falling	V	E	3					V	E	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	D	2	-
Colliding with objects in motion	beeing knocked by collisions	III	D	3					III	D	3	-
Knocked by objects or tools	beeing knocked by objects/tools	II	E	2		x			II	E	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3					III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1		x			II	D	2	-
Trapped by or between objects	beeing trapped	III	E	3					III	E	3	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2		x			II	D	2	-
Overexertion	working too long/ hard	IV	E	3					IV	E	3	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	D	2		x			IV	D	2	-
Thermal contact	getting burned	III	D	2		x			III	D	2	-
Exposure to electric connections	beeing shocked	III	E	3					III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2				x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2				x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2				x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2				x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2				x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	C	1		x			II	D	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2		x			II	E	2	-
"In itinere"	getting injured during travel	IV	E	3					IV	E	3	-

Risk Assessment													
Phase: assembly/ disassembly **Work Process: unloading/ loading (a+e; V, B)** **Working equipment used: transportation vehicles, cranes**													
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	III	C	2		x			III	D	2	-
Fall of persons at the same level	falling	IV	C	2		x			IV	D	2	-
Fall of objects because of collapse	beeing knocked by falling objects	III	B	1			x		III	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	III	B	1			x		III	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	III	B	1			x		III	E	3	-
Stepping on objects	falling	V	C	3		x			V	D	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	D	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	D	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	C	2		x			III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	C	2		x			III	E	3	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2		x			IV	E	3	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	C	2		x			IV	D	3	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment

Phase: assembly/ disassembly
Work Process: installation of footings
Working equipment used:

risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	2		x			III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	D	2	-
Overexertion	working too long/ hard	IV	C	3		x			IV	D	2	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	C	3					IV	D	2	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	C	1			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment

Phase: assambly/ disassambly
Description of activities: -
Work Process: installation of floor modules
Working equipment used:
Materials used: prebuild module

risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	2	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	D	2	-
Overexertion	working too long/ hard	IV	C	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	C	2			x		IV	D	2	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment

Phase: assambly/ disassambly
Description of activities: -
Work Process: installation of the core module
Working equipment used:
Materials used: prebuild module

risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	2	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	D	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	C	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	D	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	E	3			x		IV	D	2	-
Thermal contact	getting burned	III	D	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	D	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment

Phase: assambly/ disassambly
Work Process: installation of the carrying structure
Materials used: wooden beams

risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	III	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	2	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	D	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	D	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	C	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-
Thermal contact	getting burned	III	E	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment														
Phase: assambly/ disassambly **Work Process: installation of the ceiling and roof** **Materials used: prebuild modules**														
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	III	C	2	x	x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	2	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	D	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	D	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	C	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	C	2			x		IV	E	3	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment													
Phase: assambly/ disassambly **Work Process: installation of the solid walls (e,w,n)** **Materials used: prebuild modules**													
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	III	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	2	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	D	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	D	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	C	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	C	2			x		IV	E	3	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment

Phase: assambly/ disassambly

Work Process: installation of the glass facade (s,n)

Materials used: prebuild modules

risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	III	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	III	D	2			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	III	D	2			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	C	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	C	2			x		IV	E	3	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	III	E	3			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment														
Phase:	**assambly/ disassambly**													
Work Process:	**installation of the folding facade**													
Materials used:	**prebuild modules**													
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks		
		M	P	Z	CP	PI	PP	S	M	P	Z			
Fall of persons at a different level	falling	III	D	3		x			IV	E	3	-		
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-		
Fall of objects because of collapse	beeing knocked by falling objects	III	D	2			x		IV	E	3	-		
Fall of objects because they com loose	beeing knocked by falling objects	III	D	2			x		IV	E	3	-		
Fall of objects because of manipulation	beeing knocked by falling objects	III	E	3			x		IV	E	3	-		
Stepping on objects	falling	V	C	3		x			V	C	3	-		
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-		
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-		
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-		
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-		
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-		
Trapped by or between objects	beeing trapped	III	C	2		x			III	D	2	-		
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-		
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-		
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-		
Thermal contact	getting burned	III	E	2			x	x	III	E	3	-		
Exposure to electric connections	beeing shocked	III	E	2			x	x	III	E	3	-		
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-		
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-		
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-		
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-		
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-		
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-		
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-		

Risk Assessment

Phase: assambly/ disassambly
Work Process: installation of the PV modules
Materials used: wooden beams

risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	D	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	D	2			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	D	2			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	C	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-
Thermal contact	getting burned	III	D	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	D	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

ROOFTOP

Risk Assessment													
Phase: assambly/ disassambly **Work Process: installation of terrace** **Materials used: prebuild module**													
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	D	2	-
Overexertion	working too long/ hard	IV	C	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	C	2			x		IV	D	2	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

ROOFTOP

Risk Assessment													
Phase:	**assambly/ disassambly**												
Work Process:	**installation of pool**												
Materials used:	**prebuild module**												
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	C	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	D	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	D	2			x		II	D	2	-
Overexertion	working too long/ hard	IV	C	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting sunburned/ freezed	IV	C	2			x		IV	D	2	-
Thermal contact	getting burned	III	E	3			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

ROOFTOP

Risk Assessment													
Phase:	**assambly/ disassambly**												
Work Process:	**installations/ disassemble installations**												
Materials used:	**set connections of pipes, cables, ventilation**												
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks	
		M	P	Z	CP	PI	PP	S	M	P	Z		
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-	
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-	
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-	
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-	
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-	
Stepping on objects	falling	V	C	3		x			V	C	3	-	
Colliding with still objects	beeing knocked by collisions	IV	C	2		x			IV	C	2	-	
Colliding with objects in motion	beeing knocked by collisions	III	C	2		x			III	C	2	-	
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-	
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-	
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-	
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-	
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-	
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-	
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-	
Thermal contact	getting burned	III	D	2			x	x	III	E	3	-	
Exposure to electric connections	beeing shocked	III	D	2			x	x	III	E	3	-	
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-	
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-	
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-	
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-	
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-	
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-	
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-	
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-	

ROOFTOP

Risk Assessment														
Phase: assambly/ disassambly **Work Process: place furniture** **Materials used: furniture**														
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	C	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	D	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	C	1			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-
Thermal contact	getting burned	III	E	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment													
Phase: assambly **Work Process: implementation**													
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	D	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	D	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	D	2			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-
Thermal contact	getting burned	III	E	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	D	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment													
Phase: assambly/ disassambly													
Work Process: dispose of waste													
risk	**safety objectiv = prevent persons from:**	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	D	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	D	2		x			III	C	2	-
Knocked by objects or tools	beeing knocked by objects/tools	III	D	2		x			II	D	2	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	D	2			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	D	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-
Thermal contact	getting burned	III	E	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	D	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

Risk Assessment

Phase: competition
Description of activities: diner party
Work Process: building operation

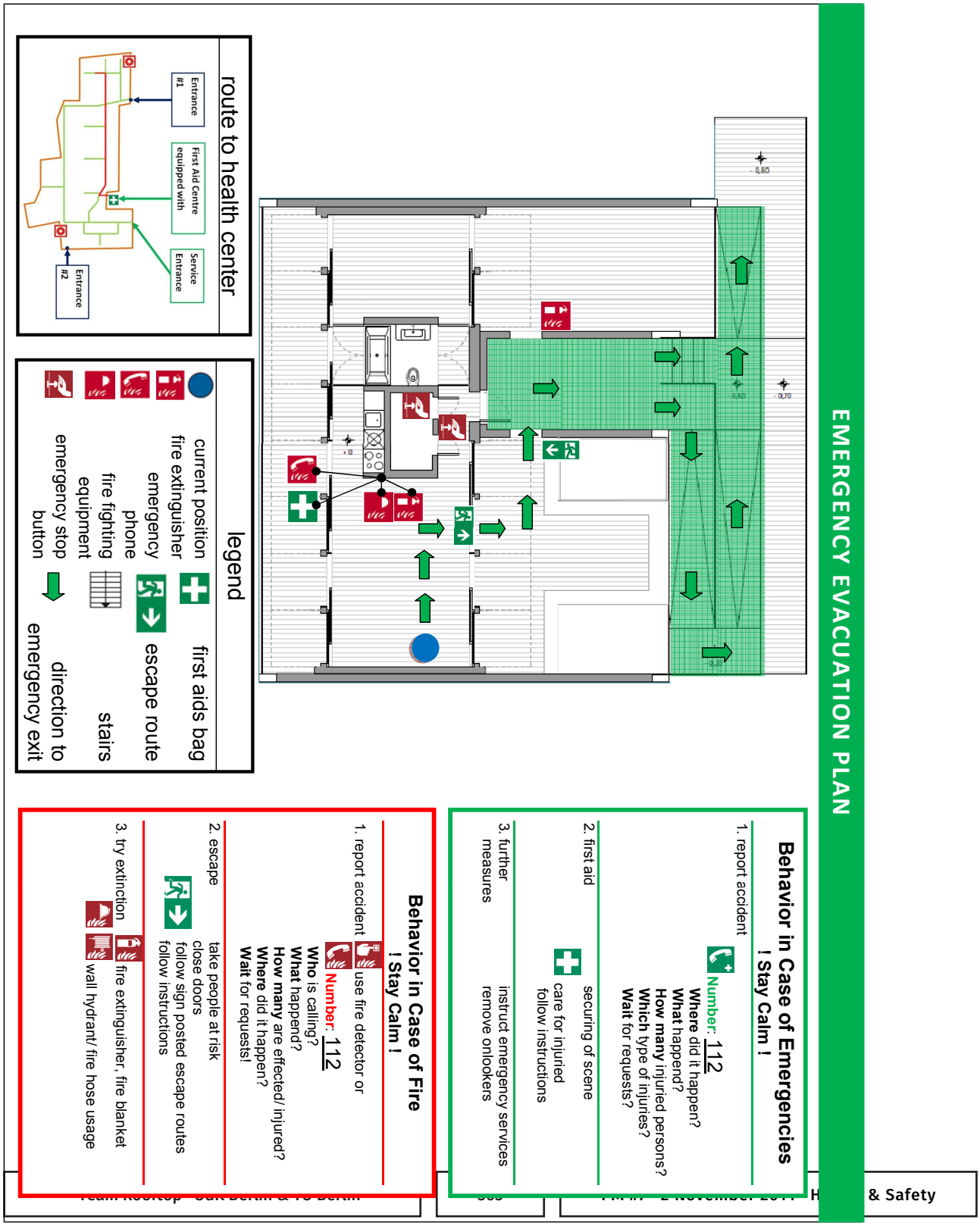
risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3					IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	C	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3					IV	E	3	-
Fall of objects because they come loose	beeing knocked by falling objects	IV	E	3					IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3					IV	E	3	-
Stepping on objects	falling	V	D	3			x		V	D	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	D	2	-
Colliding with objects in motion	beeing knocked by collisions	III	E	3					III	E	3	-
Knocked by objects or tools	beeing knocked by objects/tools	III	E	3					II	E	3	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beeings	II	D	2			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	E	3					III	E	3	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2					II	E	2	-
Overexertion	working too long/ hard	IV	E	2					IV	E	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3					IV	E	3	-
Thermal contact	getting burned	III	E	3				x	III	E	3	-
Exposure to electric connections	beeing shocked	III	E	3				x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2					II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2					II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2					II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2					I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2				x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2					II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2					II	E	2	-
"In itinere"	getting injured during travel	IV	E	3					IV	E	3	-

10.22.2 IDENTIFICATION OF RISKS FOR POSSIBLE LATER WORKS

Risk Assessment																
Phase: maintenance Work Process: maintenance																
risk	safety objectiv = prevent persons from:	risk without measure			determeined precaution				remaining risk with measure			resulting new risks
		M	P	Z	CP	PI	PP	S	M	P	Z	
Fall of persons at a different level	falling	IV	E	3		x			IV	E	3	-
Fall of persons at the same level	falling	IV	C	2		x			IV	E	3	-
Fall of objects because of collapse	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because they com loose	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Fall of objects because of manipulation	beeing knocked by falling objects	IV	E	3			x		IV	E	3	-
Stepping on objects	falling	V	D	3		x			V	C	3	-
Colliding with still objects	beeing knocked by collisions	IV	D	2		x			IV	C	2	-
Colliding with objects in motion	beeing knocked by collisions	III	E	3			x		III	E	3	-
Knocked by objects or tools	beeing knocked by objects/tools	III	E	3		x			III	E	3	-
Flying fragments or particles	inhaling harmful particles/fragments	III	E	3			x		III	E	3	-
Accidents caused by living beings	causing accidents involving other living beings	II	D	2			x		II	D	2	-
Trapped by or between objects	beeing trapped	III	E	2		x			III	D	2	-
Trapped by turned over machines, tractors or vehicles	beeing trapped	II	E	2			x		II	E	2	-
Overexertion	working too long/ hard	IV	D	2			x		IV	D	2	-
Exposure to extreme environmental temperatures	getting highly sunburned/ freezed	IV	E	3			x		IV	E	3	-
Thermal contact	getting burned	III	D	2			x	x	III	E	3	-
Exposure to electric connections	beeing shocked	III	D	2			x	x	III	E	3	-
Exposure to radiation	beeing influenced by harmful radiation	II	E	2			x	x	II	E	2	-
Exposure to harmful substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Contact with caustic or corrosive substances	getting into direct contact to such substances	II	E	2			x	x	II	E	2	-
Explosion	beeing in zone of influence of explosion	I	E	2			x	x	I	E	2	-
Fire	beeing in zone of influence of fire	I	E	2			x	x	I	E	2	-
Run over or hit by vehicles	beeing injured by vehicles	II	E	2			x		II	E	2	-
Non traumatic pathologies	beeing injured non traumatic	II	E	2			x		II	E	2	-
"In itinere"	getting injured during travel	IV	E	3			x		IV	E	3	-

10.23. APPENDIX 2: EMERGENCY EVACUATION PLANS

10.23.1 EMERGENCY EVACUATION PLAN – LIVING ROOM



10.23.2 EMERGENCY EVACUATION PLAN – SLEEPING ROOM

EMERGENCY EVACUATION PLAN

Behavior in Case of Emergencies

! Stay Calm !

1. report accident
   Number: 112
   Where did it happen?
   What happend?
   How many injuried persons?
   Which type of injuries?
   Wait for requests?
2. first aid
   securing of scene
   care for injuried
   follow instructions
3. further measures
   instruct emergency services
   remove onlookers

Behavior in Case of Fire

! Stay Calm !

1. report accident
   use fire detector or
   Number: 112
   Who is calling?
   What happend?
   How many are effected/ injured?
   Where did it happen?
   Wait for requests!
2. escape
   take people at risk
   close doors
   follow sign posted escape routes
   follow instructions
3. try extinction
   fire extinguisher, fire blanket
   wall hydrant/ fire hose usage

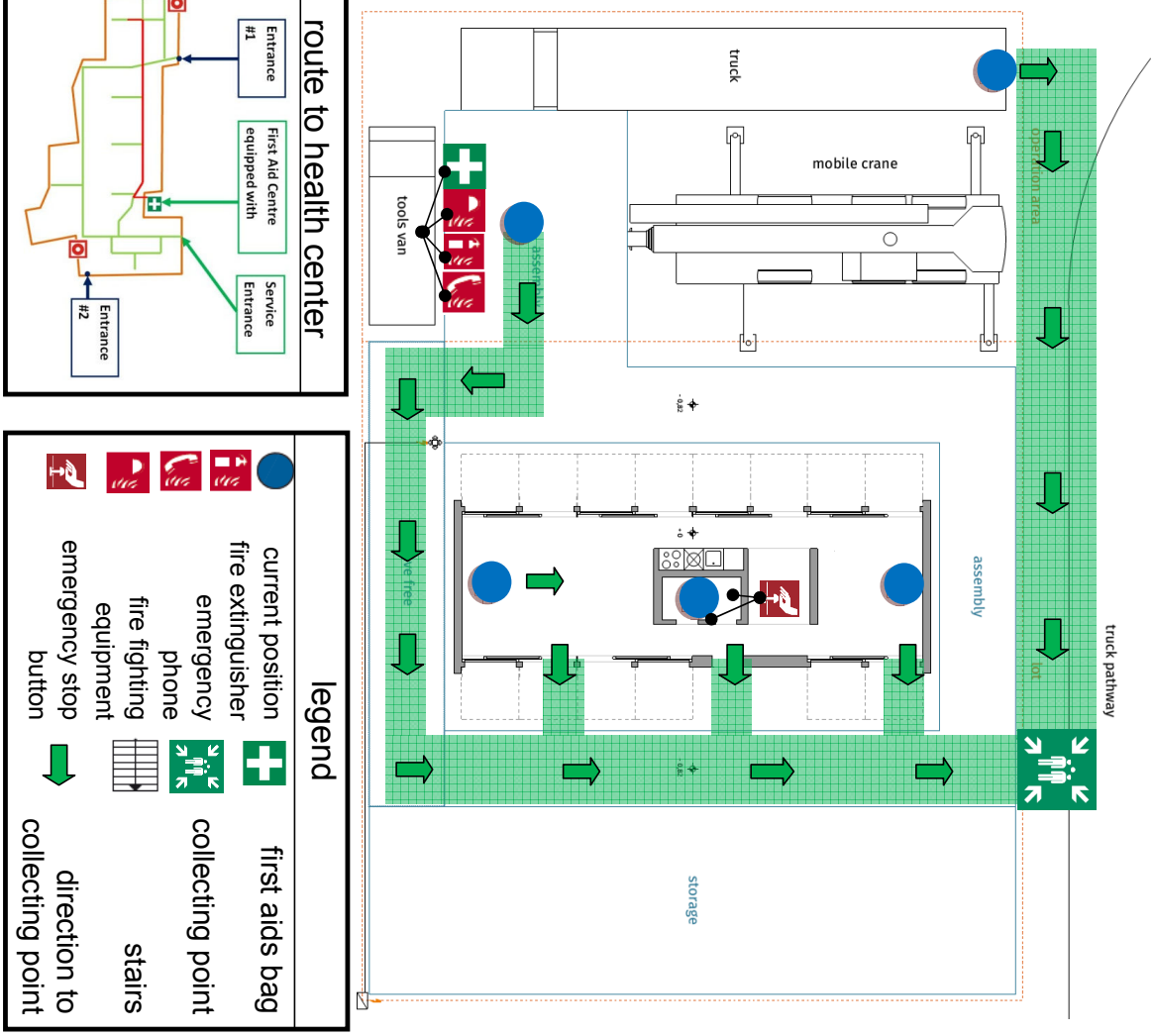
legend

- current position
- first aids bag
- fire extinguisher
- escape route
- emergency phone
- stairs
- fire fighting equipment
- direction to emergency exit
- emergency stop button

route to health center

10.23.3 EMERGENCY EVACUATION PLAN – DIS-/ ASSEMBLY PHASES

EMERGENCY EVACUATION PLAN



route to health center

legend

- current position
- fire extinguisher
- emergency phone
- fire fighting equipment
- emergency stop button
- first aids bag
- collecting point
- stairs
- direction to collecting point

Behavior in Case of Emergencies

! Stay Calm !

1. report accident
   - Number: 112
   - **Where** did it happen?
   - **What** happend?
   - **How many** injuried persons?
   - **Which** type of injuries?
   - **Wait** for requests?
2. first aid
   - securing of scene
   - care for injuried
   - follow instructions
3. further measures
   - instruct emergency services
   - remove onlookers

Behavior in Case of Fire

! Stay Calm !

1. report accident
   - use fire detector or
   - Number: 112
   - **Who** is calling?
   - **What** happend?
   - **How many** are effected/ injured?
   - **Where** did it happen?
   - **Wait** for requests!
2. escape
   - take people at risk
   - close doors
   - follow sign posted escape routes
   - follow instructions
3. try extinction
   - fire extinguisher, fire blanket
   - wall hydrant/ fire hose usage

10.24. APPENDIX 3 - GENERAL INSTRUCTIONS IN CASES OF ACCIDENTS

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CONSIGNE GENERALE CONDUITE A TENIR EN CAS D'ACCIDENT

GENERAL INSTRUCTIONS IN CASE OF ACCIDENT

SOLAR

VERSAILLES
SOLAR DECATHLON
EUROPE 2014

OBJET: Cette consigne définit le processus de gestion d'accident de la prise en compte de la victime jusqu'à l'arrivée des secours

This instruction defines the process for managing an accident and caring for the victim until emergency services arrives

1) OBJET / *SUBJECT* :

Gestion des accidents survenant lors de la compétition. Cette procédure est applicable dès le début des approvisionnements, jusqu'au repli total des prototypes.

Management of accidents during the competition. This document is applicable from the beginning of the supplying until the complete withdrawal of each prototype.

2) CHAMPS D'APPLICATION / *SCOPE* :

Cette consigne s'applique à l'ensemble des participants au SOLAR DECATHLON EUROPE 2014.

These instructions apply to all participants of the SOLAR DECATHLON EUROPE 2014.

3) ANALYSER LA SITUATION / *ANALYSE THE SITUATION* :

Pour un soin mineur, blessure légère (coupure, contusion, ...) ou la victime est capable de se déplacer seule.

La victime devra impérativement être accompagnée au point d'alerte et de premiers secours (de 08h à 20h).

L'accompagnement de la victime sera défini par l'Observateur SDE present sur place.

Le point d'alerte et de premiers secours sera alerté de l'arrivée de la victime par l'Observateur SDE.

Numéro du PAPS : **XX XX XX XX XX**

Numéro d'astreinte SDE2014 : **XX XX XX XX XX**

La blessure est grave et/ou la victime ne peut pas se déplacer : voir les points de 4 à 7.

For minor injuries (cuts, bruises, etc.), when the victim is capable of walking on his/her own :

The victim must be accompanied to the first aid centre (8am – 8pm).

The SDE Observer will define who will go to the medical centre, with the victim.

The SDE Observer will alert by phone, prior to the arrival of the victim.

The first aid centre will be alerted prior to the arrival of the victim, by the SDE Observer.

First aid centre n : **XX XX XX XX XX**

SDE2014 on call service n : : **XX XX XX XX XX**

If the injury is serious and/or the victim is unable to walk on his/her own: see points 4 to 7

4) PROTEGER / *PROTECT* :

En cas d'accident(s), le témoin direct doit avant tout éviter le sur accident.

Se poser des questions sur les circonstances de l'accident afin d'identifier le risque résiduel éventuel (anoxie, risque électrique, chute d'objet, départ de feu...).

Se protéger, protéger (ou faire protéger) les tiers et la victime (consignation électrique, balisage,..).

Ne pas déplacer une victime sauf si danger grave et imminent persistant.

In case of accident(s), the first witness must above all, prevent further accidents.

Analyse the circumstances of the accident in order to identify any residual risks (suffocation, electrical risks, falling objects, fire outbreak, etc.)

Protect yourself, protect (or make them protected) all third parts and the victim (electrical lockout, safety delimitation, etc)

Only move the victim if there is a continuing risk of serious and imminent danger.

5) EXAMINER / *EXAMINE* :

Dans tous les cas, que la personne soit secouriste ou non, ne pas déplacer la victime.

Identifier :

- Si la victime est consciente (en lui parlant)
- Si elle a des saignements apparents
- La nature de la blessure : brulure, plaie, corps étranger, douleur, etc.

Even if the person closed to the accident is a trained first worker, the victim should not be moved.

Identify :

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- *If the victim is conscious (by speaking to him/her),*
- *If there is any visible bleeding,*
- *The type of injury: burn, cut, foreign object, pain, etc.*

6) ALERTER OU FAIRE ALERTER / *RAISE THE ALARM*:

Entre 8h et 20h, victime sur chantier, l'Observateur SDE alerte le point d'alerte et de premier secours.

Les secouristes se déplaceront sur les lieux en fonction de la gravité.

Ils déclencheront l'appel des secours extérieurs (18 ou 112)

En parallèle, ils informeront rapidement l'équipe SDE qui sera chargée de guider les secours extérieurs arrivant par l'entrée 1 ou par l'entrée de service du site.

Un véhicule SDE sera à disposition pour que le personnel SDE guide les secours au plus au proche de l'accident.

Entre 8h et 20h, victime déjà au point d'alerte et de premier secours

Le secouriste déclenchera l'appel des secours extérieurs (18 ou 112)

En parallèle, il informera rapidement l'équipe SDE qui sera chargé de guider les secours extérieurs arrivant par l'entrée du site.

En dehors des heures de présence de l'équipe de secouristes

L'équipe alerte l'Observateur SDE.

L'Observateur SDE fait cesser les travaux et alerte l'équipe SDE.

Le membre le plus proche du SDE formé au secourisme se rend sur place.

Il sera chargé de déclencher l'appel des secours extérieurs (18 ou 112) et de rapporter à l'organisation SDE.

Si nécessaire, il demandera à quelqu'un d'aller chercher le défibrillateur semi-automatique (DSA) disponible au poste de premiers secours.

Le SDE sera chargée de guider les secours extérieurs arrivant par l'entrée 1 ou par l'entrée de service du site.

Dans tous les cas de figure, le message d'alerte à donner par l'équipe SDE sera :

- **Je suis à Versailles, allée des Matelots**
- **Sur le site du SDE2014**
- **On vous guidera vers l'entrée**

- OU SE TROUVE LA VICTIME (SI HORS DU LOT)
- Il y a : NOMBRE DE VICTIMES
- La personne est : L'ETAT DE LA VICTIME (voir paragraphe examen)
- Il s'agit de : LA NATURE ET L'ORIGINE DE L'ACCIDENT
- Il y a : SI LE DANGER EST PERSISTANT
- Et surtout, ne pas raccrocher le premier

Between 8am and 8pm, if the victim is on the worksite, the SDE Observer alert the first aid centre

Depending on the seriousness of the accident, the first aid team will attend the accident on site.

The first-aid worker will call the emergency services (18 or 112)

The first-aid worker will also quickly notify the SDE organization which will be responsible for guiding the emergency services arriving via the entrance number 1 or the service entrance of the site.

A vehicle of SDE Organization will be made available for SDE members in order to guide the emergency services close to the place of the accident.

Between 8am and 8pm, if the victim is already in the first aid centre.

The first-aid worker will call the external emergency services (18 or 112).

The first-aid worker will also quickly notify the SDE organization which will be responsible for guiding the emergency services arriving via the entrance number 1 or the service entrance of the site.

Outside working hours of the first aid team.

The Team alert the SDE Observer.

The SDE Observer stops the work and alert the SDE Organization.

The closest member of the SDE Organization, trained in first-aid, goes on the spot.

He is responsible for calling the emergency services (18 or 112) and report to the SDE Organization.

If needed, he may ask someone around to bring him back the automated external defibrillator (AED) available in the first aid centre.

The SDE Organization is in charge of guiding the emergency service arriving via the entrance number 1 or the service entrance of the site.

7) SECOURIR / *FIRST AID* :

Dans tous les cas, rester près de la victime, la rassurer jusqu'à l'arrivée des secours.

Si vous êtes secouriste appliquez les gestes de premier secours.

In all cases, stay with the victim and reassure him/her until the emergency services arrives.

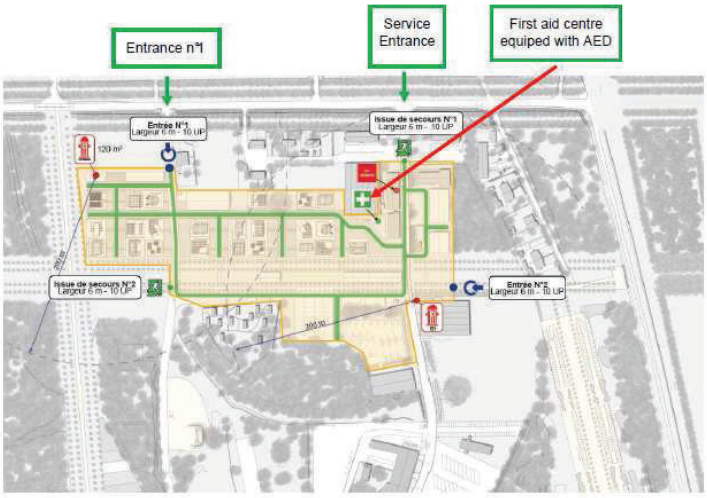
If you are a trained first aid worker, provide the first aid.

7) EXERCICE / *EXERCISE* :

Un exercice pourra être mis en place par l'équipe SDE pour verifier la comprehension et l'intégration des procédures.

An exercise may be set up to by the SDE Organization to train everyone on the procedures.

PLAN DU SITE / *SITE MAP :*



10.25. APPENDIX 4 - GENERAL INSTRUCTIONS IN CASES OF FIRE

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CONSIGNE GENERALE CONDUITE A TENIR EN CAS D'INCENDIE

GENERAL INSTRUCTIONS IN CASE OF FIRE

SOLAR

VERSAILLES
SOLAR DECATHLON
EUROPE 2014

OBJET:	Cette consigne définit la conduite à tenir en cas d'incendie et la gestion de l'évacuation générale du site. *This instruction defines how to respond in case of fire and how to manage the evacuation of the site.*

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1) OBJET / *SUBJECT* :

Conduite à tenir en cas d'incendie et définition des équipiers de première intervention

Fire response procedure and definition of an "emergency response" team.

2) CHAMPS D'APPLICATION / *SCOPE* :

Cette consigne s'applique à l'ensemble des participants au SOLARD DECATHLON 2014.

These instructions apply to all participants of the SOLAR DECATHLON 2014.

3) MESURES DE PREVENTION / *PREVENTION MEASURES* :

Sur l'ensemble du chantier, il est strictement interdit de fumer.

Avant de démarrer un chantier, repérer les lieux de dégagement, les moyens d'extinction à disposition, ainsi que les zones de repli.

Avoir en permanence, les zones de circulation libre d'accès pour les véhicules d'intervention des secours. Pour tout travail nécessitant de bloquer provisoirement une voie d'accès, une demande doit être adressée à l'organisation SDE2014 via l'astreinte téléphonique.

Pour les équipes chargées de réaliser des travaux avec un risque d'incendie :

- **Travaux concernées :** travaux de soudure, meulage, chalumage et tout autre travail générant de la chaleur ou des étincelles.
- **Mesures de sécurité** : mode opératoire et analyse de risques associée..
- **Matériel** : en bon état et conforme, présence d'un extincteur entreprise ABC à proximité du point de feu, mise à la terre des postes à souder et tout autre matériel électrique.
- **Protection collectives et individuelles** : protéger la zone de travaux (bâchage, baliser la zone si co activité,...), protections individuelles adaptées au travail à réaliser.
- **Environnement de chantier** : s'assurer que l'environnement de chantier ne présente pas un facteur aggravant (stockage de solvant, travaux de peinture, trappes d'égouts, niveau inférieur...).
- **Vigilance** : Un piquet incendie formé (cela peut être par exemple, le superviseur HS de l'équipe) assurera la surveillance du risque incendie et pourra intervenir à tout moment. Pendant les 2 heures qui suivent les travaux, une personne désignée (de l'organisation SDE2014 et munie d'un téléphone), à qui sera fournie la liste des points de feu journalier, s'assurera de l'absence de départ de feu en effectuant des tournées sur l'ensemble de ces points.
- **Contrôle** : des audits réguliers seront effectués par l'organisation SDE2014 afin de vérifier la bonne connaissance de cette consigne.

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Des exercices pourront être effectués durant la compétition.

Smoking is strictly prohibited on site.

Before beginning any work, identify emergency evacuation areas, fire extinguishing equipment and all emergency withdrawal areas.

Always ensure that roads are clear in order to make the access easier for the emergency services. For all work requiring closing a road, a request must be submitted to SDE2014 Organization via the on call system.

For teams carrying out work with a fire hazard:

- ***Work concerned**: welding, grinding, blowtorch work, and any other work that may generate heat or sparks.*
- ***Safety measures**: operating procedure and related risk assessment.*
- ***Equipment**: compliant and in good condition, presence of an ABC fire extinguisher near the hot spot, welding stations and all other electrical equipment properly grounded.*
- ***Collective and personal protective equipment**: protect the work area (placement of tarpaulins, cordon off the area if other activities are carried out in the same area, etc.), personal protective equipment adapted to the work in question.*
- ***Worksite environment**: ensure that there are no aggravating factors in the worksite environment (solvent storage, painting, lower level, etc.).*
- ***Vigilance**: A trained fire watch person (this may be the team's Safety Officer) will monitor the fire risk and may intervene at any time. For two hours following the work, a dedicated person of the SDE2014 Organization, equipped with a phone, will conduct patrol rounds to ensure that no fires have started at any of listed points.*
- ***Inspection**: audits will be often carried out by SDE2014 Organization in order to check knowledge of these instructions.*

4) EN CAS DE DEPART DE FEU / *IN CASE OF A FIRE BREAKS OUT* :

Toute personne témoin de la présence d'un foyer incendie, doit immédiatement mettre en œuvre ses propres moyens de lutte en se faisant aider éventuellement par du personnel présent dans le voisinage et/ou en même temps donner l'alerte. Si il s'agit d'un feu d'origine électrique, couper ou faire couper la source et n'utiliser que les extincteurs appropriés

a/ Cas de départ de feu rapidement maitrisé (constat immédiat, faible surface,...)

Utiliser l'extincteur approprié et prévenir l'organisation SDE2014 en indiquant la zone concernée.

L'organisation SDE2014 s'assurera de l'extinction complète et réalisera l'enquête auprès des personnes concernés.

b/ Cas d'un feu plus important et non maitrisable avec les moyens à disposition

Feu à l'intérieur du chantier clos

Prévenir immédiatement l'organisation SDE2014.

L'organisation SDE2014 contactera les secours.

L'organisation SDE2014 se tiendra à disposition pour guider l'arrivée des secours.

Le message d'alerte à donner sera :

NOM DE L'EQUIPE
LA NATURE ET L'ORIGINE DU SINISTRE
LIEU PRECIS OU SE TROUVE LE SINISTRE
NOMBRE DE VICTIMES EVENTUELLEMENT
L'ETAT DE OU DES VICTIMES
LES DANGERS ENVIRONNANTS SUSCEPTIBLE DE GENER L'ACTION DES SECOURS (encombrement, risques électriques, stockage de produits inflammables,...)

Et surtout, ne pas raccrocher le premier.

L'organisation SDE2014 guidera les secours depuis l'entrée 1 du site ou depuis l'entrée de service vers le lieu de l'incident.

Feu en limite du chantier clos

Prévenir immédiatement l'organisation SDE2014.

L'organisation SDE2014 déclenchera l'appel des secours.

Le message d'alerte à donner sera :

NOM DE L'EQUIPE
LA NATURE ET L'ORIGINE DU SINISTRE
LIEU PRECIS OU SE TROUVE LE SINISTRE
NOMBRE DE VICTIMES EVENTUELLEMENT
L'ETAT DE OU DES VICTIMES
LES DANGERS ENVIRONNANTS SUSCEPTIBLE DE GENER L'ACTION DES SECOURS (encombrement, risques électriques, stockage de produits inflammables,...)

Et surtout, ne pas raccrocher le premier.

L'organisation SDE2014 se rendra à l'entrée n°1 ou à l'entrée de service du site pour guider l'arrivée des secours.

Anyone who witnesses the outbreak of a fire must immediately use the available fire-fighting equipment with the assistance of any other staff that may be present in the area. At the same time it will be necessary to raise the alarm. If the fire come from an electrical device or system, shut down the electrical source and only use appropriate extinguishers.

a/ Small manageable fire outbreak (immediately reported, small surface, etc.)

Use the appropriate extinguisher and notify the SDE2014 Organization by indicating the affected area.

The SDE2014 Organization will ensure that the fire is completely extinguished and carry out an investigation with the concerned people.

b/ Larger fire that cannot be controlled with available resources

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Fire within the worksite area

Immediately notify the SDE2014 Organization.

The SDE2014 Organization will call emergency services.

The SDE2014 Organization will remain available to guide the emergency services.

The alert message shall be given as follows:

TEAM NAME
NATURE AND CAUSE OF THE INCIDENT
SPECIFIC LOCATION OF THE INCIDENT
NUMBER OF VICTIMS, IF ANY
CONDITION OF THE VICTIM(S)
SURROUNDING HAZARDS THAT MAY HINDER EMERGENCY OPERATIONS (obstacles, electrical risks, storage of flammable products, etc.)

And above all, do not hang up the telephone first.

The SDE2014 Organization will guide the emergency services from entrance n°1 or from the service entrance to the location of the incident.

Fire at site boundary

Immediately inform the SDE2014 Organization.

The SDE2014 Organization will call emergency services.

The alert message shall be given as follows:

TEAM NAME
NATURE AND CAUSE OF THE INCIDENT
SPECIFIC LOCATION OF THE INCIDENT
NUMBER OF VICTIMS, IF ANY
CONDITION OF THE VICTIM(S)
SURROUNDING HAZARDS THAT MAY HINDER EMERGENCY OPERATIONS (obstacles, electrical risks, storage of flammable products, etc.)

And above all, do not hang up the telephone first.

The SDE2014 Organization will guide the emergency services from entrance n°1 or from the service entrance to the location of the incident.

5) EVACUATION GENERALE DU SITE / *SITE EVACUATION* :

Dès le déclenchement de l'alerte, le personnel évacuera la zone calmement vers les zones de repli après avoir au préalable sécurisé rapidement son poste de travail (couper les compresseurs, fermer les bouteilles de gaz,...).

Les zones de repli sont identifiées par le panneau suivant :



Il faudra arrêter les engins sans encombrer la circulation.

La liste du personnel en charge de l'évacuation est la suivante :

- *A définir par SDE2014*

Ce personnel sera chargé de vérifier que l'ensemble des intervenants aura évacué le chantier vers les zones de repli.

Chaque responsable listera son personnel afin de vérifier qu'il ne manque personne à l'appel. Il sera demandé aux Safety Officers des équipes de vérifier que tous les membres de leurs équipes sont présents. L'ordre de reprise des travaux sera donné par le responsable SDE2014 de la compétition.

Pendant l'alerte, aucune personne ne devra quitter la zone de repli sauf indication de l'organisation SDE2014.

As soon as the alert is given, personnel will calmly evacuate to the emergency areas after quickly making their workstations safe (shut off compressors, close gas cylinders, etc.).

All emergency areas are identified with the following panel :



Stop all machines without blocking traffic.

The list of personnel responsible for evacuation is:

- *list to be defined by SDE2014*

These "Evacuation Officers" will be responsible for checking that all people have evacuated the worksite to the appropriate emergency areas.

Each "Evacuation Officer" list his/her personnel in order to verify that no one is missing. The Teams' Safety Officers will be asked to check that none of their team members are missing. The competition manager will give the order to resume work.

During the alert, nobody will be authorised to leave the emergency area without agreement of the SDE2014 Organization.

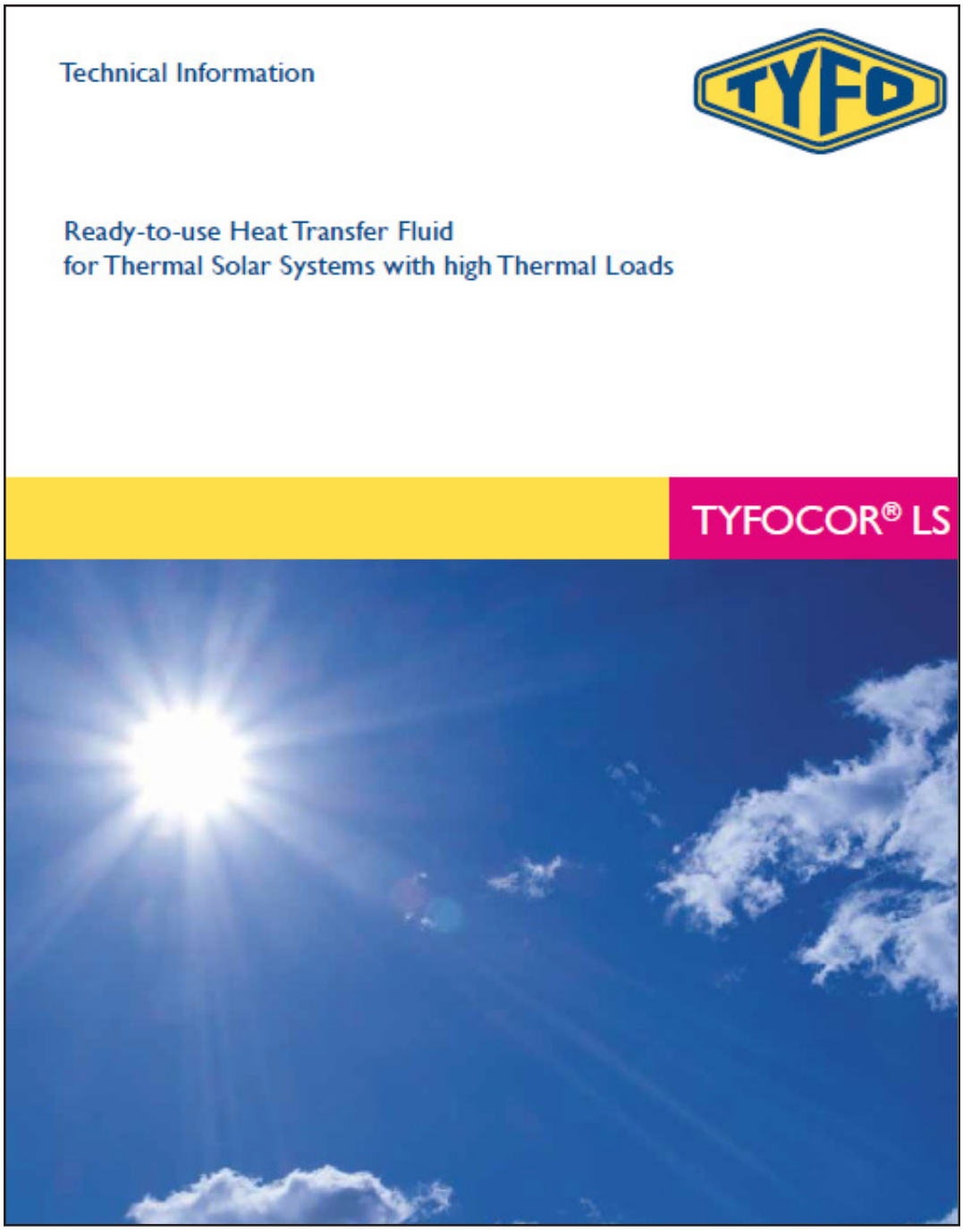


PLAN DU SITE / SITE MAP

Solar Decathlon Europe

10.26. APPENDIX 5 - DATA SHEETS OF POTENTIALLY DANGEROUS MATERIALS/ PRODUCTS

10.26.1 HEAT TRANSFER FLUID



Characteristics of TYFOCOR® LS

Appearance	clear, red-fluorescent liquid	
Boiling point	102–105 °C	ASTM D 1120
Frost protection	-28 °C	ASTM D 1177
Density (20 °C)	1.032–1.035 g/cm³	DIN 51757
Viscosity (20 °C)	4.5–5.5 mm²/s	DIN 51562
Refraction nD20	1.380–1.384	DIN 51423
pH value (20 °C)	9.0–10.5	ASTM D 1287
Water content	55–58 %	DIN 51777
Flash point	none	DIN 51758
Reserve alcalinity	> 20 ml 0.1 m HCl	ASTM D 1121

The above data represent average values that were valid when this Technical Information Bulletin went into print. They do not have the status of a product specification. Specified values are the subject of a special leaflet.

Properties

TYFOCOR® LS is a liquid based on an aqueous solution of physiologically unobjectionable propylene glycol with a faint odour. The fluid was developed especially for use in solar thermal systems with high thermal loads (vacuum tube collectors).

The corrosion inhibitors contained in the product reliably protect the metals normally used in solar technology even in mixed installations against corrosion, ageing and deposits over long periods of time. It keeps the surfaces of heat exchangers clean, and thus ensures consistently high thermal efficiency of the solar thermal system.

Miscibility

In order to maintain its specific properties, TYFOCOR® LS must neither be mixed with other heat-transfer fluids, nor it must be diluted with water! If any leakages occur, the system must be topped up with TYFOCOR® LS only!

Temperature Stability

TYFOCOR® LS can be used in solar thermal systems with high stagnation temperatures provided it is ensured that the solar fluid will completely drain out of the collectors into the membrane expansion vessel in case of stagnation.

TYFOCOR® LS must not be exposed to sustained temperatures higher than 170 °C. Temperatures higher than 200 °C lead to slow thermal decomposition of propylene glycol, which is indicated by darkening of the heat-transfer fluid. The lifetime of the fluid thus may be strongly reduced. and the reliability of the system may be endangered.

Anticorrosion Effect

The following table demonstrates the anticorrosion effect of TYFOCOR® LS after two weeks of testing at 88 °C under permanent aeration. Corrosion test according to ASTM D 1384 (American Society for Testing and Materials).

Material	Average change of weight
Copper (SF Cu)	– 2.0 g/m²
Soft Solder (L Sn 30)	– 6.0 g/m²
Brass (MS 63)	– 4.0 g/m²
Steel (HI)	– 0.1 g/m²
Cast Iron (GG 26)	– 0.2 g/m²
Cast Aluminium (G-AlSi6Cu4)	– 0.3 g/m²

Compatibility with Sealing Materials

TYFOCOR® LS does not attack the sealings that are normally used in solar technology. The following table of sealants, elastomers and plastics that are resistant to TYFOCOR® LS has been compiled from experimental results, experience, and from literature data:

Examples of sealants are Fermit®, Fermitol® (registered trademarks of Nissen & Volk GmbH, Hamburg, Germany), hemp

Butyl rubber	IIR
Chloroprene	CR
Ethylene-propylene-diene-rubber	EPDM
Fluorocarbon elastomers	FPM
Natural rubber below 80 °C	NR
Nitrile rubber	NBR
Polyacetal	POM
Polyamides below 115 °C	PA
Polybutene	PB
Polyethylene, soft, hard	PE-LD/HD
Polyethylene, crosslinked	PE-X
Polypropylene	PP
Polytetrafluorethylene	PTFE
Polyvinylchloride, rigid	PVC h
Silicone rubber	Si
Styrene butadiene rubber below 100°C	SBR
Unsaturated polyester resins	UP

Phenolic, urea-formaldehyde resins, plasticized PVC and polyurethane elastomers are not resistant.

An important point to note is that the performance of elastomers is not only governed by the properties of the rubber itself, e.g. EPDM, but also by the nature and amount of the constituent additives and the vulcanisation conditions. For this reason, it is recommended that their resistance to TYFOCOR® LS is checked by performance tests before these elastomers are taken into use for the first time. This applies in particular to elastomers intended as membranes for expansion vessels as described in DIN EN 12828 and in DIN 4807 Part 2, respectively.

Gaskets that have proved to be resistant to hot TYFOCOR® LS are: up to 160 °C gaskets made from 70 EPDM 281 (Carl Freudenberg GmbH, D-69465 Weinheim). Up to 200 °C: flat gaskets such as REINZ-AFM 34 (REINZ-Dichtungs-GmbH, D-89229 Neu-Ulm) or Centellen 3820 based on aramide/special-NBR. (Hecker Werke GmbH, D-71093 Weil im Schönbuch).

Application guidelines

In view of the specific properties of TYFOCOR® LS the following instructions must be observed to ensure long-term protection for the installations.

1. Installations must be designed as closed circuits, as otherwise the contact with atmospheric oxygen will accelerate the consumption of inhibitors.

2. Flexible-membrane expansion tanks must conform to DIN EN 12828 and DIN 4807 Part 2, resp.

3. Silver or copper brazing solders are preferably to be used on joints. Fluxes used in combination with soft solder usually contain chlorides. Their residues must be removed from the system by thorough flushing. Otherwise, an increased content of chlorides in the heat-transfer fluid may lead for example to pitting corrosion on stainless steel.

4. The only flexible connections that are permitted for use are hoses, preferably made of metal, that are resistant to oxygen diffusion.

5. The systems must not be equipped with internally galvanised heat exchangers, tanks or pipes, because zinc can be detached by propylene glycol / water mixtures.

6. Chemically speaking, TYFOCOR® LS is largely inert, but it is important to ensure that the manufacturer's recommendations state that all the seals and connector materials used are resistant up to the maximum fluid temperature.

7. Scaling on copper surfaces must be removed from the system before filling. Otherwise, these particles will be removed by the hot heat-transfer fluid and transported into other areas of the system, which may subsequently lead to formation of deposits and obstruction of the fluid flow rate.

8. It must be ensured that no external voltages are applied between parts of the system that come into contact with the solar fluid.

9. The layout of the piping must ensure that the circulation of the heat-transfer fluid will not be disturbed by gas pockets or deposits.

10. The fluid level must never be allowed to fall below the highest point in the system.

11. If automatic bleed valves are used, they must not allow subsequent suction of air into the system.

12. Dirt and water must not be allowed to enter the installation or its components during assembly and before filling. After the assembly has been completed, the system should be flushed to remove e.g. swarf, fluxes, assembly aids and any other impurities. Following to the flushing process and the leak test, the installation should be completely drained and then filled immediately with TYFOCOR® LS.

13. It must be ensured that no air remains in the solar thermal system after it has been filled. It Is essential to eliminate any existing air or gas pockets, because their collapse following a temperature drop would give rise to a vacuum and thus cause air to be sucked into the system. An insufficient deaeration furthermore affects the heat-transfer efficiency of the system.

14. In-circuit filter elements must be cleaned within 14 days at the latest after the system was put into operation, in order to ensure that no obstruction to the fluid flow may occur.

15. If fluid losses occur due to evaporation, the system must be topped up with demineralised water. Losses due to leakage or removal from the system must be replaced with TYFOCOR® LS only!

16. The frost protection of TYFOCOR® LS can be checked by measuring the fluid density with a hydrometer or an antifreeze tester suitable for propylene glycol / water mixtures. An equally convenient and accurate way to determine the frost protection is the measurement of the refractive index by using a hand-held refractometer.

Storage Stability

The product has a shelf life of at least three years in airtight containers. It must not be stored in galvanised containers.

Delivery Form and Packaging

TYFOCOR® LS is available in road tankers, in 1000 litre IBCs, in 200 litre drums, and in 30, 25, 20 and 10 litre non-returnable plastic cans.

Disposal

Spills of the product must be taken up with an absorbent binder and disposed of in accordance with the regulations. For further information please refer to the Safety Data Sheet.

Ecology

TYFOCOR® LS is classified in water hazard class (WGK) 1, (low-rate endangering, Germany) acc. german water hazard regulations (*Verwaltungsvorschrift für wassergefährdende Stoffe* of May 17, 1999). The product is readily biodegradable.

Handling

The usual safety and industrial hygiene measures relating to chemicals and the information and instructions given in our Safety Data Sheet must be observed in handling TYFOCOR® LS.

Safety Data Sheet

A current Safety Data Sheet in accordance with EU Directive 1907/2006/EC [REACH] is available on our website www.tyfo.de.

Thermophysical properties of TYFOCOR® LS as a function of temperature

T [°C]	Density [kg/m³]	Specific heat capacity [kJ/kg·K]	Thermal conductivity [W/m·K]	Kinematic viscosity [mm²/s]	Cubic expansion coefficient [•10⁻⁴/K]	Vapour pressure [bar]
200	-	-	-	-	-	14.9
190	-	-	-	-	-	12.0
180	-	-	-	-	-	9.20
170	-	-	-	-	-	7.10
160	-	-	-	-	-	5.60
150	-	-	-	-	-	4.20
140	-	-	-	-	-	3.20
130	-	-	-	-	-	2.50
120	959	3.990	0.483	0.50	87	1.80
110	969	3.960	0.476	0.63	84	1.40
100	977	3.920	0.469	0.76	81	0.90
90	986	3.880	0.462	0.91	78	0.62
80	993	3.840	0.456	1.08	75	0.42
70	1001	3.800	0.449	1.32	72	0.29
60	1008	3.760	0.442	1.66	69	0.19
50	1015	3.720	0.434	1.91	66	0.12
40	1021	3.680	0.427	2.52	63	0.07
30	1029	3.640	0.420	3.40	59	0.04
20	1034	3.600	0.413	4.95	56	-
10	1040	3.560	0.406	7.90	53	-
0	1045	3.520	0.399	14.5	49	-
-10	1049	3.480	0.392	26.9	46	-
-20	1053	3.440	0.385	57.1	43	-

Note

The information submitted in this publication is based on our current knowledge and experience. In view of the many factors that may affect processing and application these data do not relieve processors of the responsibility of carrying out their own tests and experiments, neither do they imply any legally binding assurance of certain properties or of suitability for a specific purpose. It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislations are observed.

TYFOROP CHEMIE GmbH
Anton-Rée-Weg 7
D - 20537 Hamburg

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Fax: +49-(0)40 20 94 97-20
e-mail: info@tyfo.de
Internet: www.tyfo.de

10.27. APPENDIX 6 - CERTIFICATES OF FIRST AIDERS



11/ 591255 Reg Nr. 3.0301

Deutsches Rotes Kreuz

Ausbildung in Erster Hilfe

Teilnahmebescheinigung Nr. 1249-3

Name/Vorname Koc Altunay Bilge

Geburtsdatum 16.05.1989 Ausbildungsbeginn 17.5.14

Lehrgangsleitung Kahnert/Ulbrich Ausbildungsende 18.05.14

Ort, Datum Berlin, den 18.05.14

Unterschrift K. Ulbrich

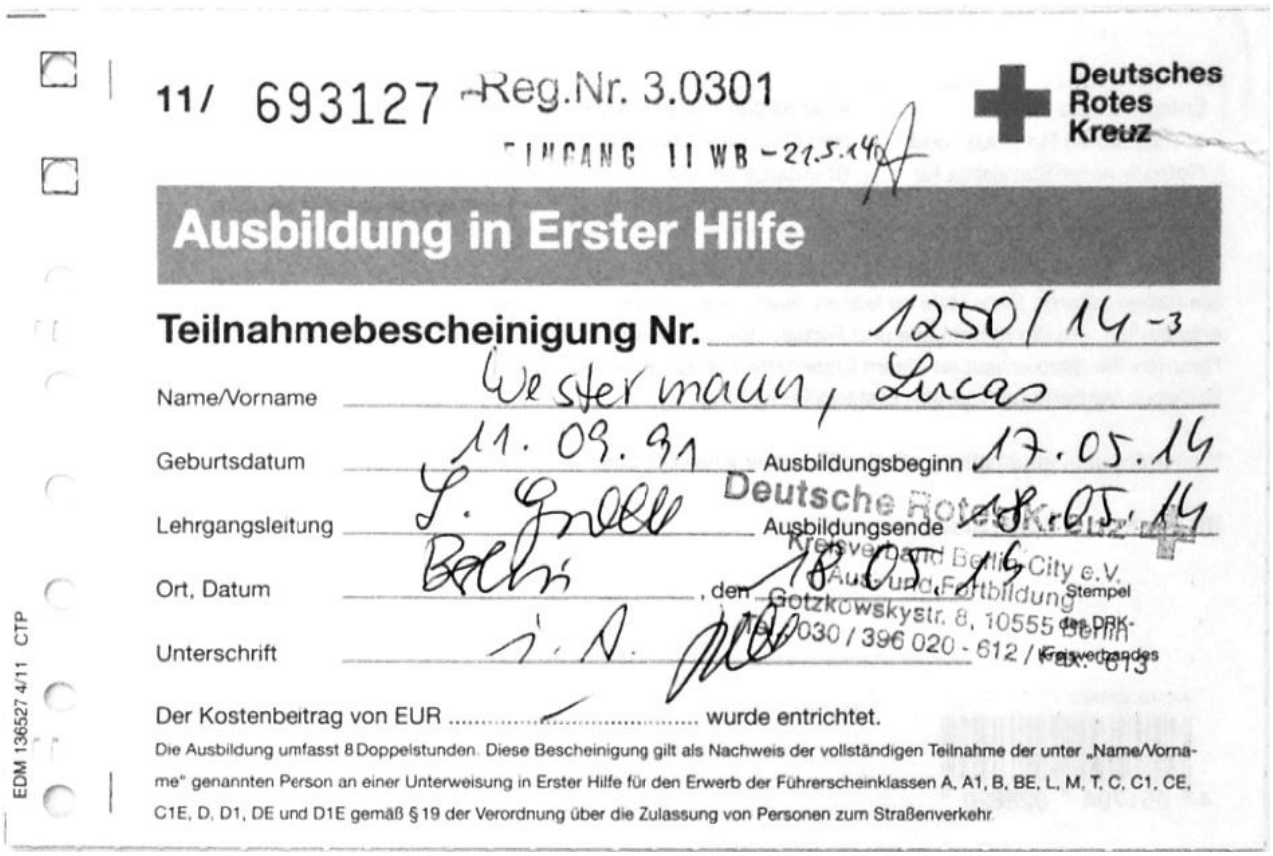
Stempel des DRK-Kreisverbandes

Deutsches Rotes Kreuz Kreisverband Berlin-City e.V. Aus- und Fortbildung Gotzkowskystr. 8, 10555 Berlin Tel.: 030 / 396 020 - 612 / Fax: - 613

Der Kostenbeitrag von EUR ..... wurde entrichtet.

Die Ausbildung umfasst 8 Doppelstunden. Diese Bescheinigung gilt als Nachweis der vollständigen Teilnahme der unter „Name/Vorname" genannten Person an einer Unterweisung in Erster Hilfe für den Erwerb der Führerscheinklassen A, A1, B, BE, L, M, T, C, C1, CE, C1E, D, D1, DE und D1E gemäß § 19 der Verordnung über die Zulassung von Personen zum Straßenverkehr.

EDM 136527 4/11 · CTP



11/ 693127 Reg.Nr. 3.0301

EINGANG 11 WB - 21.5.14

Deutsches Rotes Kreuz

Ausbildung in Erster Hilfe

Teilnahmebescheinigung Nr. 1250/14-3

Name/Vorname Westermann, Lucas

Geburtsdatum 11.09.91 Ausbildungsbeginn 17.05.14

Lehrgangsleitung L. Grell Ausbildungsende 18.05.14

Ort, Datum Berlin, den 18.05.14

Unterschrift i. A.

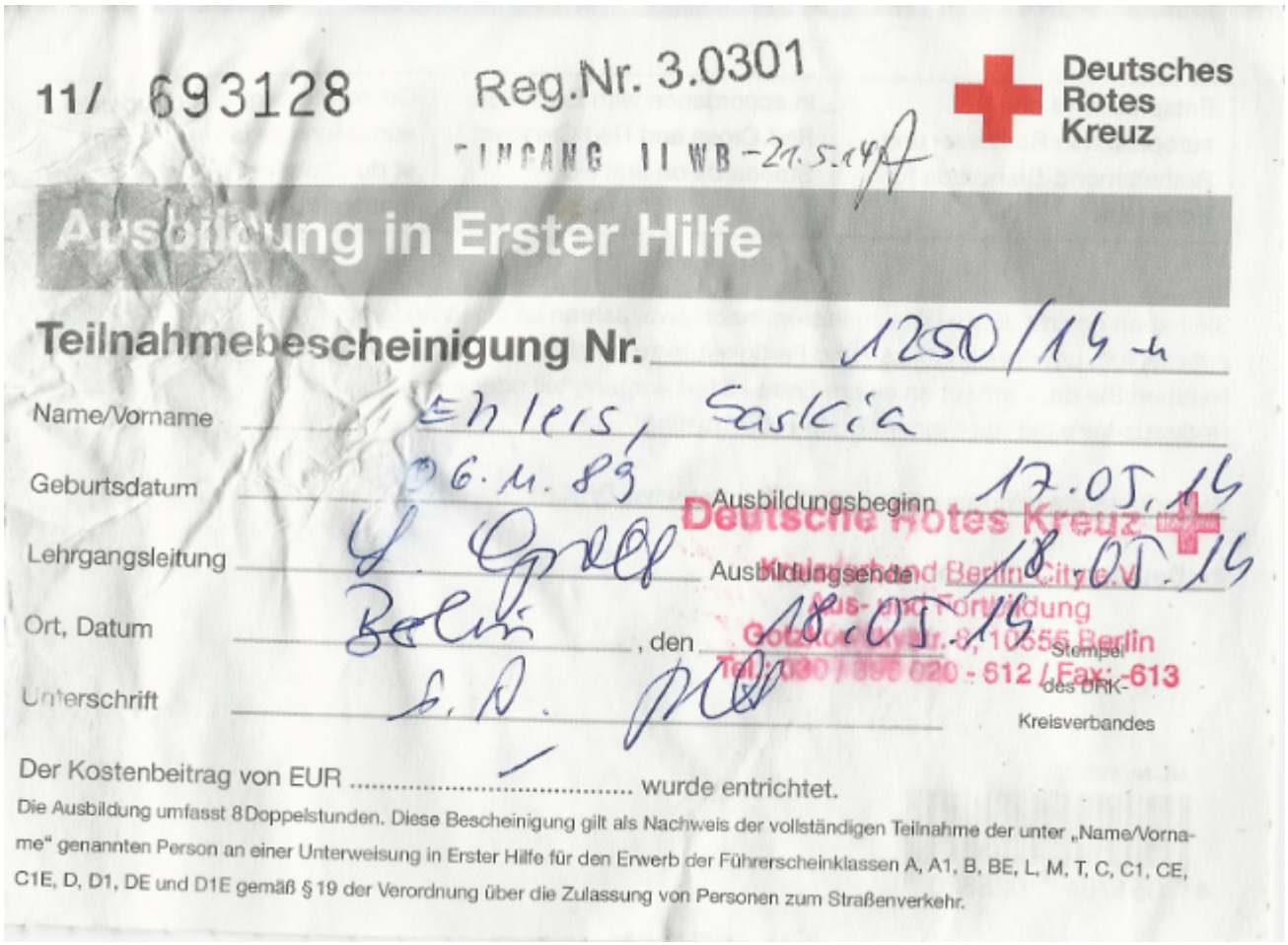
Stempel des DRK-Kreisverbandes

Deutsche Rotes Kreuz Kreisverband Berlin-City e.V. Aus- und Fortbildung Gotzkowskystr. 8, 10555 Berlin Tel.: 030 / 396 020 - 612 / Fax: 613

Der Kostenbeitrag von EUR ..... wurde entrichtet.

Die Ausbildung umfasst 8 Doppelstunden. Diese Bescheinigung gilt als Nachweis der vollständigen Teilnahme der unter „Name/Vorname" genannten Person an einer Unterweisung in Erster Hilfe für den Erwerb der Führerscheinklassen A, A1, B, BE, L, M, T, C, C1, CE, C1E, D, D1, DE und D1E gemäß § 19 der Verordnung über die Zulassung von Personen zum Straßenverkehr.

EDM 136527 4/11 · CTP



11/ 693128 Reg.Nr. 3.0301

EINGANG 11 WB -21.5.14

Deutsches Rotes Kreuz

Ausbildung in Erster Hilfe

Teilnahmebescheinigung Nr. 1250/14-4

Name/Vorname Emlers, Saskia

Geburtsdatum *06.11.89 Ausbildungsbeginn 17.05.14

Lehrgangsleitung [illegible] Ausbildungsende 18.05.14

Ort, Datum Berlin, den 18.05.14

Unterschrift [illegible]

Deutsche Rotes Kreuz Kreisverband Berlin-City e.V. Aus- und Fortbildung Gotzkowskystr. 8, 10555 Berlin Tel.: 030 / 396 020 - 612 / Fax: -613

Stempel des DRK-Kreisverbandes

Der Kostenbeitrag von EUR ..... wurde entrichtet.

Die Ausbildung umfasst 8 Doppelstunden. Diese Bescheinigung gilt als Nachweis der vollständigen Teilnahme der unter „Name/Vorname" genannten Person an einer Unterweisung in Erster Hilfe für den Erwerb der Führerscheinklassen A, A1, B, BE, L, M, T, C, C1, CE, C1E, D, D1, DE und D1E gemäß § 19 der Verordnung über die Zulassung von Personen zum Straßenverkehr.



11/ 602415 Reg.Nr. 3.0301

Deutsches Rotes Kreuz

Ausbildung in Erster Hilfe

Teilnahmebescheinigung Nr. 1277/14/8

Name/Vorname Haucke, Katharina

Geburtsdatum 22.12.89 Ausbildungsbeginn 26-

Lehrgangsleitung Pelle Ausbildungsende 27.5.14

Ort, Datum Berlin, den 27.5.14

Unterschrift Pelle

Deutsches Rotes Kreuz Kreisverband Berlin-City e.V. Aus- und Fortbildung Gotzkowskystr. 8, 10555 Berlin Tel.: 030 / 396 020 - 612 / Fax: - 613

Stempel des DRK-Kreisverbandes

Der Kostenbeitrag von EUR ..... wurde entrichtet.

Die Ausbildung umfasst 8 Doppelstunden. Diese Bescheinigung gilt als Nachweis der vollständigen Teilnahme der unter „Name/Vorname" genannten Person an einer Unterweisung in Erster Hilfe für den Erwerb der Führerscheinklassen A, A1, B, BE, L, M, T, C, C1, CE, C1E, D, D1, DE und D1E gemäß § 19 der Verordnung über die Zulassung von Personen zum Straßenverkehr.

EDM 136527 4/11 · CTP

10.28. APPENDIX 7 - CERTIFICATES OF MEDICAL EXAMINTATIONS

Walter Meier
Facharzt für Innere Medizin
Facharzt für Arbeitsmedizin

Berlin, den 28.05.2014

Arbeitsmedizinische Vorsorgeuntersuchung
Ärztliche Bescheinigung

Personalien Personalnummer:

Name von Fritsch, Bertram geb. 10.07.1986
Anschrift: 10115 Berlin, Torstr. 201
Geschlecht: männlich Staatsangehörigkeit:
Berufsgenossenschaft:

Tätigkeit studierender der UdK

Einstellung am:
Ausgeschieden am:

Grundsatz / Untersuchung	Arbeitsbereich / Art der Tätigkeit	Beginn	Ende
G 25 Fahr,Steuer und Überwachungstätigkeiten	Studierender der UdK		

Arbeitsmedizinische Untersuchung

Datum: 28.05.2014

Grundsatz / Untersuchung	Untersuchungsart	Beurteilung	Nächste Untersuchung	Untersucher
G 25 Fahr,Steuer und Überwachungstätigkeiten	Erstuntersuchung	geeignet	05.2017	Meier

Bemerkungen / Voraussetzungen

Für Arbeitgeber:

Walter Meier
Facharzt für Arbeitsmedizin
und Innere Medizin
Hedemannstraße 13 · 10969 Berlin
Tel.: 030-786 54 00 · Fax: 25 29 54 27

Walter Meier

Seite 1 von 1

Technische Universität Berlin
Betriebsärztlicher Dienst Tel.: 314 - 25080 / 25066
Straße des 17. Juni 135
10623 Berlin

☐ Für die Mitarbeiterin / den Mitarbeiter

☒ Kopie für die /den Institutsleiter/in bzw. Werkstattleiter/in

☐ Bleibt beim Arzt

Ärztliche Bescheinigung

Pflichtvorsorge nach § 6 Absatz 3 der Verordnung zur arbeitsmedizinischen Vorsorge

Familienname: Gabler **Vorname: Felix**

Geburtsdatum: 30.10.1987

Tätigkeit: Student

Fahr-, Steuer- und Überwachungstätigkeiten

Die arbeitsmedizinische Vorsorge wurde durchgeführt am: 21.05.2014

Nächste arbeitsmedizinische Vorsorge: 05/2017

Unterschrift des Betriebsarztes (Dr. Pels Leusden)

Datum der Bescheinigung: 21.05.2014

Dr. Reinhard Pels Leusden
Facharzt für Arbeitsmedizin
Dipl. Tropenmedizin
Betriebsärztlicher Dienst
Technische Universität Berlin
Straße des 17. Juni 135
10623 Berlin
Telefon 030 314-25079

Bemerkungen:

Hinweis für gesetzlich Unfallversicherte: Sie sind berechtigt, eine Entscheidung der zuständigen gesetzlichen Unfallversicherung (Unfallkasse Berlin) herbeiführen zu lassen, wenn Sie die Bescheinigung für unzutreffend halten.

Dr. med. M. Engelhardt-Schagen Fachärztin für Arbeitsmedizin
Planufer 93 a 10967 Berlin *Tel 813 78 53 email:betriebsaerztin @udk.de

Ärztliche Bescheinigung über arbeitsmediziniche Eignungsuntersuchung für das Führen von Flurförderzeugen (Gabelstapler)

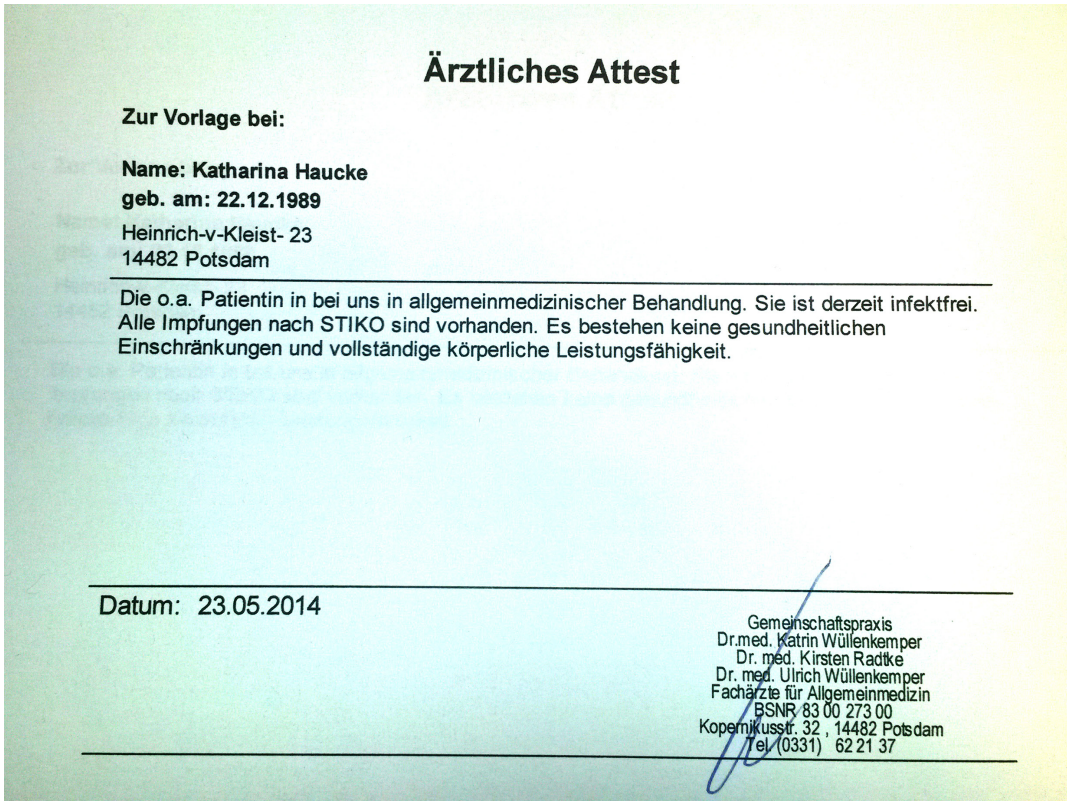
für Fetten, Sophie **Geburtsdatum** 13.6.1988

	Untersuchungen nach Grundsatz	nächster Termin*) Monat/Jahr	Bemerkung
keine gesundheitlichen Bedenken	G 25	5/2017	
keine gesundheitlichen Bedenken unter bestimmten Voraussetzungen			
befristete gesundheitliche Bedenken			
dauernde Gesundheitliche Bedenken			

Datum 28.5.2014

Betriebsärztin der UdK Berlin

UdK Berlin
Universität der Künste Berlin
Dr. M. Engelhardt-Schagen
Betriebsärztin
Hardenbergstr. 33 Raum 32, 10623 Berlin
Tel.: 3185 - 2925
email: betriebsaerztin@udk-berlin.de



Ärztliches Attest

Zur Vorlage bei:

Name: Katharina Haucke
geb. am: 22.12.1989
Heinrich-v-Kleist- 23
14482 Potsdam

Die o.a. Patientin in bei uns in allgemeinmedizinischer Behandlung. Sie ist derzeit infektfrei. Alle Impfungen nach STIKO sind vorhanden. Es bestehen keine gesundheitlichen Einschränkungen und vollständige körperliche Leistungsfähigkeit.

Datum: 23.05.2014

Gemeinschaftspraxis
Dr.med. Katrin Wüllenkemper
Dr. med. Kirsten Radtke
Dr. med. Ulrich Wüllenkemper
Fachärzte für Allgemeinmedizin
BSNR 83 00 273 00
Kopernikusstr. 32 , 14482 Potsdam
Tel. (0331) 62 21 37

10.29. H&S-PLAN REFERENCES

10.29.1 GERMAN AND EUROPEAN LAWS:

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PSA-BV (1996): Verordnung über Sicherheit und Gesundheitsschutz bei der Benutzung persönlicher Schutzausrüstungen bei der Arbeit (PSA-Benutzungsverordnung).

SGB (2013): Sozialgesetzbuch. SGB I – Erstes Buch – Allgemein. SGB V – Fünftes Buch – Gesetzliche Krankenversicherung. SGB VII – Siebtes Buch – Gesetzliche Unfallversicherung.

10.29.2 FURTHER REFERENCES

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Risikoanalyse_01: http://vds.de/fileadmin/vds_publikationen/vds_2021_web.pdf

Muster Vorlage Risikobeurteilung Version 0.9: http://www.siemens.de/industry/automation/mitte/downloads/Documents/Muster_Vorlage_Risikobeurteilung_Version_2.doc

Vorlage-Risikobeurteilung: http://www.suva.ch/vorlage-risikobeurteilung.doc

DETAILED WATER BUDGET

Water is life. And we are dealing with it in a smart way. In this section you can have a look at the numbers behind the pipes that are hidden in the walls of our core module.

DETAILED WATER BUDGET

This chapter gives information about the water needed in the competition time for the Rooftop House and about the chosen container dimensions. The calculation based on the Rules from SDE (version 4) and the Event Calendar (version 2).

As stated in Rules 8.2 and 8.3, the SDE Organization will supply non potable water for competition purposes and remove grey and black water according to a specific schedule.

Water delivery

The Rooftop House has six water draws. Three of them have also a hot water connection (basin and bathtub in the bathroom and the sink in the kitchen). In the competition phase, the hot water draws will be tested. After Sub- contest 6.7. in the SDE Rules, ("Hot water draws") each draw should be deliver hot water for a time period of 10 minutes. At least 50 liters. It may be that in one day three hot water draws will be used consecutively. To know how much hot water we consume in 10 minutes per fitting we look at the flow rate.

According to the manufacturer´s instructions our selected fittings have a flow rates by a pressure of 3 bar (0,3 MPa):

Fitting	Flow rate [l/min]	Water budget in 10 minutes [l]
Basin fitting	5	50
Bathtub fitting	9	90
Sink fitting	12 (mono spray)	120
total		**260 litre**

Table 51: **Flow rate and hot water delivery in 10 minutes for the hot water draws**

In order to spend less much water by the test, we will finish the sub- competition after 55 liters. Is this not possible, than we will not open the entire valve, which is in the fitting.

Other sub- competitions are Clothes- Washing, Dishwasher, Cooking and Dinner. The selected washing machine uses 45 liters per cycle for 3 kg mixed clothes by a water temperature of 40° C. For cooking is just 2,3 kg water allowed and approximately for dinner we need 4 liters of water. In addition the dishwasher from BOMANN used 8 liters per cycle.

The following two tables show each water competition, water budget per day and after a week. In 7th July

the water tank will be refilled.

Day	1	2	3	4	5
Date	June 30th	July 1st	July 2nd	July 3rd	July 4th
Weekday	Mo	Tu	We	Th	Fr
	1 x Clothes - Washer	1 x Clothes - Washer	1 x Clothes - Washer	1 x Clothes - Washer	1 x Clothes - Washer
	1 x - Dish-washer	-	1 x - Dish-washer	1 x - Dish-washer	1 x - Dish-washer
	3 x Hot water Draws	2 x Hot water Draws	3 x Hot water Draws	2 x Hot water Draws	3 x Hot water Draws
	Cooking	-	Cooking	Cooking	-
	-	Dinner	-	Dinner	-
Water Consumption	**225,3 l**	**163 l**	**225,3 l**	**173,3 l**	**223 l**

Table 52: **Each water contests from 7th to 11th July and the water needs per competition day**

Water removal

We separate the waste water in greywater and black water. Black water is the waste water of dishwasher and sink. The parts cooking and dinner belong to sink and in the calculation is always one hot water draw the sink in the kitchen. End of the first week 331 liters get together and in the second 216,2 liters. According to the Event calendar is on 15th July the only water removal, therefor we agreed to use also a 600 liter tank.

The grewater system includes the waste water of the washing machine, bathtub, washbasin and also the heat pump condensation with 21 liters per day. In these case there is after the first week a budget of 786 liters and after the second week of 321,2 liters. This water is going to the grey water reed bed, which can be used for irrigation and cleaning (SDE rules 51.8, part 2). It is good, that daily water flows in the greywater treatment, because in summer time there is a loss of water due to evaporation. And the greywater bed has also a role as a heat exchanger. That´s why it should be enough water in this bed.

Container

On the basis of the estimated values we chose two 600 liter drink water tanks, which will be connected to one big black water container and one 390 liter black water container. For detailed information, see chapter Plumbing System (see section 5.3.3).

First filling of all water treatments

In the Rooftop House are several water systems. These are:

Sanitary:

- warm water tank in the heat pump (235 liters)
- drink water circulation (45 liters)
- greywater bed (2000 liters)

Heating and cooling:

- Solar storage (200 liters)
- PCM pipes (60 liters)

The underfloor heating will be not used in the summertime, for this is not extra water necessary.

The greywater bed is easily to fill, because the top is open and local it will be standing near the street, so a truck could fill it.

ROOFTOP

PROJECT
SPECIFICATIONS



The structure proposed by the SDE organisation we refer to:

1	Structure
1.1	Foundations
1.2	Structural floors and sections
2	Architecture
2.1	Enclosure
2.2	Openings
2.3	Partitions
2.4	Finishes
2.5	Furnishings
3	Systems Installations
3.1	Fire Suppression
3.2	Plumbing
3.3	HVAC
3.4	Electrical
3.5	Solar Systems – Photovoltaic and thermal
3.6	Telecommunications and Building Automation
4	Safety Information
4.1	Fire Safety table
4.2	Safety in Use table
5	Appliances and Home Electronic Equipment specifications and user manuals

Structure

All structurally relevant parts are being built by Knobelsdorff-Schule, a German 'zweiter Bildungsweg' institution, where middle schoolers are being educated in craftmanship. The carpenters and electricians work with us on realizing our project.

All structurally relevant parts are being built by the carpenters. For now please refer to the next section „Structural Calculations and Approval“ where all material properties and dimensions are clearly indicated.

12.1. ARCHITECTURE

In this section you find our data on the different parts for the house.

12.1.1 ENCLOSURE

12.1.2 OPENINGS

12.1.3 PARTITIONS

DAMTEC®
3D 17/8

KRAIBURG RELASTEC

Produktdatenblatt Nr. 9444 - R - 02
Stand: November 2013

1. Einsatzzweck

DAMTEC® 3D 17/8 ist eine profilierte Gummigranulatmatte zur Trittschalldämmung und zur Schwingungsdämpfung und Körperschallentkopplung. Sie findet ihren Einsatz in verschiedenen Anwendungen, wie z.B. unter schwimmenden Estrichen oder unter Maschinenfundamenten.

2. Werkstoff

Hochwertige Gummifasern auf Recyclingbasis mit PU-Elastomer gebunden.

3. Produktdesign

Farbe:	schwarz
Oberfläche:	Granulatstruktur, einseitig profiliert

4. Maße / Toleranzen

Standardbreite:	1.250 mm	± 1,5 %
Standardlänge:	8,0 m	± 1,5 %
Dicke:	17/8 mm	± 1,0 mm
Raumgewicht:	500-600 kg/m³	

Das Datenblatt unterliegt keinem Änderungsdienst! Alle Angaben erfolgen ohne Gewähr. Die jeweils aktuelle, gültige Fassung ist abrufbar unter www.kraiburg-relastec.com/damtec

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Fon +49-(0) 86 83-701-1 42 · Fax +49-(0) 86 83-701-41 42
christina.wallner@kraiburg-relastec.com · www.kraiburg-relastec.com/damtec

Made in Germany
qualityaustria SYSTEMZERTIFIZIERT ISO 9001:2008 NR.00186/0

asdfasdfa

PRODUKTBESCHREIBUNG

Duripanel – die Holzzementplatte

Eine Platte, mit der Sie im modernen Holz- und Holzrahmenbau eine Vielzahl von Konstruktionen ausführen können. Das ist Duripanel, die dreischichtige Holzzementplatte mit besonderer Eignung für den vorbeugenden Brandschutz und die Schalldämmung. Duripanel ist ein aus natürlichen Rohstoffen hergestellter Baustoff und trägt die Umwelt-Produktdeklaration (EPD) des Instituts Bauen und Umwelt e.V.

Duripanel B1 Basisplatte



Duripanel B1, ungeschliffen

Werkstoff:	Zementgebundene Spanplatte nach DIN EN 634-2 Klasse 1; mit CE-Kennzeichnung nach DIN EN 13986.
Oberflächen:	ungeschliffen – glatt, zementgrau, Dickentoleranz ± 0,7 - 1,5 mm oder geschliffen – beidseitig geschliffen, gelblich-braun mit Feinspanoptik, Dickentoleranz ± 0,3 mm.
Dicken:	13 Dicken im Bereich von 8 - 40 mm als B1 Basisplatte.
Format:	3.100 x 1.250 mm und 2.600 x 1.250 mm.
Anwendung:	gehobener Innenausbau, tragende und aussteifende Platte (B1) im Holzbau, Containerbau, Schallschutz.
Klassifizierung des Brandverhaltens:	B-s1, d0 (DIN EN 13501-1), schwerentflammbar

Duripanel A2 Basisplatte



Duripanel A2, ungeschliffen

Werkstoff:	Zementgebundene Spanplatte nach DIN EN 634-2 Klasse 2; mit CE-Kennzeichnung nach DIN EN 13986.
Oberflächen:	ungeschliffen – glatt, zementgrau mit rotem Kern, Dickentoleranz ± 0,7 - 1,5 mm oder geschliffen – beidseitig geschliffen, gelblich bis rot mit Feinspanoptik, Dickentoleranz ± 0,3 mm.
Dicken:	8 Dicken im Bereich von 10 - 32 mm als A2 Basisplatte.
Format:	3.100 x 1.250 mm und 2.600 x 1.250 mm.
Anwendung:	gehobener Innenausbau, Dachschalungen, Holzbau, Containerbau mit erhöhten Brandschutzanforderungen.
Klassifizierung des Brandverhaltens:	A2-s1, d0 (DIN EN 13501-1), nichtbrennbar

Objektbeispiel Duripanel Basisplatte



Innovationscampus Autovision in Wolfsburg von O. M. Architekten. Duripanel an Trennwänden und auf Türblättern.

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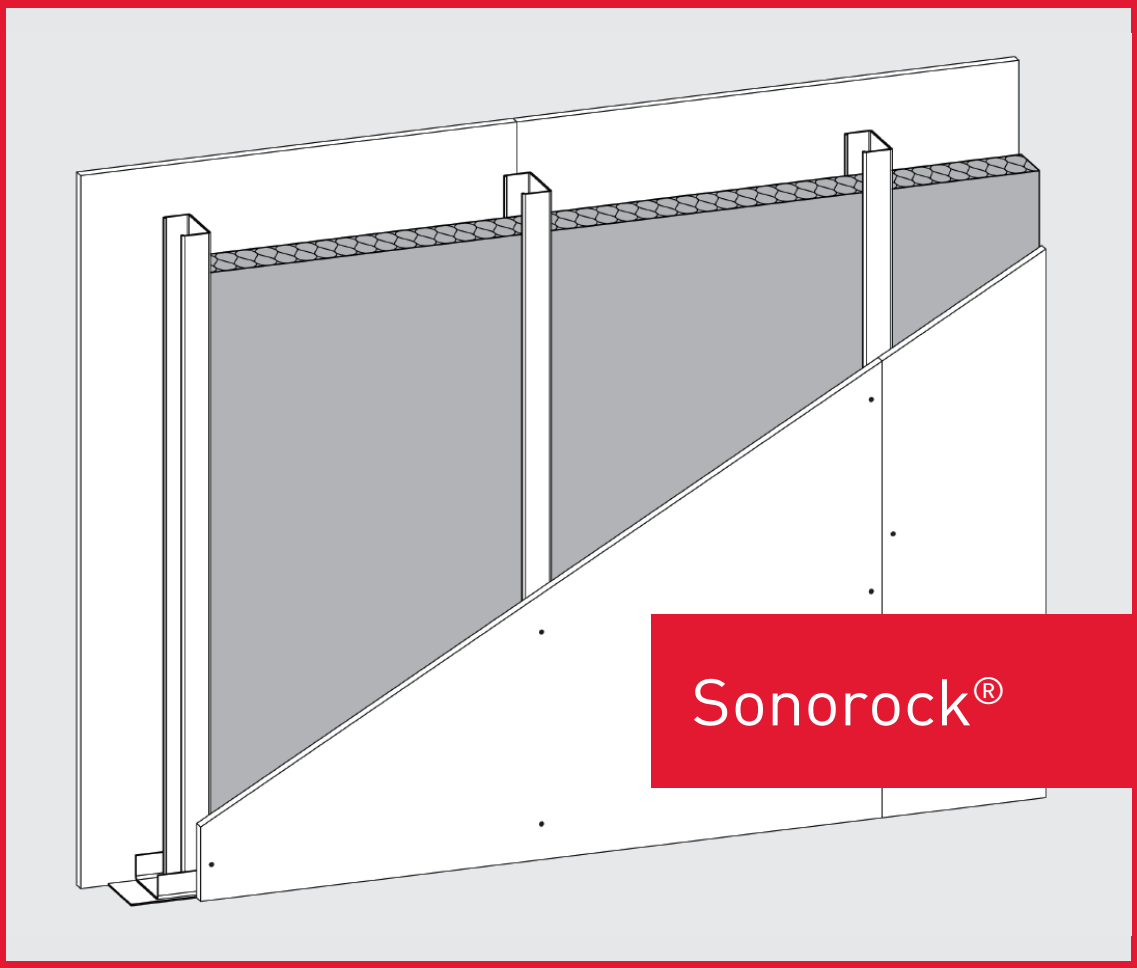
FÜR DEN FACHBETRIEB/FACHMANN

TECHNISCHES DATENBLATT
AUSGABE 11/2013



Sonorock®

Trennwandplatte Sonorock®

Formstabile Steinwolle-Dämmplatte zur Schall- und Wärmedämmung von leichten Trennwänden, auch mit Brandschutzanforderungen.

- Wärmedämmstoff für Gebäude – werksmäßig hergestellte Mineralwolle (MW) gem. DIN EN 13162
- nichtbrennbar, Euroklasse A1
- Schmelzpunkt > 1000°C
- wärme- und schalldämmend
- diffusionsoffen
- standfest zwischen der Ständerkonstruktion
- recycelbar

RAL GÜTEZEICHEN
Erzeugnisse aus MINERALWOLLE

ROCKWOOL®
DÄMMT PERFEKT & BRENNT NICHT

CREATE AND PROTECT®

asdfasdfa

DAMTEC®
3D 17/8

KRAIBURG RELASTEC

Produktdatenblatt Nr. 9444 - R - 02
Stand: November 2013

1. Einsatzzweck

DAMTEC® 3D 17/8 ist eine profilierte Gummigranulatmatte zur Trittschalldämmung und zur Schwingungsdämpfung und Körperschallentkopplung. Sie findet ihren Einsatz in verschiedenen Anwendungen, wie z.B. unter schwimmenden Estrichen oder unter Maschinenfundamenten.

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Hochwertige Gummifasern auf Recyclingbasis mit PU-Elastomer gebunden.

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4. Maße / Toleranzen

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Das Datenblatt unterliegt keinem Änderungsdienst! Alle Angaben erfolgen ohne Gewähr. Die jeweils aktuelle, gültige Fassung ist abrufbar unter www.kraiburg-relastec.com/damtec

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christina.wallner@kraiburg-relastec.com · www.kraiburg-relastec.com/damtec

Made in Germany
qualityaustria SYSTEMZERTIFIZIERT ISO 9001:2008 NR.00186/0

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12.1.4 FINISHES

12.1.5 FURNISHINGS

12.2. SYSTEMS INSTALLATIONS

12.2.1 FIRE SUPPRESSION

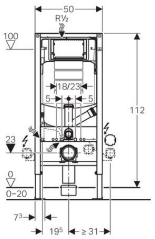
12.2.2 PLUMBING

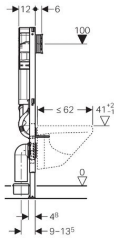
Produktdatenblatt

GEBERIT

Duofix Wand-WC, 112 cm, mit UP-Spk. UP320 für Geruchsabsaugung Umluft







Verwendung

- Zum Anschluss einer Geruchsabsaugung über Sigma40 Betätigungsplatte
- Geeignet für Beplankung bis max. 4,5 cm inkl. Fliesen
- Zum Einbau in teilhohe oder raumhohe Vorwandinstallation
- Zum Einbau in raumhohe Installationswand
- Zum Einbau in Duofix Systemwand
- Geeignet für Fußbodenaufbau 0 - 20 cm

Eigenschaften

- Trockenbauelement
- Selbsttragend
- Rahmen pulverbeschichtet, Farbe Geberit blau
- Rahmen mit Löchern ø 9 mm für Befestigung im Holzständerbau
- Keramikbefestigungen M12, Befestigungsabstand 18 cm oder 23 cm
- Fußstützen mit cm-Raster-Markierung, rutschsicher, höhenverstellbar, verzinkt
- Fußplatte drehbar, für den Einbau in UW50 und UW75 Profile
- Wand-WC-Bogen tiefenverstellbar in 8 Positionen, Verstellbereich 45 mm, Befestigung schallgedämmt
- UP-Spülkasten UP320 mit Betätigung von vorne, 25 Jahre Ersatzteilsicherheit
- UP-Spülkasten vorbereitet für Geruchsabsaugung Umluft
- UP-Spülkasten für werkzeuglose Montage und werkzeuglose Servicearbeiten
- UP-Spülkasten schwitzwassergedämmt
- UP-Spülkasten für 2-Mengen-, 1-Mengen- oder Spül-Stopp-Spülung
- Bauschutz für Serviceöffnung werkzeuglos montierbar und werkzeuglos ablängbar
- Spülmenge einstellbar
- Bei Werkseinstellung sofortiges Nachspülen möglich
- Wasseranschluss oben, seitlich nach links versetzt

Technische Daten

Spülmenge Werkeinstellung	6 und 3	l
Kleine Spülmenge Einstellbereich	3 - 4	l
Große Spülmenge Einstellbereich	4,5 / 6 / 7,5	l
Fließdruck Einsatzbereich	0,1 - 10	bar

RON
ühlen

PRODUKTDATENI

cher SBP 200/400 E cool

ol bestechen die SBP-Standspeicher
es herausragendes Extra. Denn sie
nur die Wärme für den Heizungsbetrieb
ern bevorraten im Umkehrbetrieb der
ekühltes Wasser für die Temperierung
eißen Tagen. Damit schöpft der SBP E
eistungsspektrum einer
eizung im Winter wie im Sommer



Abbildung exemplarisch: SBP 200 cool

Merkmale

- nit 200 und 400 Litern (je nach Gerät)
- Heiz- und Kühlbetrieb
- hochwirksame Isolierung für geringe (optional)

EBEL ELTRON

data sheet

Z 304/404 SOL

design plus cooling function.

successful LWZ complete system for energy-efficient es has been developed into the LWZ 304/404 SOL. e appliances are attractive, as they not only provide ng, ventilation and DHW, but also have an integral ng function. Completely revised casing design. ediately noticeable through its new design that fits lessly into the current visual lineup from STIEBEL ON. The sturdy and sound-optimised front hides an ged DHW cylinder with 235 litre capacity. The oved thermal insulation reduces heat losses to a mum. The revised power connection is now even er and easier to wire.



Example LWZ 304 SOL

most important features

- mpact appliances with ventilation, central heating, *W* heating and cooling functions
- tilation with up to 90% heat recovery
- be combined with a solar thermal system
- ion of remote control via FES Comfort gramming unit
- itive user prompts
- rdy, sound-optimised casing design
- gral high efficiency heating circuit pump
- h-grade thermal insulation
- onomic arrangement of the programming unit

12.2.3 HVAC

EBEL ELTRON

data sheet

Z 304/404 SOL

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Example LWZ 304 SOL

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RON
ühlen

PRODUKTDATENI

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eistungsspektrum einer
eizung im Winter wie im Sommer



Abbildung exemplarisch: SBP 200 cool

Merkmale

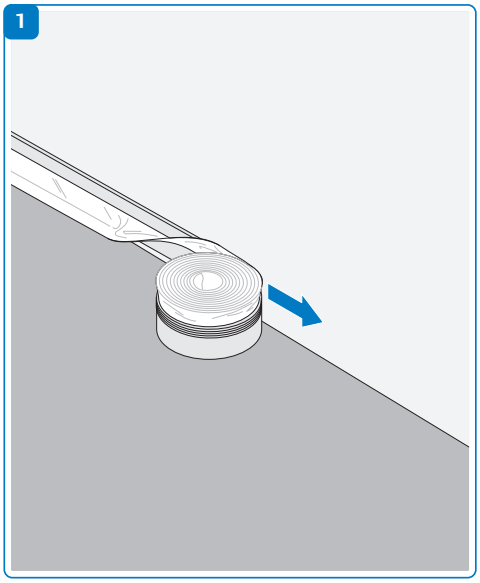
- nit 200 und 400 Litern (je nach Gerät)
- Heiz- und Kühlbetrieb
- hochwirksame Isolierung für geringe (optional)

Montage

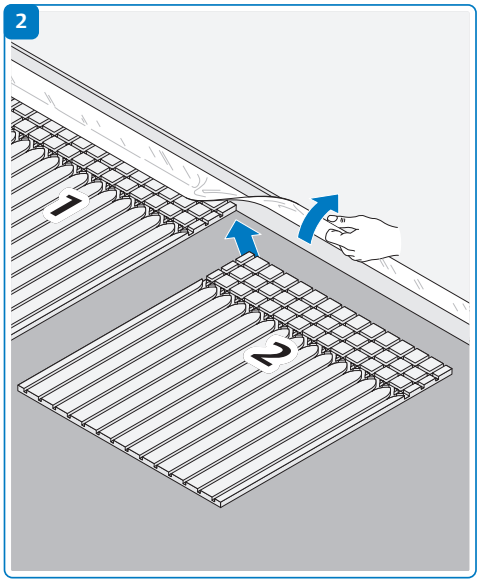
Allgemein

Die nachfolgende Kurzanleitung gibt die Montage des Uponor Siccus Systems nur auszugsweise wieder. Bitte beachten Sie zusätzlich die Montageanleitungen, die den Produkten beigepackt sind oder unter www.uponor.de als Download zur Verfügung stehen.

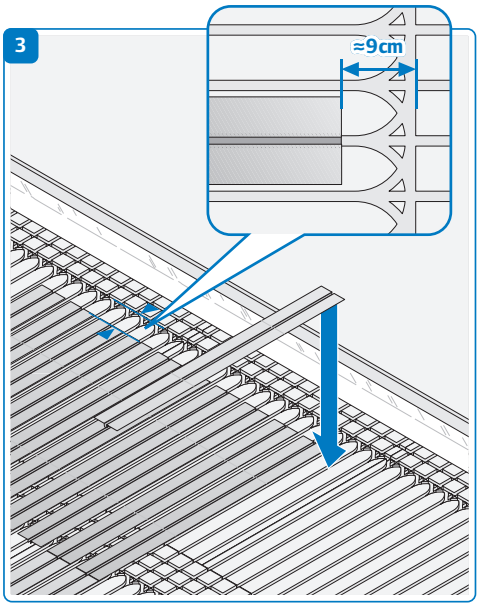
Übersicht der Montageschritte



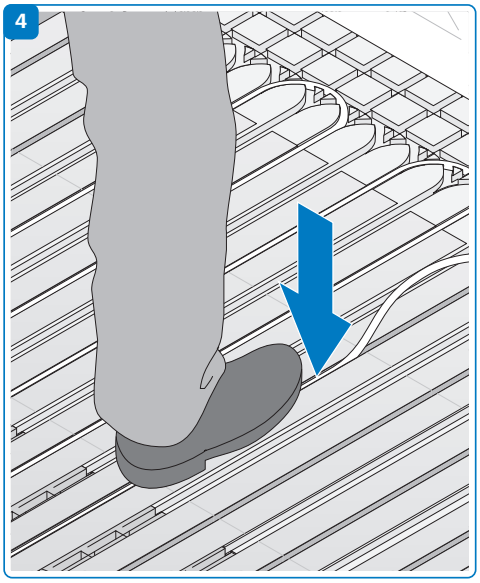
Randdämmstreifen montieren



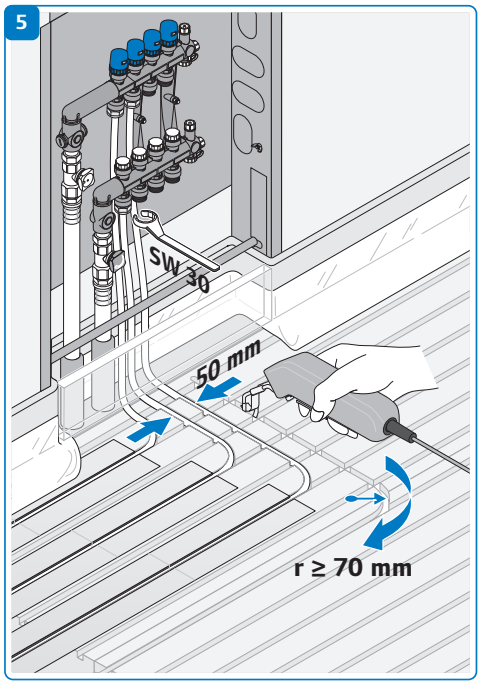
Verlegeplatten montieren



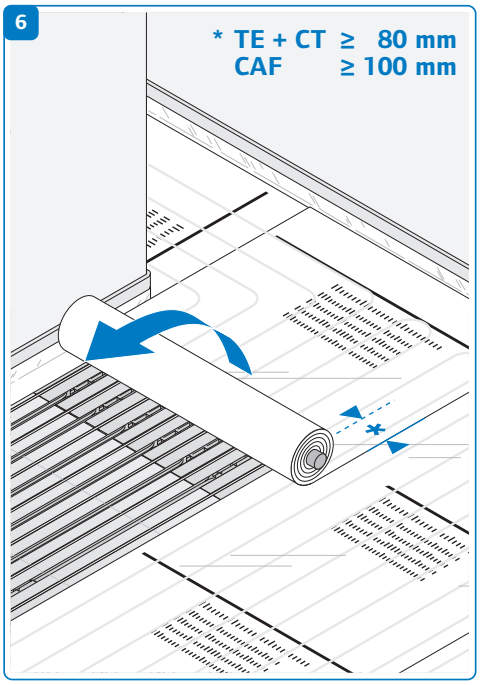
Wärmeleitlamellen montieren



Heizungsrohr montieren

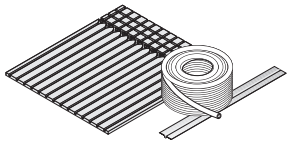


Heizungsrohre an den Verteiler anschließen

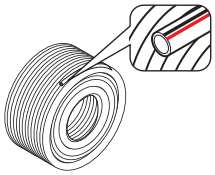


Abdeckfolie PE-Typ 200 auslegen

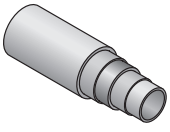
Technische Daten



Uponor Siccus Element	
Werkstoff (Verlegeplatte, Wärmeleitlamelle, Rohr)	Polystyrol, Aluminium, PE-Xa
max. Nutzlast	7,5 kN/m²
Wärmeleitwiderstand Verlegeplatte	0,622 m2K/W
Verlegeabstände	Vz 15, Vz 22,5, Vz 30
minimale Aufbauhöhe	50 mm
Systemart	Trockensystem
Lastverteilschicht	Trocken- oder Nassestrich
Zulassungen	CE



Uponor PE-Xa Rohr 14 x 2 mm	
Rohrdimension	14 x 2 mm
Werkstoff	PE-Xa
Farbe	Natur mit schwarz-rotem Längsstreifen
Herstellung	gem. DIN EN ISO 15875
Sauerstoffdichtheit	gem. DIN 4726
Dichte	0,938 g/cm³
Wärmeleitfähigkeit	0,35 W/mK
lin. Ausdehnungskoeffizient	bei 20 °C 1,4x10^{-4} 1/K, bei 100 °C 2,05x10^{-4} 1/K
Kristallitschmelztemperatur	133 °C
Baustoffklasse	B2
min. Biegeradius	70 mm
Rohrrauigkeit	0,007 mm
Wasserinhalt	0,079 l/m
Rohr-Kennzeichnung	[Laufende-Meterangabe] m < PE-Xa 14 x 2.0 Sauerstoffdicht gem. DIN 4726 EN ISO 15875 class 4/5/10 bar [DIN-geprüft Zeichen] 3V210 PE-X KOMO vloerverw en KOMO CV 6 bar ATG 2399 ÖNORM B 5153 GEPRÜFT [Herstellerzeichen] [Material/Maschinen/Produktions/Datums-Code]
max. Dauerbetriebsdruck (Wasser 20 °C)	20,4 bar (Sicherheitsfaktor ≥ 1,5)
max. Dauerbetriebsdruck (Wasser 70 °C)	11,8 bar (Sicherheitsfaktor ≥ 1,5)
Einsatzbereich Heizung	90 °C/6 bar
kurzzeitige Betriebstemperatur	110 °C
DIN-Register-Nr.	3V209 PE-X
Rohrverbindungen	Verbindungskupplungen und Klemmring-verschraubungen Typ Uponor 14 x 2
optimale Montagetemperatur	≥ 0 °C
freigegebener Wasserzusatz	Uponor Frostschutzmittel GNF Stoffklasse 3 gem. DIN 1988 Teil 4
UV-Schutz	lichtundurchlässiger Karton (Restbund muss im Karton gelagert werden!)

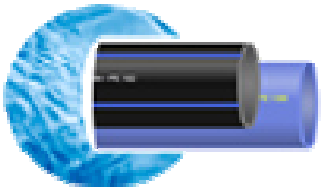


Uponor Verbundrohr MLCP RED 14 x 1,6 mm	
als Ringmaterial zur Verwendung als Flächenheizungsrohr, Verbindung mit Klemmringverschraubung bzw. Pressverbinder.	
Werkstoff	Mehrschichtverbundrohr (PE-RT - Haftvermittler - sicherheitsüberlappt längsverschweißtes Aluminium - Haftvermittler - PE-RT), SKZ-überwacht, sauerstoff-dicht nach DIN 4726.
max. Betriebstemperatur	60 °C
max. Betriebsdruck	4 bar

3.3 Schlitzauslässe







Farbe: schwarz mit blauen Streifen für Trinkwasser
PE-Druckrohre für Trinkwasser werden zusätzlich mit DVGW Zeichen gefertigt.

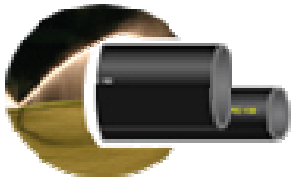
Werkstoff: PE 80
SDR / PN: SDR 11 (PN 12,5)
Normen: DIN EN 12201
Zulassungen: DVGW

Abmessung Ø x Stärke in mm	Preise €/m
20x1,9	0,65
25x2,3	0,97
32x2,9	1,50
40x3,7	2,30
50x4,6	3,58
63x5,8	5,60

Werkstoff: PE LD
SDR / PN: SDR 6 (PN 10)
Normen: DIN 8072/73 DIN 19533
Zulassungen: DVGW

Abmessung Ø x Stärke in mm	Preise €/m
25x4,2	1,79
32x5,4	2,93
40x6,7	4,53
50x8,4	7,10

Beregnungs- und Gärtnerrohre

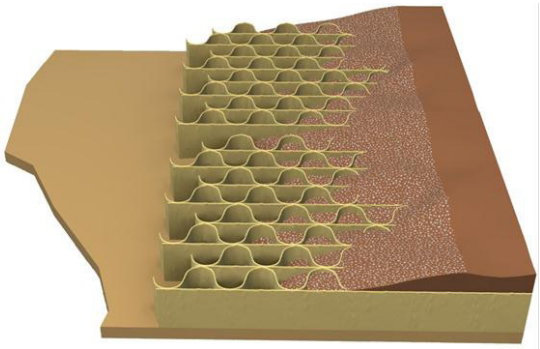


Farbe: schwarz
Werkstoff: PE 80
SDR / PN: SDR 17,6 (PN 7,5)

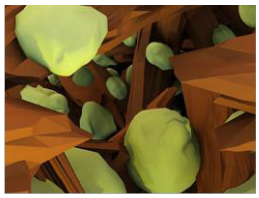
Abmessung Ø x Stärke in mm	Preise €/m
25x1,8	0,73
32x1,9	1,06
40x2,3	1,52
50x2,9	2,35
63x3,6	3,65

Farbe: schwarz
Werkstoff: PE LD
SDR / PN: SDR 9 (PN 6)
Grundlage: DIN 8072/73

Abmessung Ø x Stärke in mm	Preise €/m
20x2,2	0,63
25x2,7	0,94
32x3,5	1,57
40x4,3	2,42
50x5,4	3,78



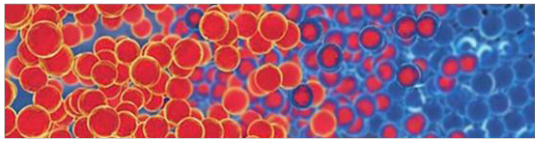
pcm-passiv 16 mm 13,5 kg/m²

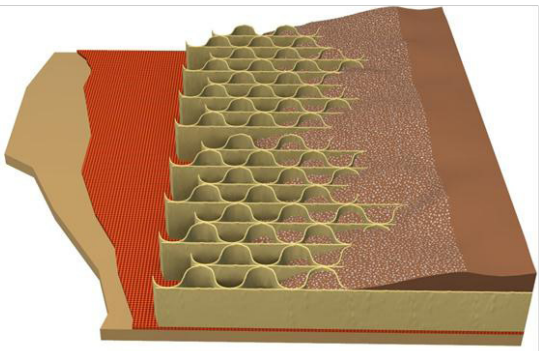


23°/26° C

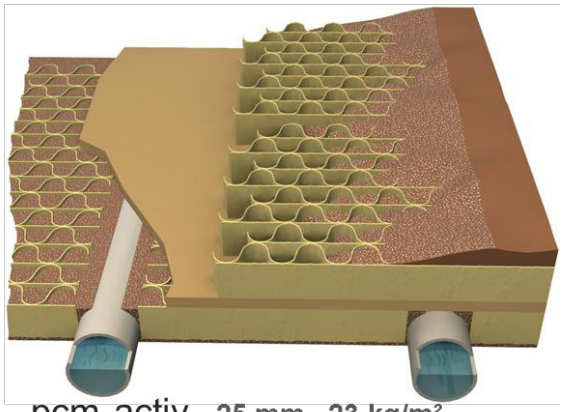
1250 x 625 mm

3-6 kg a 100-110 kJ / m²





pcm-plus 16 mm 13,5 kg/m²



pcm-activ 25 mm 23 kg/m²

Technische Daten	pcm-passiv	pcm-activ	pcm-plus
D x L x B in mm	16 x 1250 x 625	25 x 1250 x 625	16 x 1250 x 625
Größe in m²	0,781 m² / Platte	0,781 m² / Platte	0,781 m² / Platte
Flächengewicht	13,5 kg/m²	23 kg/m²	13,5 kg/m²
Schmelzpunkt	23° / 26° C wählbar	23° / 26° C wählbar	23° / 26° C wählbar
Latente Wärme	100 Wh/m²	200 Wh/m²	100 Wh/m²
Latente Wärmespeicherung	26°C: 330 kJ/m² 23°C: 300 kJ/m²	26°C: 660 kJ/m² 23°C: 600 kJ/m²	26°C: 330 kJ/m² 23°C: 300 kJ/m²
Spezifische Wärmekapazität Cp	ca. 1,3 kJ/kgK	ca. 1,3 kJ/kgK	ca. 1,3 kJ/kgK
Gesamte Speicherkapazität	802 kJ/m²	1520 kJ/m²	802 kJ/m²
Brandklasse nach orientierender Prüfung	B, C inkl. Putz	B, C inkl. Putz	B, C inkl. Putz
Wasserdiffusionswiderstand μ	μ 5-10	n/a	μ 5-10
Wärmeleitfähigkeit λ	ca. 0,47 W/mK	n/a	ca. 0,47 W/mK
Rohdichte ρ	1000 kg/m³	1000 kg/m³	1000 kg/m³
PCM-Gehalt	3 kg/m²	6 kg/m²	3 kg/m²

Lehmbauplatten im Einsatz

Im Trockenbau. Passivhaus. Niedrigenergiehaus. Holzhaus. Neubauten und Bauen im Bestand. Kommunale und öffentliche Bauten. Gewerbeobjekte und Industriebauten. Eigenheim.

Energie- und ressourcenschonend, ökologisch und zukunftsweisend: Die PCM-Lehmbauplattenfamilie von lehmorange®

Die lehmorange Lehmbauplatte wurde konsequent weiterentwickelt, um Planern und Bauherren weitere Anwende-Möglichkeiten zu bieten.
Lehm, gemischt mit High Tech Wachsen (Micronal® PCM), ergibt die PCM-Lehmbauplatte. Unter Beibehaltung der geringen Plattenstärke konnte die Wärmespeicherkapazität um ein Vielfaches erhöht werden. Die „latente Wärme" wird dabei in den Platten gespeichert. Die pcm-passiv dient als Überhitzungsschutz im Raum und das Element pcm-activ und pcm-plus versorgen den Raum mit Wärme.

lehmorange®
moderne Lehm-Trockenbausysteme

lehmorange® – Reiserdorf 13 – 92721 Reiserdorf – Tel.: 09602/9390101 – Fax: 09602/9390106 – info@lehmorange.de – www.lehmorange.de



Lieferaufmachung

- Die Bundware wird in 50 m- bzw. 25 m-Bunden geliefert.
- Pro Bund ist eine Doppelsteckmuffe montiert.
- Jeder Bund ist mit einer eingelegten **Einzugshilfe** ausgestattet.
- Die Stangenware wird als 6 m-Stangen in HRVs geliefert.
- Jede Stange ist mit einer aufgesteckten Doppelsteckmuffe ausgerüstet.
- Andere Längen auf Anfrage.

Rohre

DN/OD	**40**	**50**	**63**	**75**	**90**	**110**	**120**	**125**	**160**	**175**	**200**
Bunde/Art.-Nr.	102801	102811	102821	102831	102841	102851	102861	102871	102881	102891	-
da (mm)	40	50	63	75	90	110	120	125	160	175	-
di (mm) ca.	30	40	50	60	74	93	100	106	136	150	-
Bundinhalt (m)	50	50	50	50	50	50	50	50	25/50	25/50	-
Biegeradius ca. (bei 20 °C; m)	0,35	0,35	0,46	0,46	0,46	0,46	0,50	0,50	0,65	0,70	-
Stangen/Art.-Nr.	-	102901	102911	102921	102931	102941	102951	102961	102971	102981	102991
da (mm)	-	50	63	75	90	110	120	125	160	175	200
di (mm) ca.	-	40	50	60	74	93	100	106	136	150	174
Biegeradius ca. (bei 20 °C; m)	-	2,5	3,0	3,0	3,5	4,0	4,0	6,0	8,0	8,0	15
Zubehör											
Bogen 45° einschl. Muffe; schwarz	-	246481	246491	102531	102541	102551	102561	102571	102581	102591	102601
Biegeradius (m)	-	0,60	0,60	0,75	0,75	1,10	1,10	1,10	1,10	1,10	1,40
Bogen 90° einschl. Muffe; schwarz	-	246461	246471	102611	102621	102631	102641	102651	102661	102671	-
Biegeradius (m)	-	0,60	0,60	0,75	0,75	1,10	1,10	1,10	1,10	1,10	-
Doppelsteckmuffe aus PE-HD; schwarz	102691	102701	102711	102721	102731	102741	102751	102761	102771	102781	102791
Verschlussstopfen aus PE	103001	103011	103021	103031	103041	103051	103061	103071	103081	103091	103101
Dichtring aus EPDM; schwarz	102421	102431	102441	102451	102461	102471	102481	102491	102501	102511	102521
Abstandshalter aus PE; schwarz; mehrzügig; doppelseitig	*	*	*	*	*	*	*	*	*	-	*
Übergangsmuffe auf glattwandiges Rohr; aus PVC-U	-	*	*	*	*	*	*	*	*	-	-

** auf Anfrage*

12.2.4 ELECTRICAL SYSTEM

We work close together in the electrical planning process with the Knobelsdorffschule Berlin.

For technical details and specifications and the approval of our electrical drawings see the following pages.

CABLES AND SPECIFICATION

Cables for interior lighting installation

- Halogen free, copper
- NHXMH-J
- Cross section: 1,5 mm²
- Length: approx. 100m
- Cable cores: 3 (L1,N,PE)

Cables for interior distribution installation

- Halogen free, copper
- NHXMH-J
- Cross section: 2,5 mm²
- Length: approx. 200m
- Cable cores: 3 (L1,N,PE)

Cables for interior distribution installation

- Halogen free, copper
- NHXMH-J
- Cross section: 2,5 mm²
- Length: approx. 200m
- Cable cores: 3 (L1,N,PE)

Cables for motor distribution installation

- UV resistant, copper
- H07RN-F3G
- Cross section: 2,5 mm²
- Length: approx. 100m
- Cable cores: 3 (L1,N,PE)

Cables for Potential equalization

- Halogen free, copper
- Green-yellow
- H07V-K-6GG
- Cross section: 6 mm²
- Length: approx. 50m
- Cable core: 1

Cables for communication

- JHSTH 2*2*08
- Length: approx. 50m

Cables for sensors and monitoring devices

- Cat 7 SFTP
- Length: approx. 100m
- Shielded cable

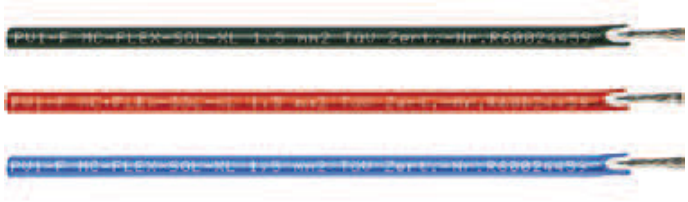
PV-Cables

- Multi contact FLEX-SOL-XL 6,0
- PV-cable with maximum resistant against UV and weather conditions
- Minimal losses
- Cross section. 6mm²
- Length: approx. 150m
- MC4 connectors

Cables for main connection installation

- UV resistant, copper
- H07RN-F3G
- Cross section: 16 mm²
- Length: approx. 20m
- Cable cores: 3 (L1,N,PE)

Câble solaire FLEX-SOL-XL — Solar Cable FLEX-SOL-XL



Données électriques	**Electrical data**	
Tension nominale	Nominal voltage	**U_0/U: 0,6/1kV AC/max. 1,8kV DC**
Tension d'essai selon EN 50395-6	Test voltage according to EN 50395-6	**6,5kV AC/15kV DC (5min.)**
Courant assigné	Rated current	**2,5mm²: 41A; 4mm²: 55A 6mm²: 70A; 10mm²: 98A**
Tension assignée	Rated voltage	**1000V DC**
Résistance d'isolement de l'ensemble du câble selon EN 50395-8.2	Insulation resistance of the complete cable according to EN 50395-8.2	**10^{14} Ωcm (20°C)/10^{11} Ωcm (90°C)**
Caractéristiques thermiques et mécaniques	**Thermal and mechanical properties**	
Température ambiante Température maximale sur le conducteur	Ambient temperature Maximum conductor temperature	**-40°C ... +90°C max. +120°C**
Haute résistance thermique	Highly heat resistant	**-40°C ... +90°C (> 150.000 heures/hours) -40°C ... +105°C (> 70.000 heures/hours) -40°C ... +120°C (> 20.000 heures/hours)**
Durée d'utilisation calculée	Expected usable life	**25 ans/years**
Haute résistance mécanique	Mechanically highly stressable	
Souple à basses températures	Flexible at low temperatures	
Résistance à l'usure	Abrasion resistance	**Très bonne/Very good**
Résistance à la traction	Tensile strength	**18N/mm²**
Allongement à la rupture	Elongation at rupture	**160%**
Dureté	Hardness	**40 Shore D**
Résistance aux conditions ambiantes	**Resistance to environmental influences**	
Résistance à...	Resistant to...	**UV Ozone/Ozone Hydrolyse/Hydrolysis**
Résistance à... selon CEI 60811-2-1	Resistance to... tested according to IEC 60811-2-1	**Acides, lessives et huile (IRM 902) Acids, alcalis and oil (IRM 902)**
Comportement au feu	**Fire behaviour**	
Isolation	Insulation	**ignifuge** avec un dégagement de fumée particulièremen faible **flame retardant** with particularly low smoke emission
Composition du câble	**Cable structure**	
Conducteur; âme de cuivre étamé à brins fins; nombre supérieur à la spécification des normes	Conductor: fine-wire tinned copper strands Number larger than standard	**Classe 5 selon CEI/EN 60228 Wire class 5 in accordance to IEC/EN 6022**
Isolation intérieure (couleur naturelle) Isolation de gaine, avec couleur (noir, rouge ou bleu)	Inner insulation (natural-coloured) Sheath insulation, with colour patch (black, red or blue)	**Polyoléfine** (compound réticulé chimiquement **Polyolefin** (Chemically linked compound)
Homologations	**Approvals**	
Certification par le TÜV, testé selon 2 PfG 1169/08.07	TÜV certified, tested according to 2 PfG 1169/08.07)	**Certificat TÜV n° R 60024459 TÜV Certificate No. R 60024459**

Figure 275: **Extract of the Multi-Contact Flex-Sol cable datasheet**

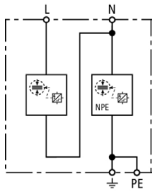
Product Data Sheet: DEHNshield®

DSH TT 2P 255 (941 110)

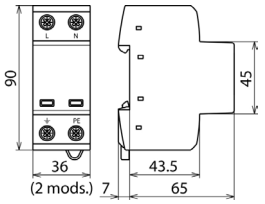
- Application-optimised prewired spark-gap-based combined lightning current and surge arrester
- Space-saving arrester for compact and simply equipped electrical installations with reduced technical requirements
- Capable of protecting terminal equipment



Figure without obligation



Basic circuit diagram DSH TT 2P 255



Dimension drawing DSH TT 2P 255

Application-optimised prewired combined lightning current and surge arrester for single-phase TT and TN-S systems ("1+1" circuit)

Type Part No.	DSH TT 2P 255 941 110
SPD according to EN 61643-11 / IEC 61643-1/-11	Type 1 / Class I
Energy coordination with terminal equipment	Type 1 + Type 2
Energy coordination with terminal equipment (≤ 5 m)	Type 1 + Type 2 + Type 3
Nominal a.c. voltage (U_N)	230 V
Max. continuous operating a.c. voltage (U_C)	255 V
Lightning impulse current (10/350 µs) [L+N-PE] (I_{total})	25 kA
Specific energy [L+N-PE] (W/R)	156.25 kJ/ohms
Lightning impulse current (10/350 µs) [L-N]/[N-PE] (I_{imp})	12.5 / 25 kA
Specific energy [L-N]/[N-PE] (W/R)	39.06 / 156.25 kJ/ohms
Nominal discharge current (8/20 µs) [L-N]/[N-PE] (I_n)	12.5 / 25 kA
Voltage protection level [L-N]/[N-PE] (U_P)	≤ 1.5 / ≤ 1.5 kV
Follow current extinguishing capability [L-N]/[N-PE] (I_{fi})	25 kA_{rms} / 100 A_{rms}
Follow current limitation/Selectivity	no tripping of a 32 A gL/gG fuse up to 25 kA_{rms} (prosp.)
Response time (t_A)	≤ 100 ns
Max. mains-side overcurrent protection	160 A gL/gG
Temporary overvoltage (TOV) [L-N] (U_T)	440 V / 5 sec.
Temporary overvoltage (TOV) [N-PE] (U_T)	1200 V / 200 ms
TOV characteristic	withstand
Operating temperature range (T_U)	-40 °C...+80 °C
Operating state/fault indication	green / red
Number of ports	1
Cross-sectional area (L, N, PE, ⏚) (min.)	1.5 mm^2 solid/flexible
Cross-sectional area (L, N, PE, ⏚) (max.)	35 mm^2 stranded/25 mm^2 flexible
For mounting on	35 mm DIN rails acc. to EN 60715
Enclosure material	thermoplastic, red, UL 94 V-0
Place of installation	indoor installation
Degree of protection	IP 20
Capacity	2 module(s), DIN 43880
Approvals	KEMA, UL
Weight	275 g
Customs tariff number	85363030
GTIN	4013364137899
PU	1 pc(s)

We reserve the right to introduce changes in performance, configuration and technology, dimensions, weights and materials in the course of technical progress. The figures are shown without obligation.

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✔, : Tested NEW: New : Discontinued Model

Back-UPS® ES 400/550/700

www.apc.com

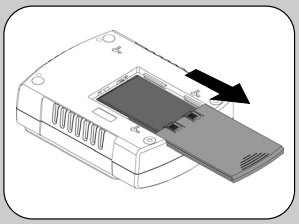
User's Guide

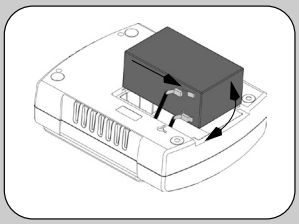
1 Connect Battery

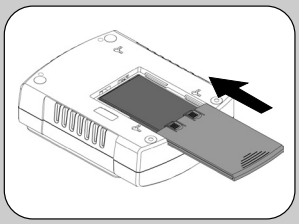
For safety, the Back-UPS ES is shipped with one battery wire disconnected. The Back-UPS ES will not operate until the wire is connected to the touch safe battery terminal.

NOTE: Small sparks may occur during battery connection. This is normal.

1. TURN the Back-UPS ES over and slide the battery compartment cover off of the battery housing.
2. LIFT the battery out of the compartment and connect the black wire to the negative (-) battery terminal. Ensure the batteries are installed as shown below.
3. Slide the battery compartment cover back onto the battery housing.



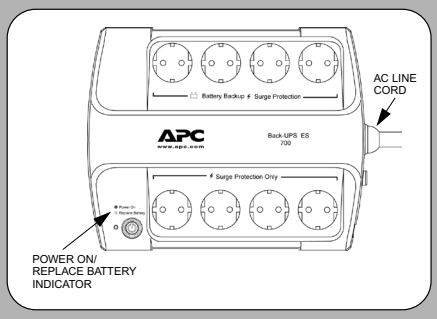




2 Connect Equipment

Battery Backup **Surge Protection**

These outlets are powered whenever the Back-UPS ES is switched ON. During a power outage or other utility problems (brownouts, over-voltages), these outlets will be powered for a limited time by the Back-UPS ES. Plug your computer, monitor, and two other data-sensitive devices (external disk or tape drive) into these outlets.



Surge Protection Only

These outlets provide full-time protection from surges even if the Back-UPS ES is switched OFF. Plug your printer, fax machine, scanner, or other peripherals that do not need battery power into these outlets.

Place the Back-UPS ES to avoid:

- Direct sunlight
- Excessive heat
- Excessive humidity or contact with fluids



Plug the Back-UPS ES power cord directly into a wall outlet; not a surge protector or power strip. The wall outlet should be located near the equipment and be easily accessible.

Connect Modem / Phone / DSL / Fax / 10/100 Base- T/HPNA to Surge Protection.

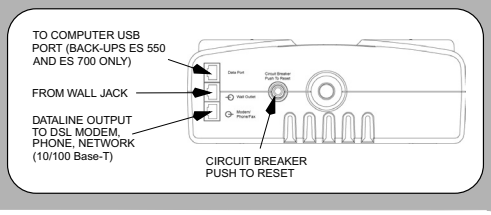
The Back-UPS protects a single line (2-wire) phone (including Digital Subscriber line - DSL), Home Phoneline Networking Association (HPNA) type equipment, modem, 10/100. Base-T Ethernet, or fax machines from surges when connected through the UPS as shown in the drawing below.

Note: Telephone Cable OR Network Cable should be connected to Surge Protection ports. Do not connect the UPS surge protection ports to both Telephone and Network System cables at the same time.

Connect Computer Cable (This is applicable for 550/700 only)

The supplied cable and software provide automatic file saving and shutdown of the operating system in the case of a sustained power outage.

Connect the cable to the Data Port of the Back-UPS ES. Connect the other end of the cable to the USB port on your computer. The software will automatically find the USB Port of your computer.



3 Power On and Install Software

Press the ON/OFF switch to power the unit ON.

A single short beep and the green "Power On" indicator confirms that Back-UPS ES is on and ready to provide protection.

The Back-UPS ES should charge for at least 16 hours to ensure sufficient runtime. The unit is being charged whenever it is connected to utility power, whether the unit is turned ON or OFF.

Install the PowerChute Personal® Edition software (This is applicable for 550/700 only.)

Place the PowerChute Personal Edition CD-ROM into your computer and follow the installation instructions on the screen.

Status Indicators

The Back-UPS ES indicates operating status using a combination of visual and audible indicators. Use the following table to identify the status of the Back-UPS ES.

Status	Visual Indications (Power On - Green) (Replace Battery - Red)	Audible Indication	Alarm Terminates When
Power On - UPS is supplying conditioned utility power to the load.	Power On LED - ON	None	Not applicable.
On Battery - UPS is supplying battery power to the load connected to the Battery outlets.	Power On LED - ON (off during beep)	Beeping 4 times every 30 seconds	UPS transfers back to Power On operation, or when UPS is turned off.
Low Battery Warning - UPS is supplying battery power to the load connected to the Battery outlets and the battery is near exhaustion.	Power On LED - flashing	Rapid beeping (every 1/2 second)	UPS transfers back to normal operation, or when UPS is turned off.
Replace Battery - Battery is in need of charging or is at the end of its usual life and must be replaced.	Power On and Replace Battery LEDs - Flashing (alternating)	Constant tone	UPS turned off with the power switch.
Battery Disconnected - The battery is disconnected or bad battery.	Replace Battery LED - flashing	Constant tone	UPS turned off with the power switch.
Overload Shutdown - During On Battery operation a battery power supplied outlet overload was detected.	None	Constant tone	UPS turned off with the power switch.
Sleep Mode - During On Battery operation the battery power has been completely exhausted and the UPS is waiting for utility power to return to normal.	None	Beeping once every 4 seconds.	Utility power is restored, or if utility power is not restored within 32 seconds, or the UPS is turned off.

See the Troubleshooting section for additional assistance.

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Troubleshooting

Use the table below to solve minor Back-UPS ES installation or operation problems. Consult APC Online Technical Support or call APC Technical Support for assistance with problems that cannot be resolved using the table below:

Problem	Probable Cause	Solution
Back-UPS ES will not turn on.	Battery is disconnected or utility power is not available at the wall outlet.	Connect the battery (see *Connect Battery*) and ensure power is available at the wall outlet.
No power available at the Surge Protection Only outlets.	Surge Protection Only outlets have been overloaded.	Reduce the amount of equipment plugged into Surge Protection Only outlets.
	Utility power not available at the wall outlet.	Ensure the fuse or circuit breaker for the outlet is not tripped, and that the wall switch controlling the outlet (if any) is in the ON position.
Connected equipment loses power.	Equipment is connected to the Surge Protection Only outlets.	Ensure the equipment you want to stay powered during a power failure is plugged into the Battery Backup/Surge Protection outlets and NOT the Surge Protection Only outlets.
	The Back-UPS ES is overloaded.	Make sure the equipment plugged into the Battery Backup/Surge Protection outlets of the unit are not overloading the capacity of the unit. Try removing some of the equipment and see if the problem continues.
	PowerChute Personal Edition software has performed a shutdown due to a power failure.	The Back-UPS ES is operating normally.
	The Back-UPS ES has exhausted its available battery power.	The Back-UPS ES can only operate on battery power for a limited amount of time. The unit will eventually turn off when the available battery power has been used. Allow the unit to recharge for 16 hours before continuing use of the unit.
	Connected equipment does not accept the step-approximated sine waveform of the Back-UPS ES.	The output waveform is designed for computers and computer-related equipment. It is not designed for use with motor-type equipment.
	The Back-UPS ES may require service.	Contact APC Technical Support for further troubleshooting.
The Power On indicator is lit and the Back-UPS ES is beeping four times every 30 seconds.	The Back-UPS ES is using battery.	The Back-UPS ES is operating normally and using battery power. Once On Battery, you should save your current work, power down your equipment, and turn the unit OFF. Once normal power is restored, you may turn the unit back ON and power your equipment.
The Power On indicator flashes once per second and the Back-UPS ES beeps once per second at the same time.	Battery capacity is low (about 2 minutes of use remaining).	The Back-UPS ES is about to shut off due to a low battery charge condition! When the unit beeps once every second, the battery has about 2 minutes of power remaining. Immediately power down your computer and turn the unit OFF. When normal power returns, the unit will recharge the battery.
Inadequate runtime.	The battery is not fully charged.	Allow the unit to charge by leaving it plugged into the wall for at least 16 hours.
	Battery is near the end of useful life.	As a battery ages, the amount of runtime available will decrease. You can replace the battery by ordering one at www.apc.com. Batteries also age prematurely if the Back-UPS ES is placed near excessive heat.

Specifications

Item	Specification	BE400	BE550	BE700
Input	Voltage	230 Vrms Nominal		
	Frequency	50 - 60 Hz (auto sensing)		
	Brownout Transfer	180 Vrms, typical		
	Over-voltage Transfer	266 Vrms, typical		
Output	Voltage On Battery	230 Vac rms +/- 8%		
	Total Amperage (8 outlets)	10 Amps (including UPS output)		
	UPS Capacity (4 outlets)	400VA/240W	550VA/330W	700VA/405W
	Frequency - On Battery	50/60 Hz +/-1 Hz		
	Transfer Time	6 ms typical, 10 ms maximum		
Protection and Filter	AC Surge Protection	Full time, 310 joules		
	Phone/fax/DSL Surge Protection	Single line (2-wire)		
	Network Surge Protection	10/100Base-T Ethernet		
	EMI/RFI Filter	Full time		
	AC Input	Resettable circuit breaker		
Battery	Type	Sealed, maintenance-free lead acid		
	Average Life	3 - 5 years depending on the number of discharge cycles and environmental temperature		
Physical	Net Weight	5.4kg	6.4kg	6.8kg
	Dimensions (H x W x D)	285 x 230 x 86 mm (11.18" x 9.05" x 3.3 in.)		
	Operating Temperature	0 °C to 40 °C (32 °F to 104 °F)		
	Storage Temperature	-15 °C to 45 °C (5 °F to 113 °F)		
	Operating Relative Humidity	0 to 95% non-condensing		
	Operating Elevation	0 to 3000 m (0 to 10,000 ft)		
Safety/Regulatory	Safety Approvals	CE, Nemko-GS, PCBC, GOST, IEC62040-1-1, IEC60884, IEC61643-1		
	EMC Compliance	EN50091-2, EN55022 Class B		

Order Replacement Battery

Replace with an APC qualified battery. Replacement batteries can be ordered from www.apc.com (valid credit card required). For Back-UPS ES 400, order **APCRBC106** as directed by APC Technical Support. For Back-UPS ES 550, order **RBC2.** For Back-UPS ES 700, order **RBC17.**

Warranty

The standard warranty is 3 years from the date of purchase. APC's standard procedure is to replace the original unit with a factory reconditioned unit. Customers who must have the original unit back due to assigned asset tags and set depreciation schedules must declare such a need at first contact with APC Technical Support. APC will ship the replacement unit once the defective unit is received by the repair department or cross-ship upon the provision of a valid credit card number. The customer pays for shipping to APC, and APC pays ground freight transportation costs back to the customer.

Service

Please DO NOT RETURN Back-UPS ES to the place of purchase under any circumstances.

1. Consult the Troubleshooting section to eliminate common problems.

2. Verify the battery is connected (see *Connect Battery*) and that the Circuit Breaker is not tripped (see *Troubleshooting* section).

If you still have problems or questions, please contact APC via the internet or at one of the phone numbers listed below.

3. Before contacting APC, please be sure to record the date purchased, UPS model, and serial number (on bottom of unit).

4. Be prepared to troubleshoot the problem over the telephone with a Technical Support Representative. If this is not successful, the representative will issue a Return Material Authorization Number (RMA#) and a shipping address.

5. Pack the unit in its original packaging. If the original packaging is not available, ask APC Technical Support about obtaining a new set. Pack the unit properly to avoid damage in transit. Never use foam beads for packaging. Damage sustained in transit is not covered under warranty (insuring the package for full value is recommended).

6. Write the RMA# on the outside of the package.

7. Return the unit by insured carrier to the address given to you by APC Technical Support.

Wall Mount of UPS

The UPS can be mounted vertically or horizontally to a wall surface. Use the template below to position the mounting fasteners (not supplied). Wall mount the UPS as follows;

1. Hold this page against the wall in the desired mounting location.

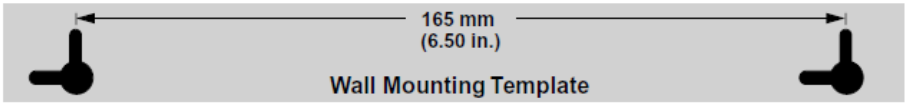
2. Use thumbtacks or tape to hold this page in place against the wall. Use a sharp nail or pin to puncture the center of each template circle to mark the wall.

3. Install the mounting fasteners at the marked locations. Leave the head of both fasteners 8 mm (5/16) out from the face of the wall. The fasteners must be able to support 6.8 Kg.

4. Mount the UPS by positioning the key-hole slots over the mounting fasteners heads. For vertical mounting, slide the UPS down into place. For horizontal mounting , Turn it slightly counterclockwise until it is securly in place.

APC Contact Information

APC Europe	353 91 702000
APC Asia Pacific	61 2 9955 9366
Mexico	292 0253 / 292 0255
Brazil	0800 555 272
Worldwide	1.401.789.5735
Internet	http://www.apc.com
Technical Support	http://www.apc.com/support



Wall Mounting Template

Protection against direct contact

See 5.3.4

IP code II if possible, devices which have IP I class will be equipped with an additional housing

Insolation class 0 is life threatening and so not installed at all in our building

Sockets will be protected by additional children protection in the team colour orange.

Exterior Equipment

See 5.3.4

Sockets will have IP 65

Connectors will be double insolated

Cables and LED stripes will be UV-resistant

Transformer will be installed in water free parts of the building

Protective devices

The size of the protective devices was calculated by the epINSTROM software. For further information see the one line diagramm in the project drawings and the following tables. See the results of epINSTROM electric planning on the following pages. Mr. Karsten PUls, electrician of the Knobelsdorffschule signated all the pages. He is allowed to plan and activate electrical systems by the network operator Vatenfall. This certificate is on the next page.

VATTENFALL

Vattenfall Europe Distribution Berlin GmbH
Postanschrift: 12432 Berlin

Oberstufenzentrum
Bautechnik/Holztechnik
Nonnendammallee 140
13599 Berlin

Vattenfall Europe
Distribution Berlin GmbH

Kundenmanagement
Netznutzung Berlin

Puschkinallee 52
12435 Berlin

Sehr geehrter Geschäftspartner,

mit der Eintragung in das Elektroinstallateurverzeichnis der Vattenfall Europe Distribution Berlin GmbH sind Sie entsprechend der Netzanschlussverordnung (NAV) berechtigt, elektrische Anlagen mit Nennspannungen bis 1000 V hinter der Hausanschlusssicherung, mit Ausnahme der Mess-, Zähl- und Steuereinrichtungen im Versorgungsbereich der Vattenfall Europe Distribution Berlin GmbH zu errichten, zu erweitern, zu ändern und zu unterhalten.

Bitte beachten Sie, dass bei einer Umfirmierung, Anschriftenänderung, Löschung oder Änderung der/des Fachtechnischen Betriebsleiter/s, wir unverzüglich gemäß den Grundsätzen, Punkt 4.5, zu informieren sind.

Für die Ausführung und Unterhaltung von Starkstromanlagen mit Nennspannungen über 1000 V ist eine Eintragungserweiterung erforderlich. Bitte wenden Sie sich diesbezüglich an unser Team Installateureintragungen.

Mit folgenden Daten sind Sie im Elektroinstallateurverzeichnis der Vattenfall Europe Distribution Berlin GmbH eingetragen:

Installateurnummer	**38**
Abteilung	**2HI**
Betriebsart	**Hilfsbetrieb intern**
Fachtechnischer Betriebsleiter	**Gerd Grahl, Karsten Puls**
Eintragungserweiterung	**Nein**

Freundliche Grüße

Vattenfall Europe Distribution Berlin GmbH
Netznutzung Berlin

i. A. Voth

i. A. Manig

Datum
01.07.2011

Unsere Zeichen
DD-GCB2

Ansprechpartner/in
Thomas Manig

Telefon-Durchwahl
030-492 02-86 78

Telefax-Durchwahl
030-492 02-89 59

E-Mail
thomas.manig
@vattenfall.de

Ihre Zeichen

Ihre Nachricht vom

www.vattenfall.de

Vorsitzender des Aufsichtsrates
Mats Fagerlund

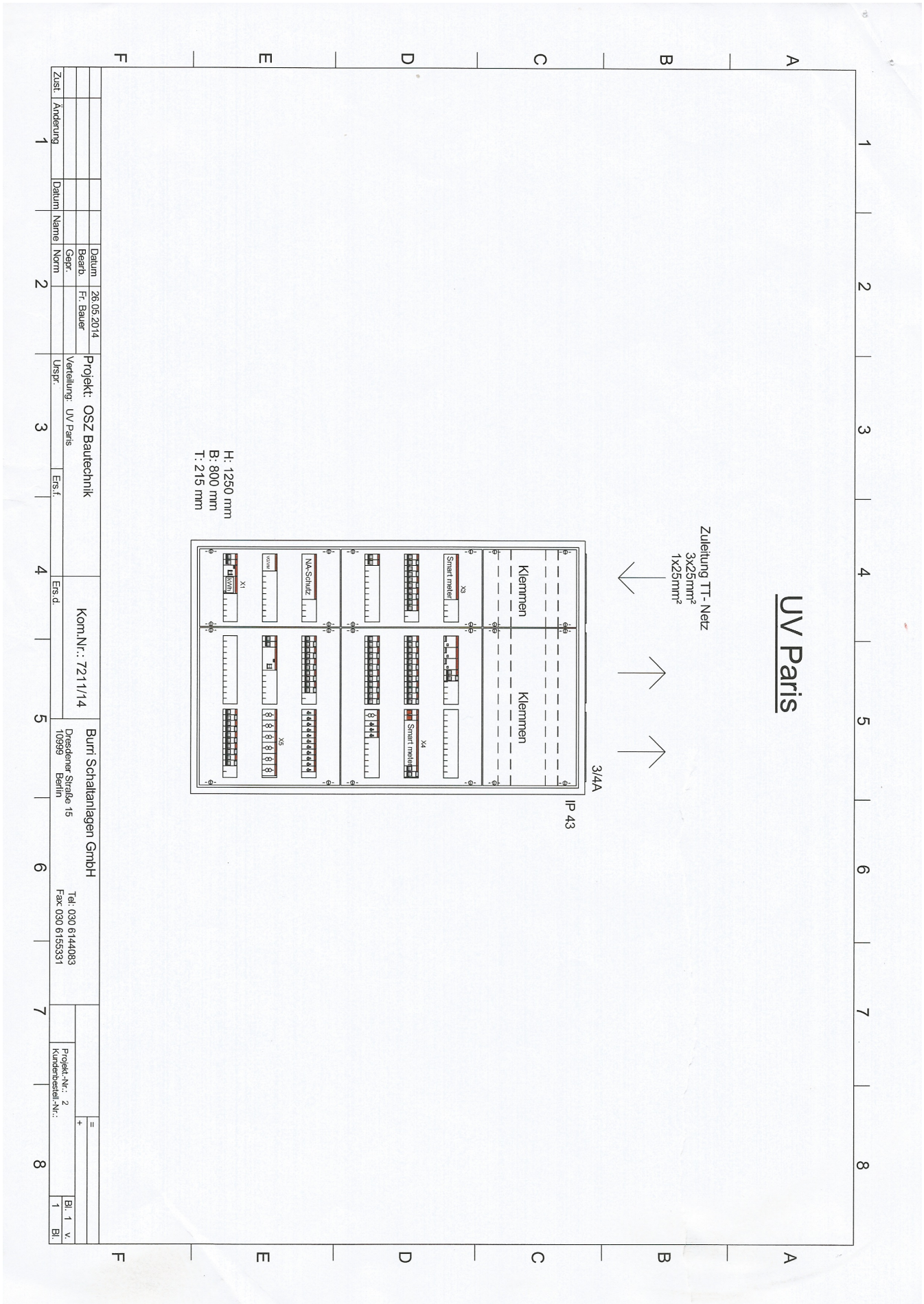
Geschäftsführer
Dr. Helmar Rendez, Vorsitzender
Dr. Dietrich Graf
Jürgen Grieger
Dr. Erik Landeck

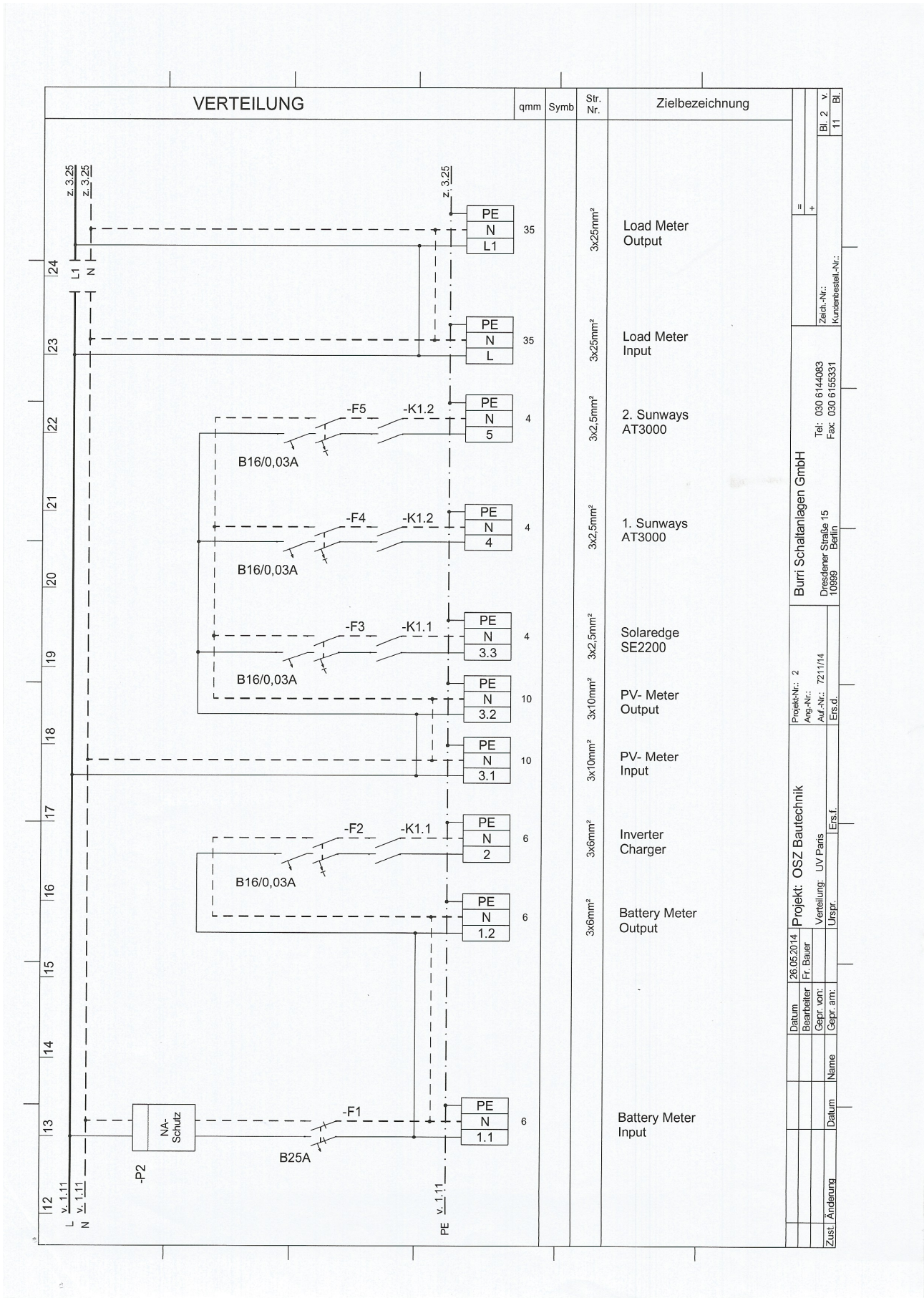
Sitz der Gesellschaft
Berlin

Handelsregister
Amtsgericht Charlottenburg
HRB 96555

Bankverbindung
Landesbank Baden-Württemberg
BLZ 600 501 01

Verwendungszweck
DSO Berlin
Konto-Nr. 2255949
DE02 6005 0101 0002 2559 49
SOLADESTXXX


UV Paris
Zuleitung TT- Netz
3x25mm²
1x25mm²
Klemmen
Klemmen
3/4A
IP 43
Smart meter
X3
X4
Smart meter
NA-Schutz
X1
X5
H: 1250 mm
B: 800 mm
T: 215 mm
Projekt: OSZ Bautechnik
Kom.Nr.: 7211/14
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Datum
Name
Bearb.
Fr. Bauer
26.05.2014
Gepr.
Norm
Verteilung: UV Paris
Urspr.
Ers.f.
Ers.d.
Zust.
Änderung
Projekt-Nr.: 2
Kundenbestell-Nr.:
Bl. 1 v. Bl. 1


VERTEILUNG
qmm
Symb
Str. Nr.
Zielbezeichnung
Load Meter Output
Load Meter Input
2. Sunways AT3000
1. Sunways AT3000
Solaredge SE2200
PV- Meter Output
PV- Meter Input
Inverter Charger
Battery Meter Output
Battery Meter Input
-F5
-K1.2
-F4
-F3
-K1.1
-F2
-F1
B16/0,03A
B25A
NA-Schutz
-P2
Burri Schaltanlagen GmbH
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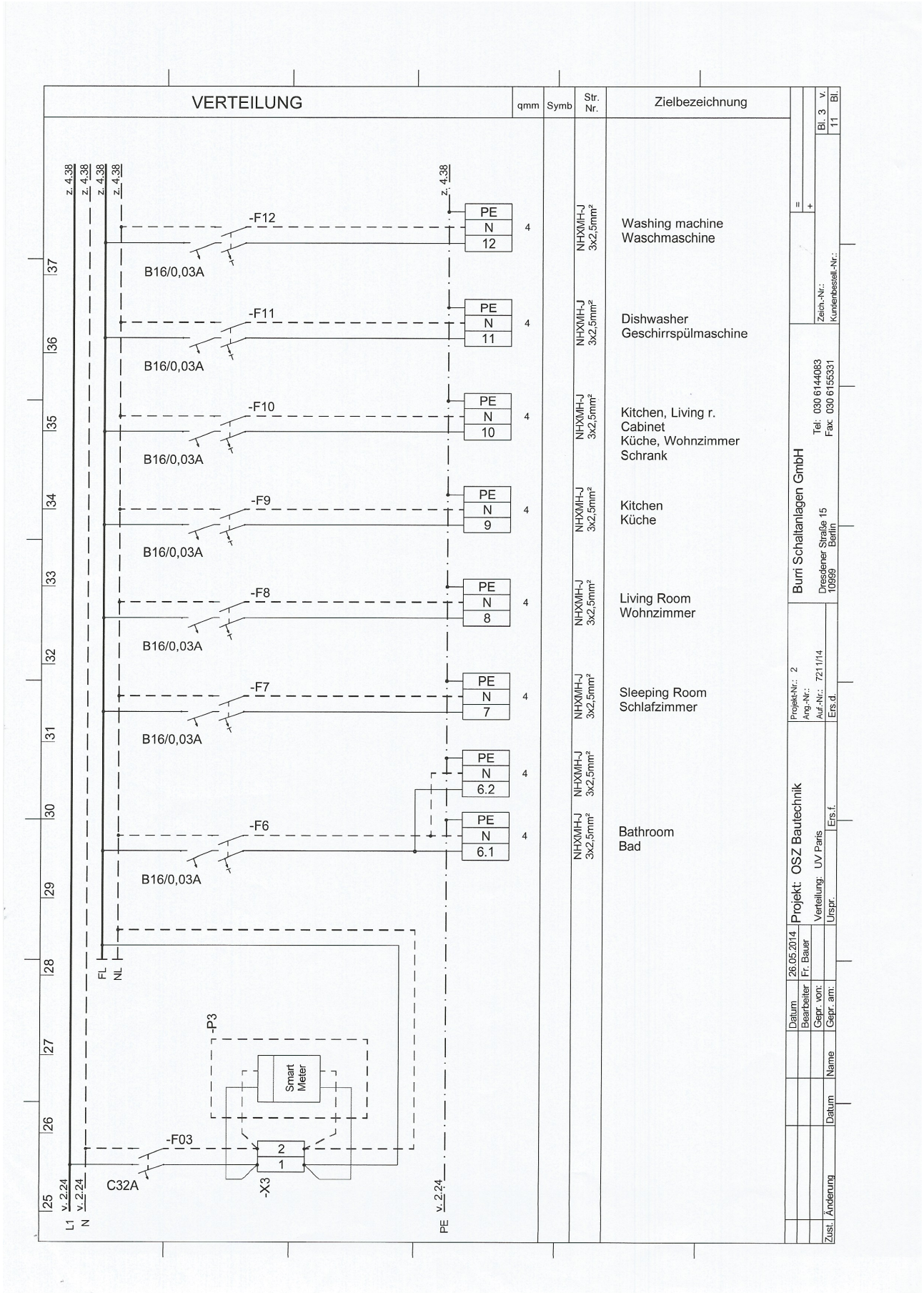
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt: OSZ Bautechnik
Verteilung: UV Paris
26.05.2014
Fr. Bauer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qmm
Symb
Str. Nr.
Zielbezeichnung
-F12
B16/0,03A
PE
N
12
Washing machine
Waschmaschine
-F11
11
Dishwasher
Geschirrspülmaschine
-F10
10
Kitchen, Living r.
Cabinet
Küche, Wohnzimmer
Schrank
-F9
9
Kitchen
Küche
-F8
8
Living Room
Wohnzimmer
-F7
7
Sleeping Room
Schlafzimmer
6.2
-F6
6.1
Bathroom
Bad
NHXMH-J
3x2,5mm²
4
z. 4.38
v. 2.24
L1
N
PE
FL
NL
-P3
Smart Meter
-F03
C32A
-X3
2
1
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt: OSZ Bautechnik
Verteilung: UV Paris
Datum
Bearbeiter
Fr. Bauer
26.05.2014
Gepr. von:
Gepr. am:
Name
Änderung
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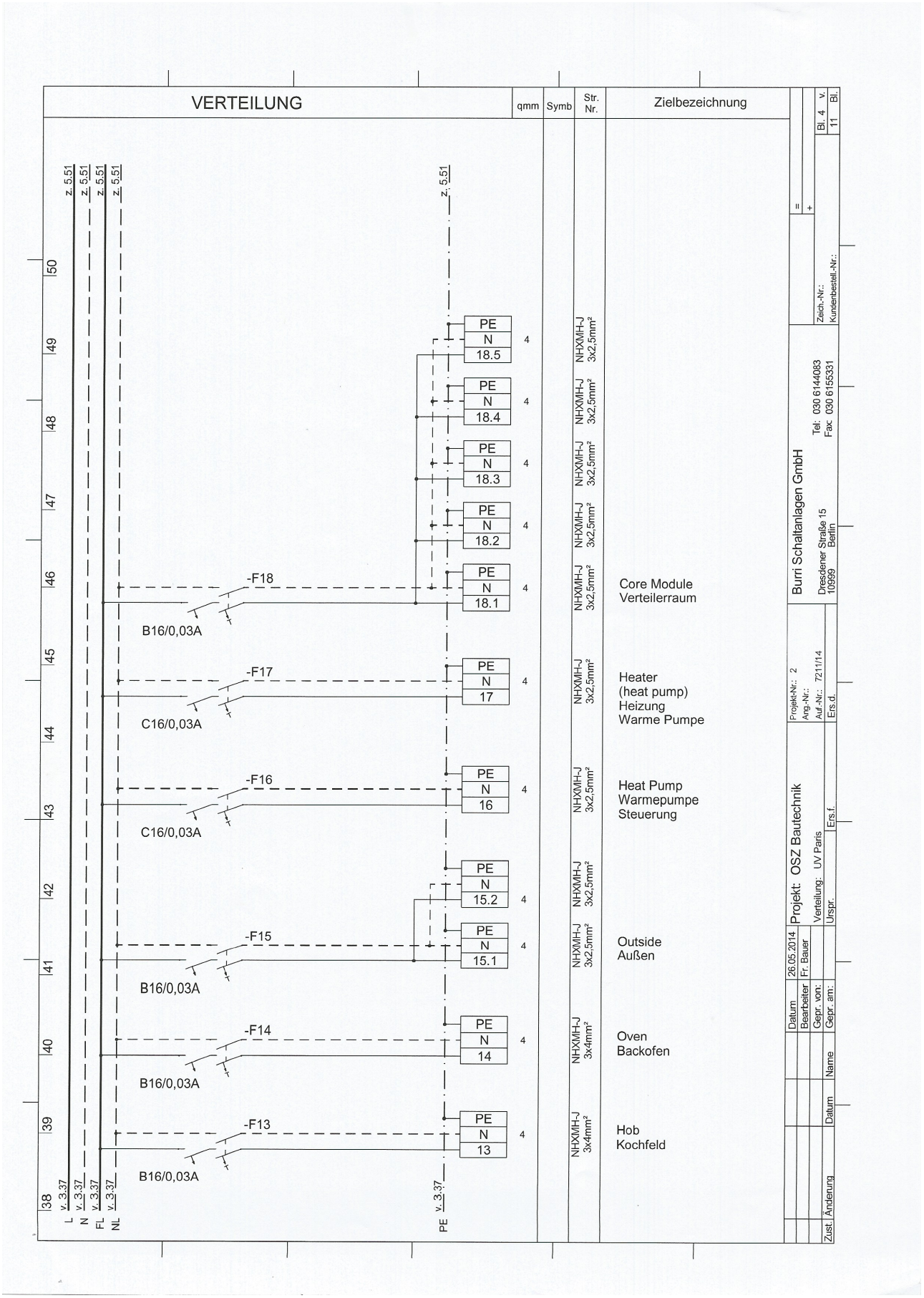
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qmm
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v. 3.37
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N
FL
NL
PE
-F18
-F17
-F16
-F15
-F14
-F13
B16/0,03A
C16/0,03A
PE
N
18.5
18.4
18.3
18.2
18.1
17
16
15.2
15.1
14
13
4
NHXMH-J 3x2,5mm²
NHXMH-J 3x4mm²
Core Module
Verteilerraum
Heater
(heat pump)
Heizung
Warme Pumpe
Heat Pump
Warmepumpe
Steuerung
Outside
Außen
Oven
Backofen
Hob
Kochfeld
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt: OSZ Bautechnik
Verteilung: UV Paris
Projekt-Nr.: 2
Arg.-Nr.:
Auf.-Nr.: 7211/14
Ers.d.
Ers.f.
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Gepr. am:
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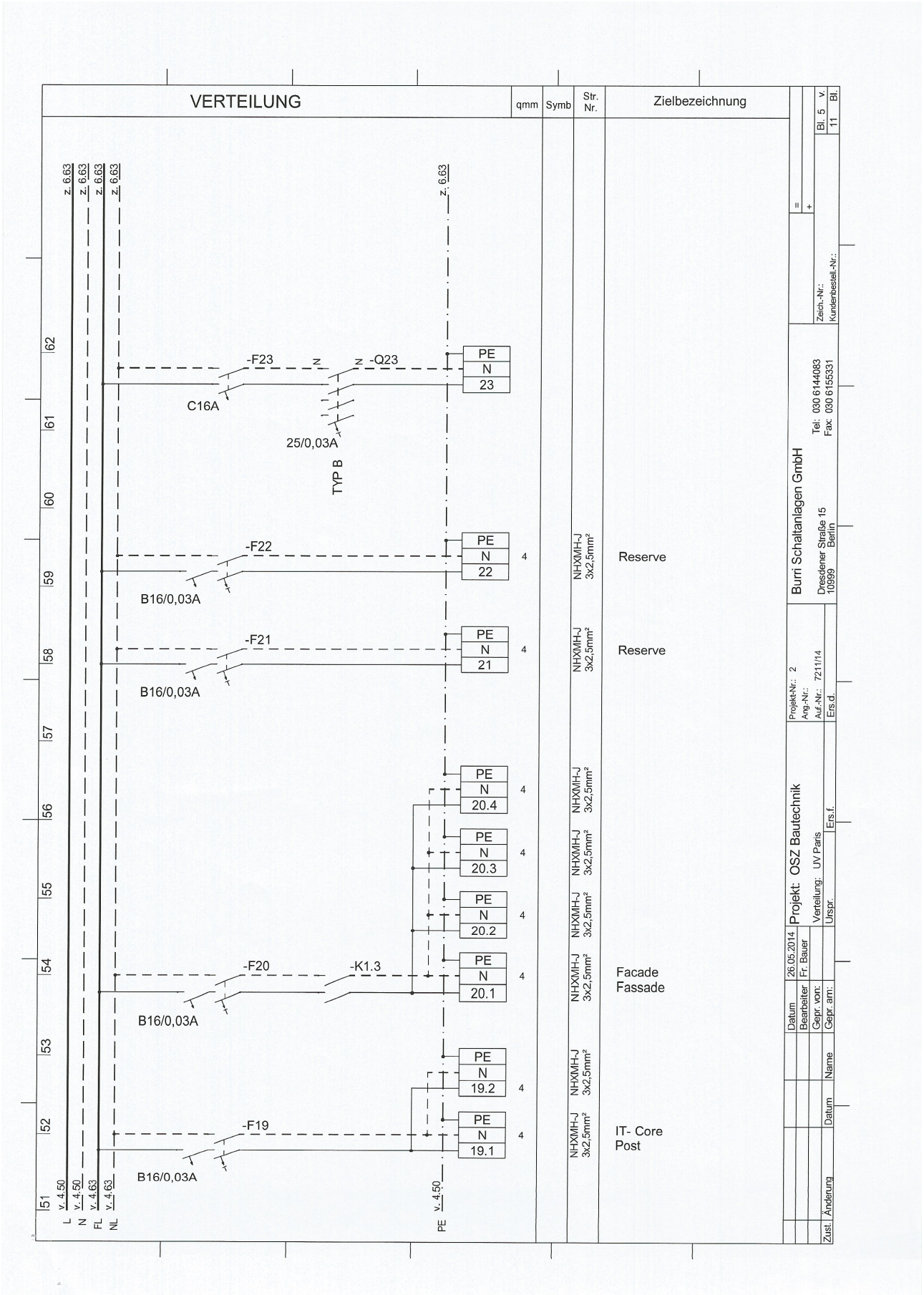
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qmm
Symb
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Zielbezeichnung
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-F23
-Q23
C16A
25/0,03A
TYP B
PE
N
23
-F22
B16/0,03A
22
Reserve
-F21
21
-F20
-K1.3
Facade
Fassade
20.4
20.3
20.2
20.1
-F19
IT- Core
Post
19.2
19.1
NHXMH-J
3x2,5mm²
v. 4.50
v. 4.63
L
N
FL
NL
PE
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt: OSZ Bautechnik
Projekt-Nr.: 2
Ang.-Nr.:
Auf.-Nr.: 7211/14
Ers.d.
Ers.f.
Verteilung: UV Paris
Ursprung
Datum 26.05.2014
Bearbeiter Fr. Bauer
Gepr. von:
Gepr. am:
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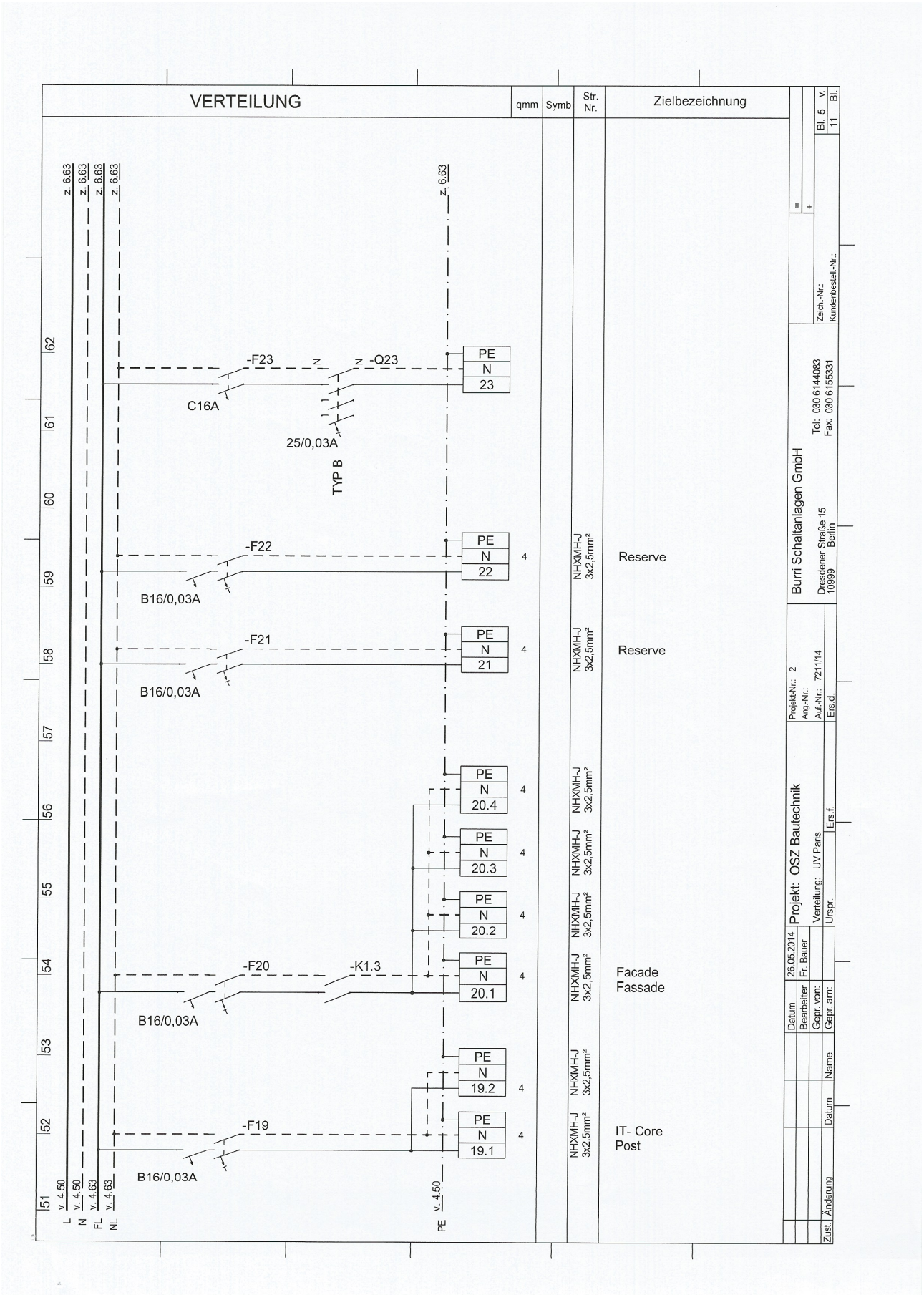
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TYP B
PE
N
23
-F22
B16/0,03A
22
Reserve
-F21
21
-F20
-K1.3
Facade
Fassade
20.4
20.3
20.2
20.1
-F19
IT- Core
Post
19.2
19.1
NHXMH-J
3x2,5mm²
v. 4.50
v. 4.63
L
N
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PE
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Fax: 030 6155331
Projekt: OSZ Bautechnik
Projekt-Nr.: 2
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Ers.f.
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Zust. Änderung
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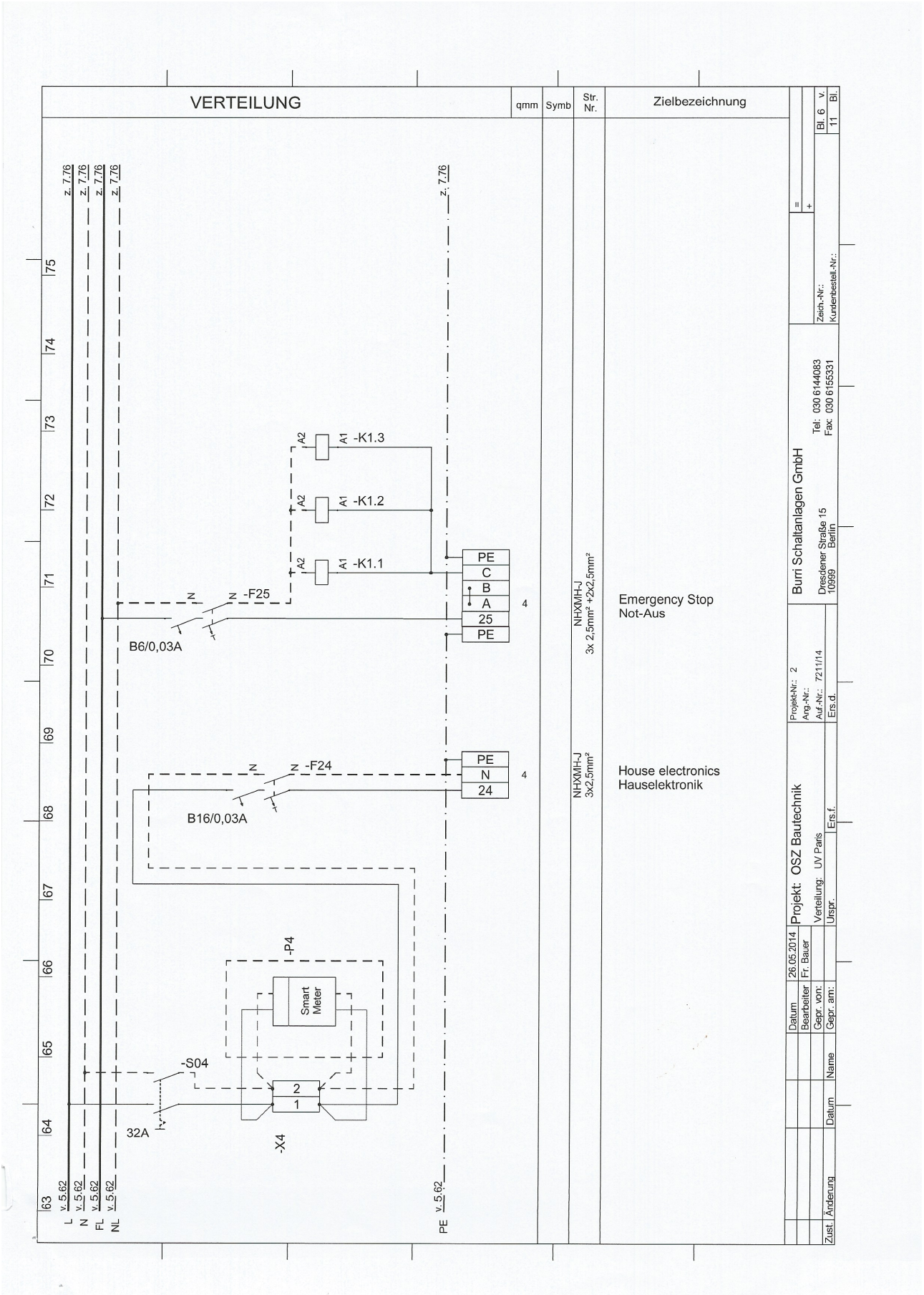
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Symb
Str. Nr.
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z. 7.76
-K1.3
-K1.2
-K1.1
-F25
B6/0,03A
PE
C
B
A
25
PE
4
NHXMH-J
3x 2,5mm² +2x2,5mm²
Emergency Stop
Not-Aus
-F24
B16/0,03A
PE
N
24
4
NHXMH-J
3x2,5mm²
House electronics
Hauselektronik
-P4
Smart Meter
-S04
2
1
32A
-X4
v. 5.62
L
N
FL
NL
PE
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt: OSZ Bautechnik
Verteilung: UV Paris
Projekt-Nr.: 2
Ang.-Nr.:
Auf.-Nr.: 7211/14
Datum 26.05.2014
Bearbeiter Fr. Bauer
Gepr. von:
Gepr. am:
Ursprr.
Ers.f.
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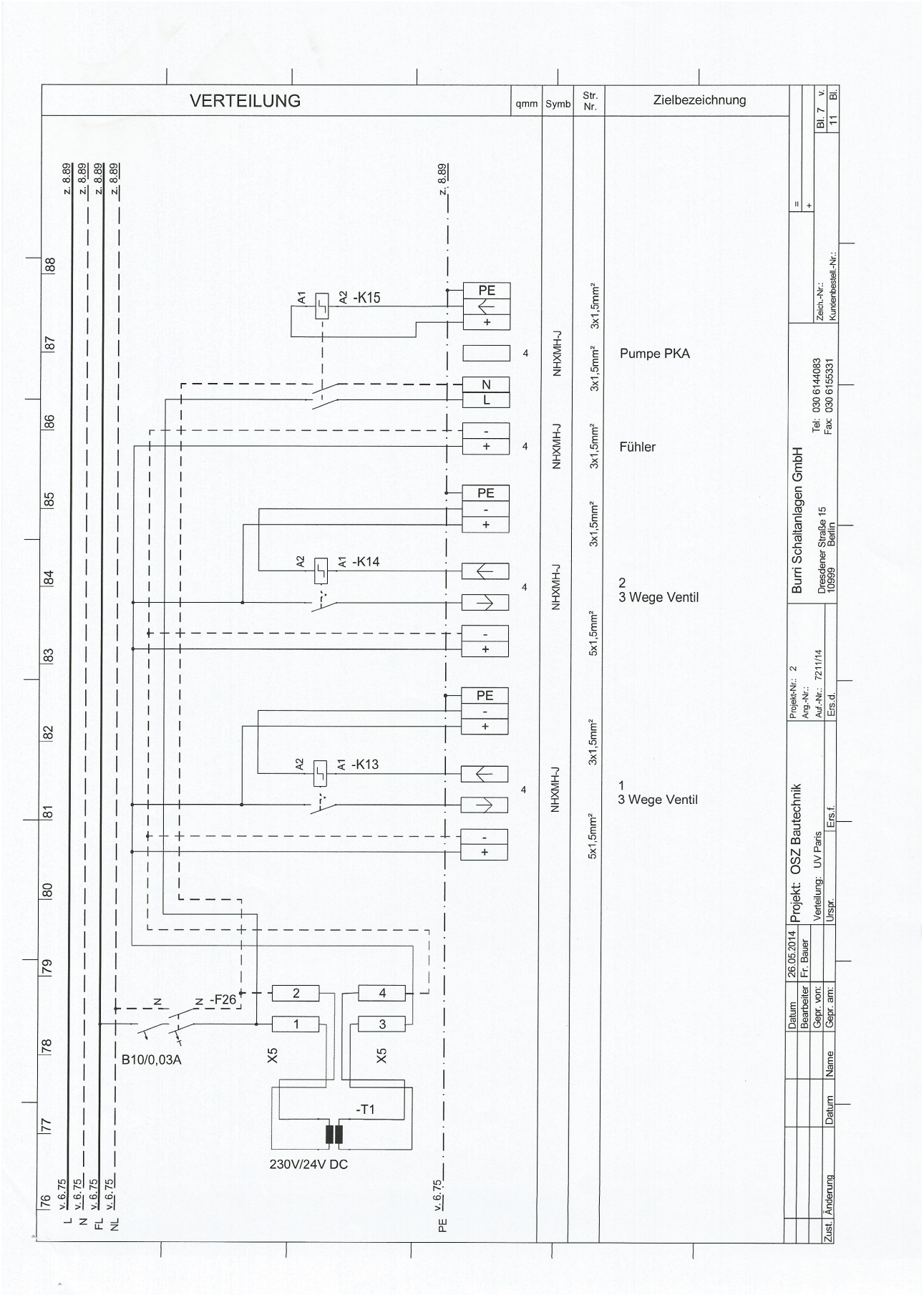
Zeich.-Nr.:
Kundenbestell.-Nr.:
Bl. 6 v.
11 Bl.
Zust.
Änderung
Datum
Name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Symb
Str. Nr.
Zielbezeichnung
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v. 6.75
L
N
FL
NL
PE
-K15
-K14
-K13
-F26
B10/0,03A
X5
-T1
230V/24V DC
NHXMH-J
3x1,5mm²
5x1,5mm²
Pumpe PKA
Fühler
2
3 Wege Ventil
1
3 Wege Ventil
Projekt: OSZ Bautechnik
Verteilung: UV Paris
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt-Nr.: 2
Arg.-Nr.:
Auf.-Nr.: 7211/14
Ers.d.
Ers.f.
Ursprr.
Datum
Bearbeiter
Gepr. von:
Gepr. am:
Name
Zust.
Änderung
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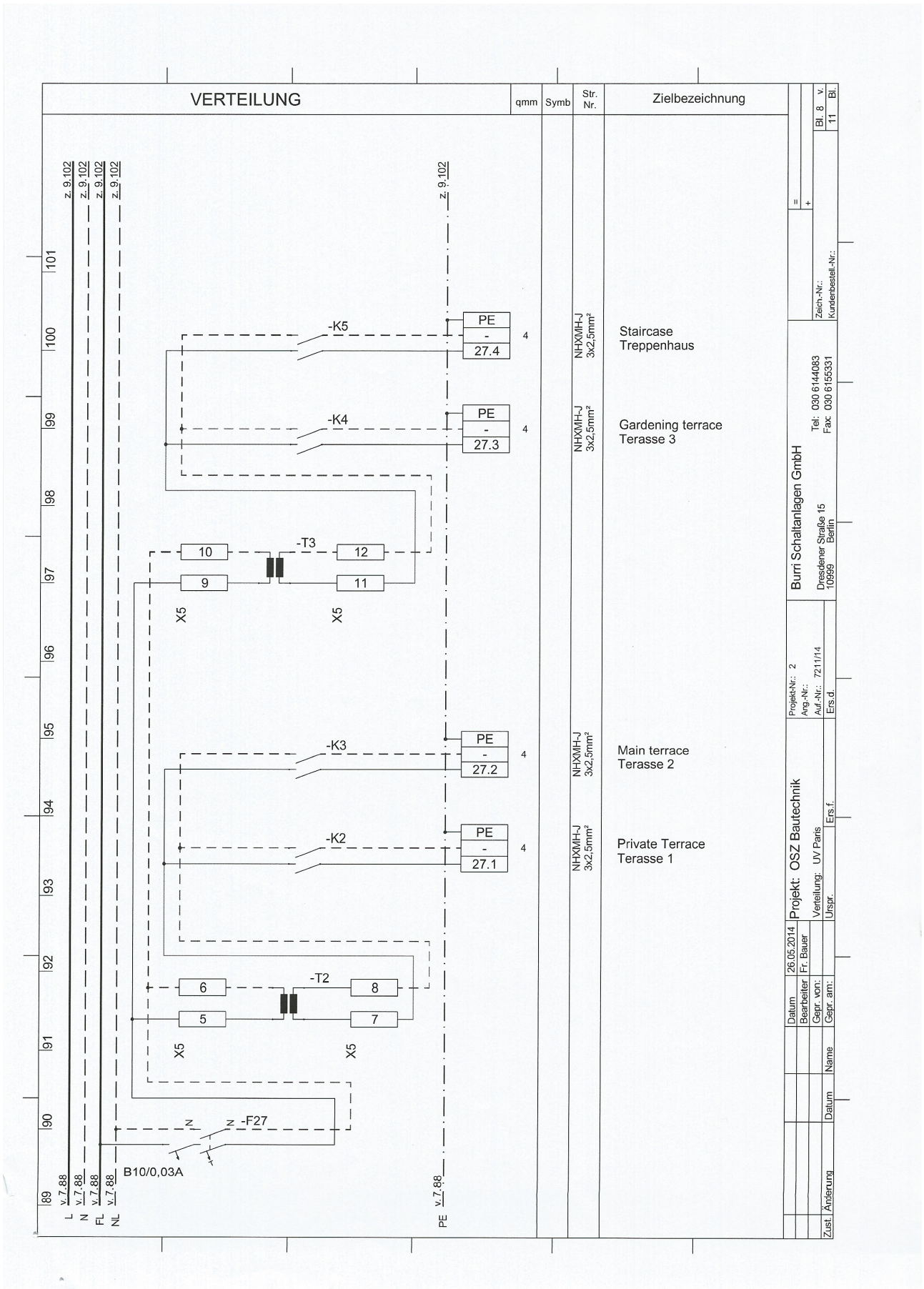
Kundenbestell.-Nr.:


VERTEILUNG
qmm
Symb
Str. Nr.
Zielbezeichnung
-K5
PE
-
27.4
NHXMH-J 3x2,5mm²
Staircase
Treppenhaus
-K4
PE
-
27.3
NHXMH-J 3x2,5mm²
Gardening terrace
Terasse 3
-T3
10
9
12
11
X5
X5
-K3
PE
-
27.2
NHXMH-J 3x2,5mm²
Main terrace
Terasse 2
-K2
PE
-
27.1
NHXMH-J 3x2,5mm²
Private Terrace
Terasse 1
-T2
6
5
8
7
X5
X5
-F27
B10/0,03A
z. 9.102
v.7.88
L
N
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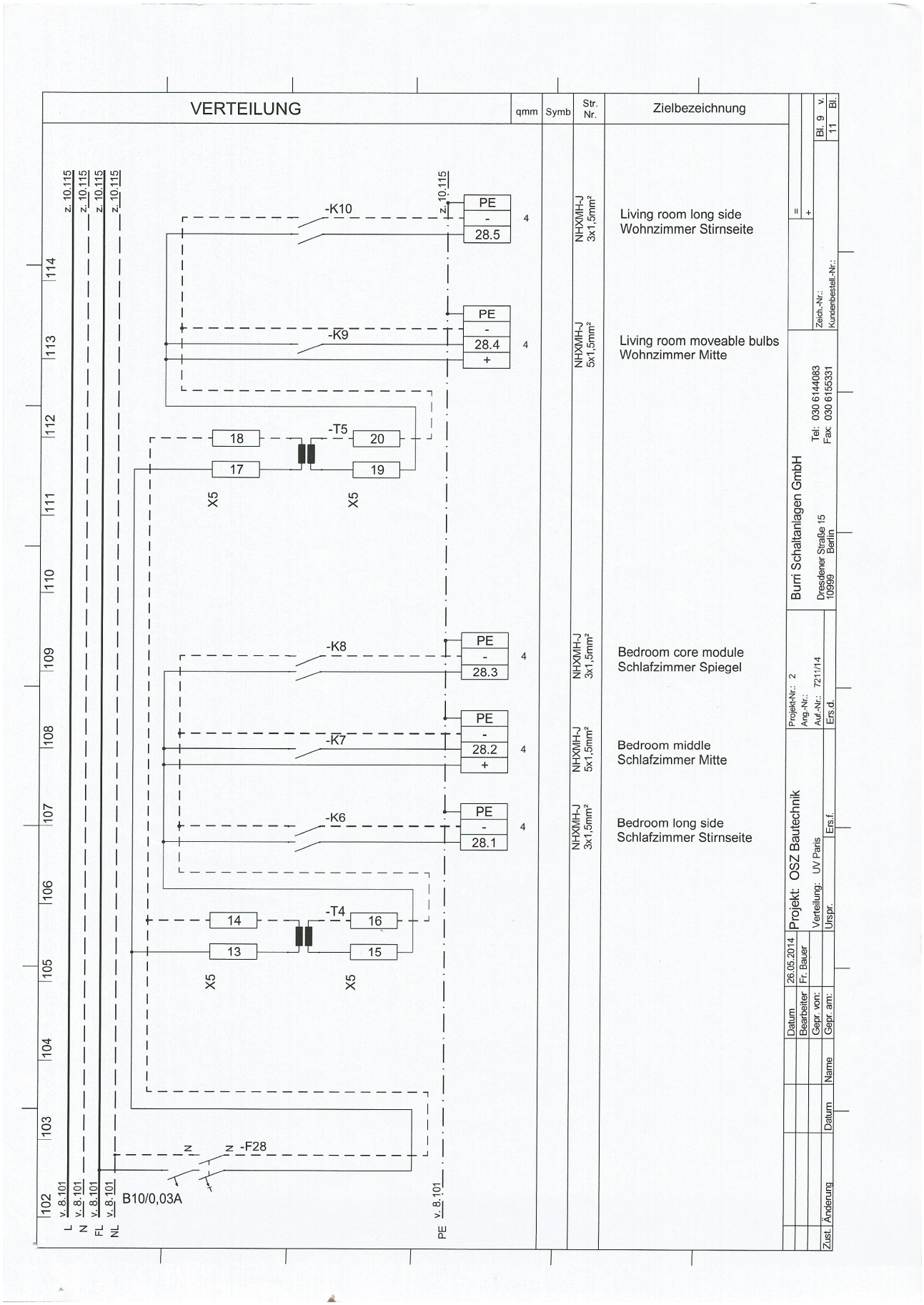
NL
PE
Burri Schaltanlagen GmbH
Dresdener Straße 15
10999 Berlin
Tel: 030 6144083
Fax: 030 6155331
Projekt: OSZ Bautechnik
Verteilung: UV Paris
Datum
Bearbeiter
Gepr. von:
Gepr. am:
Zust. Änderung
Name
Datum
26.05.2014
Fr. Bauer
Projekt-Nr.: 2
Arg.-Nr.:
Auf.-Nr.: 7211/14
Ers.d.
Ers.f.
Ursprung
Zeich.-Nr.:
Kundenbestell-Nr.:
Bl. 8
v. 11 Bl.


VERTEILUNG
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-K10
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NHXMH-J 3x1,5mm²
Living room long side
Wohnzimmer Stirnseite
-K9
PE
-
28.4
+
4
NHXMH-J 5x1,5mm²
Living room moveable bulbs
Wohnzimmer Mitte
-T5
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17
20
19
X5
X5
-K8
PE
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28.3
4
NHXMH-J 3x1,5mm²
Bedroom core module
Schlafzimmer Spiegel
-K7
PE
-
28.2
+
4
NHXMH-J 5x1,5mm²
Bedroom middle
Schlafzimmer Mitte
-K6
PE
-
28.1
4
NHXMH-J 3x1,5mm²
Bedroom long side
Schlafzimmer Stirnseite
-T4
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X5
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-F28
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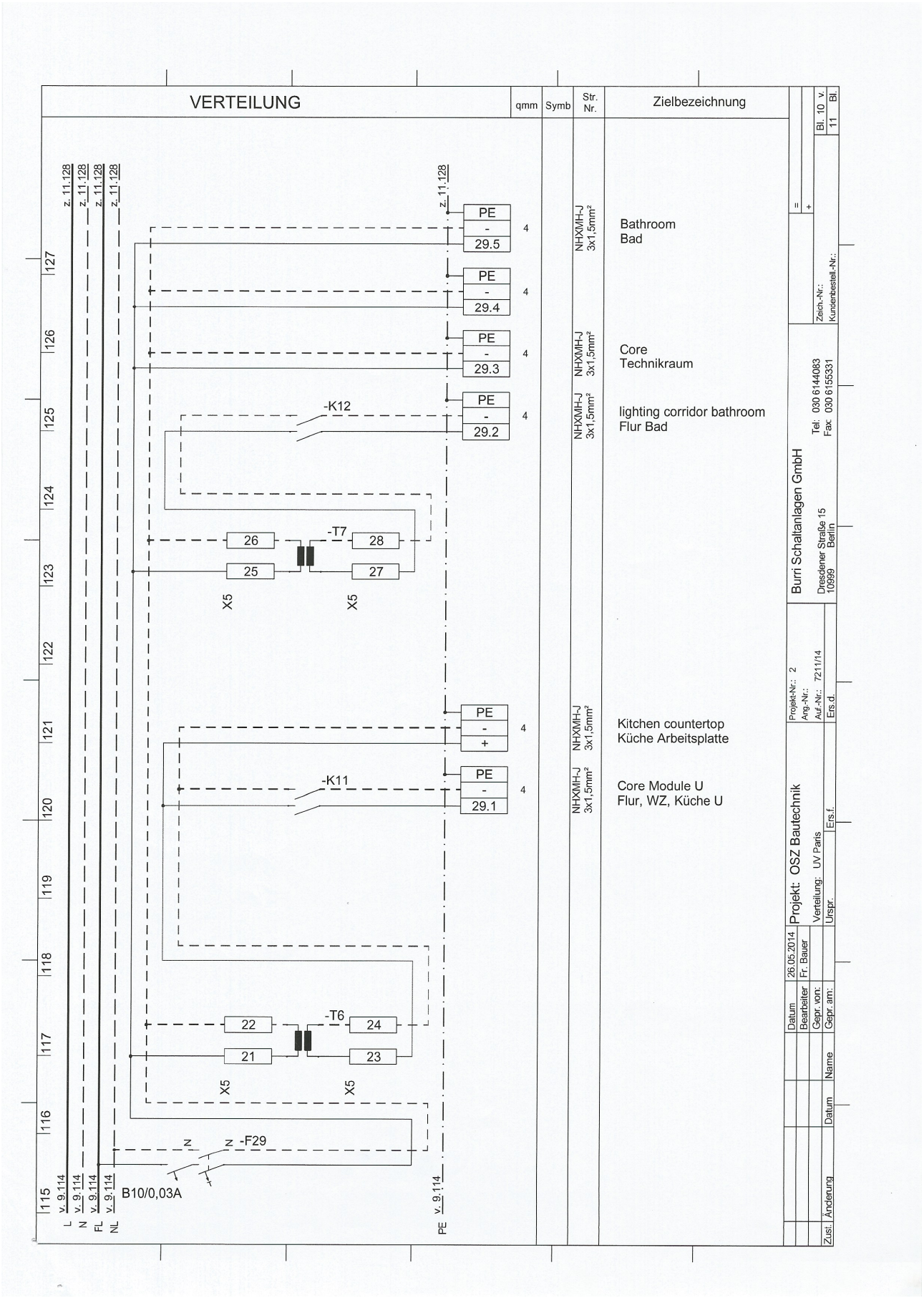
Änderung
Zust.
Zeich.-Nr.:
Kundenbestell.-Nr.:
Bl. 9 v.
11 Bl.


VERTEILUNG
qmm
Symb
Str. Nr.
Zielbezeichnung
Bathroom
Bad
Core
Technikraum
lighting corridor bathroom
Flur Bad
Kitchen countertop
Küche Arbeitsplatte
Core Module U
Flur, WZ, Küche U
NHXMH-J 3x1,5mm²
PE
-K12
-K11
-T7
-T6
-F29
X5
B10/0,03A
L
N
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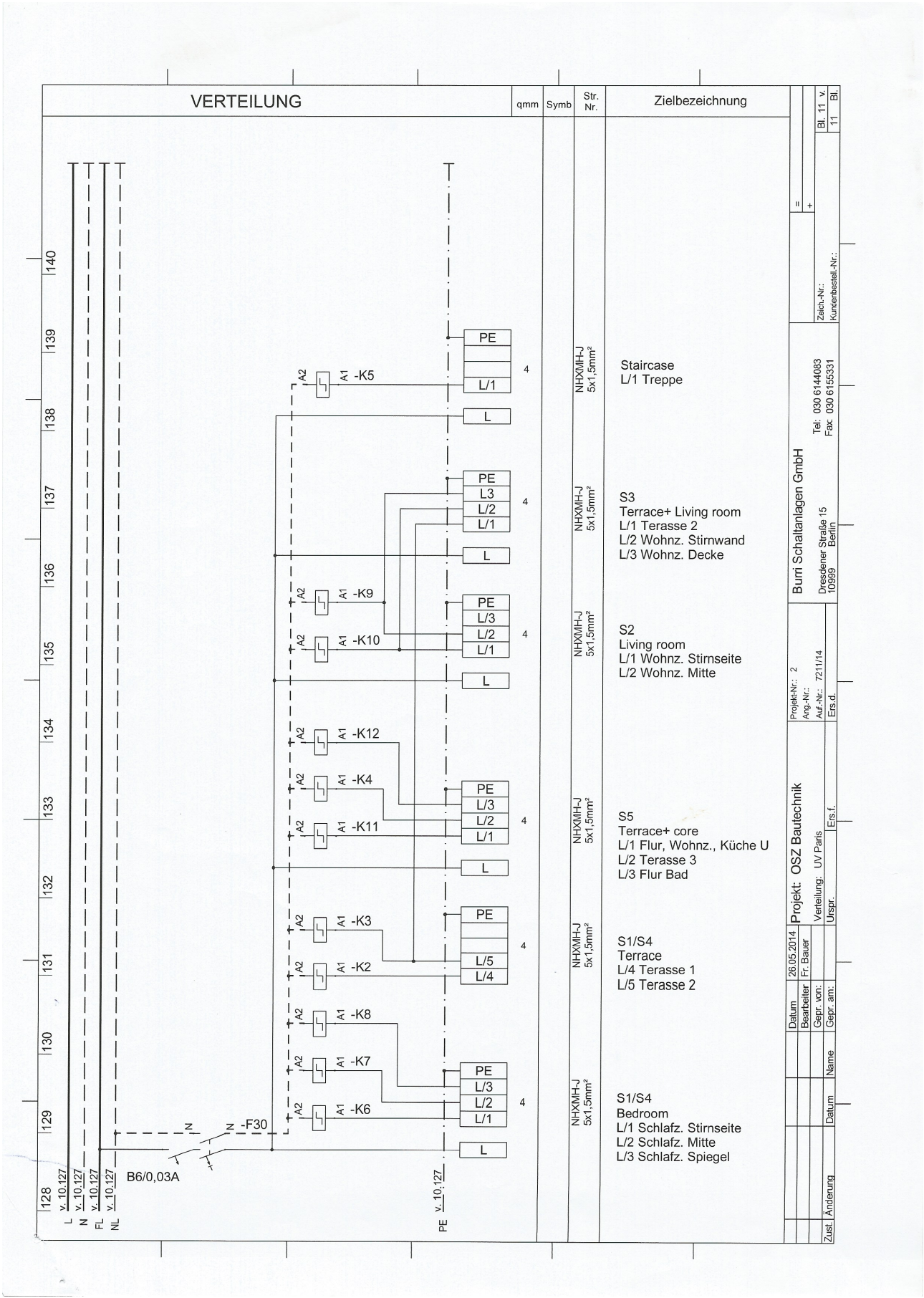
VERTEILUNG
qmm
Symb
Str. Nr.
Zielbezeichnung
-K5
-K9
-K10
-K12
-K4
-K11
-K3
-K2
-K8
-K7
-K6
-F30
B6/0,03A
PE
L/1
L
L3
L/2
L/5
L/4
NHXMH-J 5x1,5mm²
Staircase
L/1 Treppe
S3
Terrace+ Living room
L/1 Terasse 2
L/2 Wohnz. Stirnwand
L/3 Wohnz. Decke
S2
Living room
L/1 Wohnz. Stirnseite
L/2 Wohnz. Mitte
S5
Terrace+ core
L/1 Flur, Wohnz., Küche U
L/2 Terasse 3
L/3 Flur Bad
S1/S4
Terrace
L/4 Terasse 1
L/5 Terasse 2
S1/S4
Bedroom
L/1 Schlafz. Stirnseite
L/2 Schlafz. Mitte
L/3 Schlafz. Spiegel
v. 10,127
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Ers.f.
Ursprung
Zeich.-Nr.:
Kundenbestell.-Nr.:
Bl. 11 v. 11 Bl.

Fuse #	0	1	2	3	4	5	6	7	8	9
Location (DB-distribution board)	DB	DB	DB	DB	DB	DB	DB	DB	DB	DB
Description	Main grid	Lights outside 1	Lights ouside 2	Lights outside 3	Lights inside 1	Lights inside 2	lights inside 3	Bathroom	Hob	Oven
Device	RCD	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO
Type	S	A	A	A	A	A	A	A	A	A
Sensitivity [mA]	300	30	30	30	30	30	30	30	30	30
Rated current [A]	63	10	10	10	10	10	10	6	20	20
rated power of branch [W]	80	130	100	500	120	60	60	560	3400	3600
Load	housing grid	LED stripes	LED stripes	LED spots	LED stripes	LED stripes	LED stripes	Socket and LED Stripes	Hob	Oven

10	11	12	13	14	15	16	17	18	19	PV 1	PV2
DB	DB	DB	DB	DB	DB	DB	DB	DB	DB	DB	DB
Washing machine	Dish washer	Heat pump	Motor north	Motor south	Kitchen	Living room	Sleeping room	outdoor	Technique room	PV1 – AT300	PV2 – SE2200
RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO	RCBO
A	A	A	A	A	A	A	A	A	A	A	A
30	30	30	30	30	30	30	30	30	30	30	30
16	16	16	16	16	16	16	16	16	16	16	16
2300	2200	1400	400	400	2000	2000	1000	1000	500	-2875	-1840
Washing machine	Dish washer	Heat pump	12 Motors| run seperately	16 Motors| run separately	4 sockets	8 sockets	4 sockets	4 sockets	2 sockets		

SIEMENS
SINAMICS
V20
Getting Started
Compact Operating Instructions

Table of contents

1 Safety instructions 1

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1 Safety instructions

Before installing and putting this equipment into operation, read the following safety instructions and all the warning labels attached to the equipment carefully. Make sure that the warning labels are kept in a legible condition and replace missing or damaged labels. For more information, refer to the SINAMICS V20 Operating Instructions.

General



⚠ DANGER

Death from electric shock

Hazardous voltage remains present in the internal DC link capacitors when the power is removed.

Touching terminals could lead to death from electric shock.

Do not touch any terminals within five minutes after the power supply for the inverter has been switched off.

Protective earthing conductor current

The earth leakage current of the SINAMICS V20 inverter may exceed 3.5 mA AC. Therefore, a fixed earth connection is required and the minimum size of the protective earth conductor shall comply with the local safety regulations for high leakage current equipment.

The SINAMICS V20 inverter has been designed to be protected by fuses; however, as the inverter can cause a DC current in the protective earthing conductor, if a Residual Current Device (RCD) or Residual Current Monitoring Device (RCM) is to be used upstream in the supply, the device must be of type B.

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⚠ WARNING

Safe use of inverters

This equipment contains dangerous voltages and controls potentially dangerous rotating mechanical parts. Loss of life, severe personal injury, or property damage could result if the instructions contained in this manual are not followed.

Only suitably qualified personnel should work on this equipment, and only after becoming familiar with all safety instructions, installation, commissioning, operation, and maintenance procedures contained in this manual.

Any unauthorized modifications of the equipment are not allowed.

Protection in case of direct contact by means of voltages < 60 V (PELV = Protective Extra Low Voltage according to EN 61800-5-1) is only permissible in areas with equipotential bonding and in dry indoor rooms. If these conditions are not fulfilled, other protective measures against electric shock must be applied, for example, protective insulation.

The inverter must always be grounded. If the inverter is not correctly grounded, this can lead to extremely hazardous conditions which, under certain circumstances, can result in death.

The device must be disconnected from the electrical power supply before any connections with the device are established or in any way altered.

Install the inverter on a metal mounting plate in a control cabinet. The mounting plate has to be unpainted and with a good electrical conductivity.

It is strictly prohibited for any mains disconnection to be performed on the motor-side of the system, if the inverter is in operation and the output current is not zero.

Take particular notice of the general and regional installation and safety regulations regarding work on dangerous voltage installations (for example, 61800-5-1) as well as the relevant regulations regarding the correct use of tools and personal protective equipment (PPE).

Only permanently-wired input power connections are allowed. The equipment must be earthed (IEC 536 Class 1, NEC and other applicable standards).

Wherever faults occurring in the control equipment can lead to substantial material damage or even grievous bodily injury (that is, potentially dangerous faults), additional external precautions must be taken to ensure or enforce safe operation, even when a fault occurs (for example, independent limit switches, mechanical interlocks, and so on).

Commissioning

⚠ WARNING

High-voltage terminals

The following terminals can carry dangerous voltages even if the inverter is not operating:

- The mains input terminals L1, L2, L3, and PE terminal
- The motor terminals U, V, W, and output earth terminal
- The DC link terminals DC+ and DC-
- The braking resistor terminals R1 and R2 (Frame size D only)

This equipment must not be used as an "emergency stop" mechanism (*see EN 60204, 9.2.5.4*).

It is not allowed to open, connect or disconnect the equipment during its operation.

Operation

⚠ WARNING

Risks with incorrect parameterization

Certain parameter settings (for example, P1210) may cause the inverter to restart automatically after an input power failure, for example, the automatic restart function.

Motor parameters must be accurately configured for motor overload protection to operate correctly.

Use of braking resistor

If an unsuitable braking resistor is used, this could result in a fire and severe damage to people, property and equipment. Use an appropriate braking resistor and install it correctly.

The temperature of a braking resistor increases significantly during operation. Avoid coming into direct contact with braking resistors.



WARNING

Hot surface

During operation and for a short time after switching-off the inverter, the marked surfaces of the inverter can reach a high temperature. Avoid coming into direct contact with these surfaces.

Repair

WARNING

Repair and replacement of equipment

Repairs on equipment may only be carried out by Siemens Service, by repair centers authorized by Siemens or by authorized personnel who are thoroughly acquainted with all the warnings and operating procedures contained in this manual.

Any defective parts or components must be replaced using parts contained in the relevant spare parts lists.

Disconnect the power supply before opening the equipment for access.

Residual risks

CAUTION

Residual risks associated with the control and drive components of a PDS

The control and drive components of a power drive system (PDS) are approved for industrial and commercial use in industrial line supplies. Their use in public line supplies requires a different configuration and/or additional measures.

These components may only be operated in closed housings or in higher-level control cabinets with protective covers that are closed, and when all of the protective devices are used.

These components may only be handled by qualified and trained technical personnel who are knowledgeable and observe all of the safety information and instructions on the components and in the associated technical user documentation.

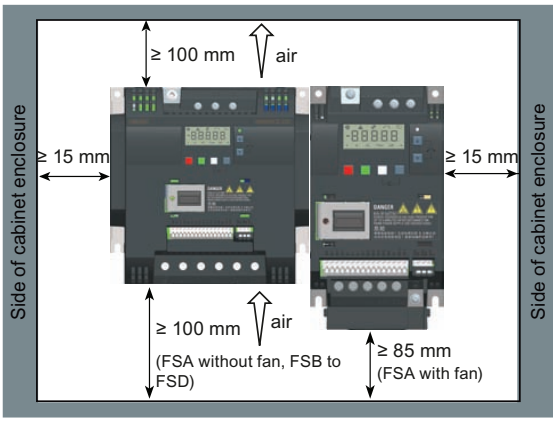
When carrying out a risk assessment of a machine in accordance with the EU Machinery Directive, the machine manufacturer must consider the following residual risks associated with the control and drive components of a PDS.

1. Unintentional movements of driven machine components during commissioning, operation, maintenance, and repairs caused by, for example:
   - Hardware defects and / or software errors in the sensors, controllers, actuators, and connection technology
   - Response times of the controller and drive
   - Operating and/or ambient conditions not within the scope of the specification
   - Condensation / conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of radio devices / cellular phones in the immediate vicinity of the controller
   - External influences / damage
2. Exceptional temperatures as well as emissions of noise, particles, or gas caused by, for example:
   - Component malfunctions
   - Software errors
   - Operating and/or ambient conditions not within the scope of the specification
   - External influences / damage
3. Hazardous shock voltages caused by, for example:
   - Component malfunctions
   - Influence of electrostatic charging
   - Induction of voltages in moving motors
   - Operating and/or ambient conditions not within the scope of the specification
   - Condensation / conductive contamination
   - External influences / damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, if they are too close.
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly.

2 Installation

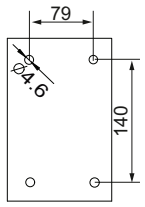
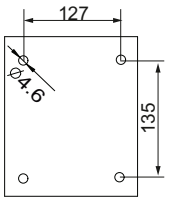
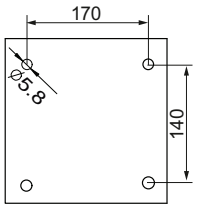
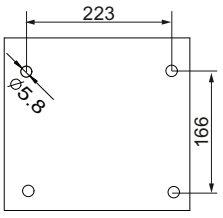
2.1 Mechanical installation

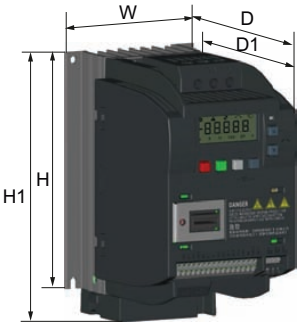
Mounting orientation and clearance



The inverter must be mounted vertically to a flat and non-combustible surface in an enclosed electrical operating area or a control cabinet.

Outline dimensions and drill patterns (cabinet-panel mounting)

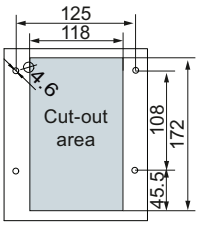
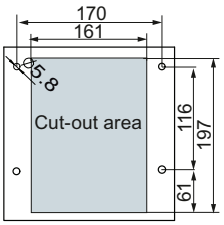
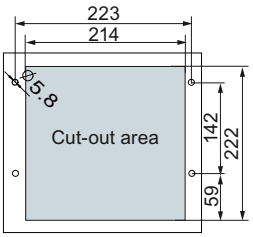
(Unit: mm)	FSA	FSB	FSC	FSD
W	90	140	184	240
H	150	160	182	206.5
H1	166	-	-	-
D	145.5 (114.5*)	164.5	169	172.5
D1	-	106	108	98
Drill pattern				
Fixings	4 x M4 screws 4 x M4 nuts 4 x M4 washers Tightening torque: 1.8 Nm ± 10%		4 x M5 screws 4 x M5 nuts 4 x M5 washers Tightening torque: 2.5 Nm ± 10%	



H1: height of frame size A with fan
D1: depth inside the cabinet for push-through mounting

* Depth of Flat Plate inverter (400 V 0.75 kW variant only).

Outline dimensions and drill patterns (push-through mounting)

	Frame size B	Frame size C	Frame size D
Drill pattern and cut-out (mm)			
Fixings	4 x M4 screws	4 x M5 screws	4 x M5 screws
Tightening torque	1.8 Nm ± 10%	2.5 Nm ± 10%	2.5 Nm ± 10%

For more information about the push-through mounting and the installation of the Flat Plate inverter, refer to the SINAMICS V20 Inverter Operating Instructions.

2.2 Electrical installation

WARNING

Requirements for United States / Canadian installations (UL/cUL)

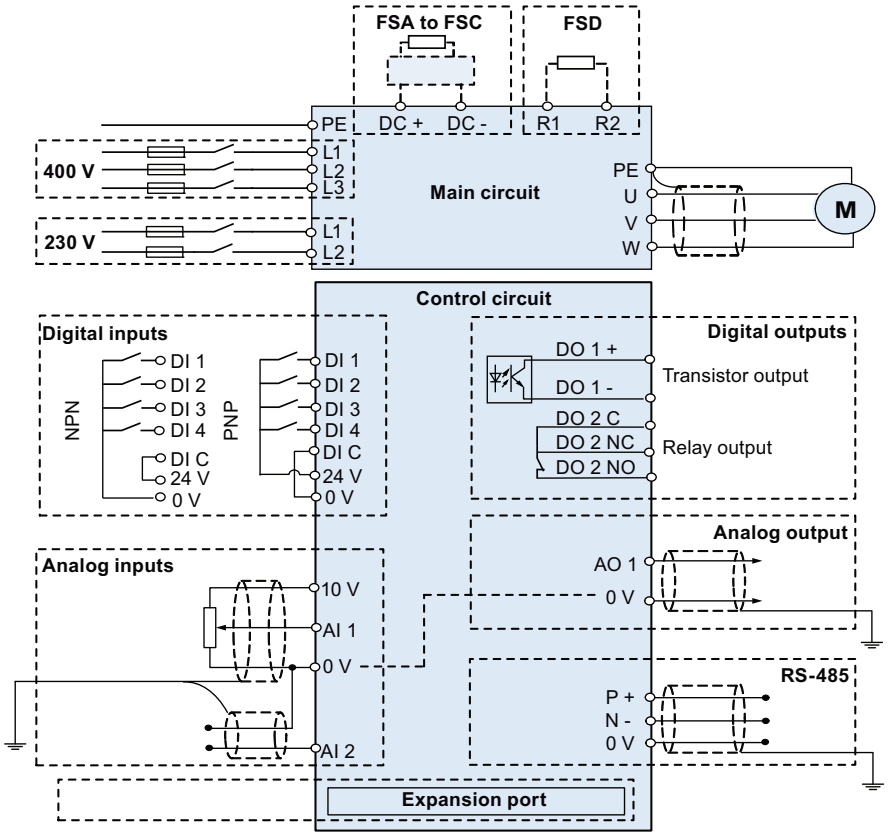
Suitable for use on a circuit capable of delivering not more than 40000 rms Symmetrical Amperes, 480 Vac maximum for 400 V variants of inverters or 240 Vac maximum for 230 V variants of inverters, when protected by UL/cUL-certified Class J fuses only. For each frame size A to D use class 1 75 °C copper wire only.

This equipment is capable of providing internal motor overload protection according to UL508C. In order to comply with UL508C, parameter P0610 must not be changed from its factory setting of 6.

For Canadian (cUL) installations the inverter mains supply must be fitted with any external recommended suppressor with the following features:

- Surge-protective devices; device shall be a Listed Surge-protective device (Category code VZCA and VZCA7)
- Rated nominal voltage 480/277 VAC (for 400 V variants) or 240 VAC (for 230 V variants), 50/60 Hz, 3-phase (for 400 V variants) or 1-phase (for 230V variants)
- Clamping voltage VPR = 2000 V (for 400 V variants) / 1000 V (for 230 V variants), IN = 3 kA min, MCOV = 508 VAC (for 400 V variants) / 264 VAC (for 230V variants), SCCR = 40 kA
- Suitable for Type 1 or Type 2 SPD application
- Clamping shall be provided between phases and also between phase and ground

Wiring diagram

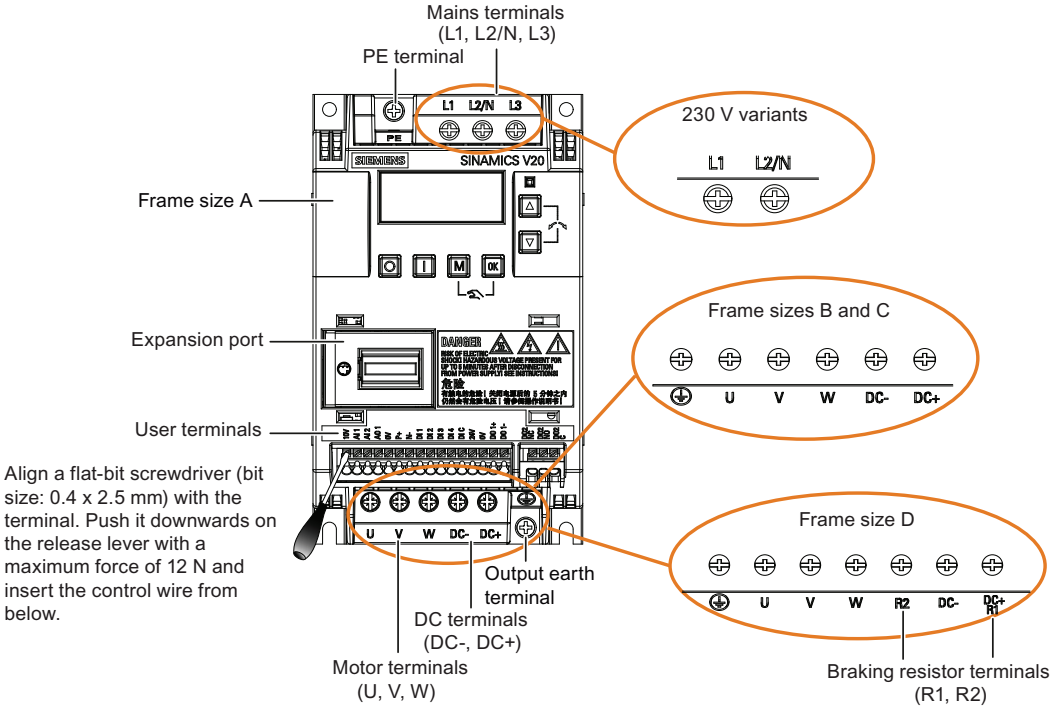


Recommended fuse types

This equipment is suitable for use in a power system up to 40,000 symmetrical amperes (rms), for the maximum rated voltage +10% when protected by an appropriate standard fuse.

Frame size		Recommended fuse type		Frame size		Recommended fuse type	
		CE-compliant (Siba URZ)	UL-compliant			CE-compliant (Siba URZ)	UL-compliant
400 V	A	50 124 34 (16 A)	15 A 600 VAC, class J	230 V	A	3NA3805 (16 A)	15 A 600 VAC, class J
	B	50 124 34 (20 A)	20 A 600 VAC, class J		B	3NA3812 (32 A)	30 A 600 VAC, class J
	C	50 140 34 (30 A)	30 A 600 VAC, class J		C	3NA3820 (50 A)	50 A 600 VAC, class J
	D	50 140 34 (63 A)	60 A 600 VAC, class J				

Terminal description



Recommended cable cross-sections and screw tightening torques

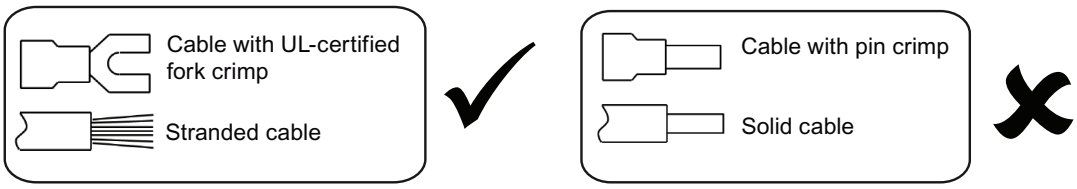
Frame size	Rated output power	Mains and PE terminals		Motor / DC / braking resistor / output earth terminals	
		Cable cross-section	Screw tightening torque (tolerance: ± 10%)	Cable cross-section	Screw tightening torque (tolerance: ± 10%)
400 V					
A	0.37 to 0.75 kW	1.0 mm²	1.0 Nm	1.0 mm²	1.0 Nm
	1.1 to 2.2 kW	1.5 mm²		1.5 mm²	
B	3.0 to 4.0 kW	2.5 mm²		2.5 mm²	1.5 Nm
C	5.5 kW	4.0 mm²	2.4 Nm	4.0 mm²	2.4 Nm
D	7.5 kW	6.0 mm²		6.0 mm²	
	11 to 15 kW	10 mm²		10 mm²	
230 V					
A	0.12 to 0.25 kW	1.5 mm²	1.0 Nm	1.0 mm²	1.0 Nm
	0.37 to 0.55 kW	2.5 mm²			
	0.75 kW	4.0 mm²			
B	1.1 to 1.5 kW	6.0 mm² *		2.5 mm²	1.5 Nm
C	2.2 to 3.0 kW	10 mm²	2.4 Nm	4.0 mm²	2.4 Nm

* With a UL-certified, suitable fork crimp

NOTICE

Damage to the mains terminals

During electrical installation of the inverter frame size A / B, use stranded cables / cables with UL-certified, suitable fork crimps rather than solid cables / cables with pin crimps for mains terminal connection.



Maximum motor cable lengths

Inverter variant	Maximum cable length					
	Without output reactor or external EMC filter			With output reactor		With external EMC filter [1]
400 V	**Unshielded**	**Shielded**	**EMC compliant (RE/CE C3)** [2]	**Unshielded**	**Shielded**	**EMC compliant (RE/CE C2)**
FSA	50 m	25 m	10 m	150 m	150 m	25 m
FSB to FSD	50 m	25 m	25 m	150 m	150 m	25 m
230 V	**Unshielded**	**Shielded**	**EMC compliant (RE/CE C2)** [2]	**Unshielded**	**Shielded**	**EMC compliant (RE/CE C2)** [3]
FSA	50 m	25 m	10 m	200 m	200 m	5 m
FSB to FSC	50 m	25 m	25 m	200 m	200 m	5 m

[1] As specified in Section B.1.8 of the SINAMICS V20 Inverter Operating Instructions.

[2] For filtered variants only. RE/CE C3 refers to EMC compliance to EN61800-3 Category C3 for Radiated and Conducted Emissions; RE/CE C2 refers to EMC compliance to EN61800-3 Category C2 for Radiated and Conducted Emissions.

[3] For unfiltered variants only.

Permissible I/O terminal cable cross-sections

Cable type	Permissible cable cross-section
Solid or stranded cable	0.5 to 1.5 mm^2
Ferrule with insulating sleeve	0.5 mm^2

2.3 Technical specifications

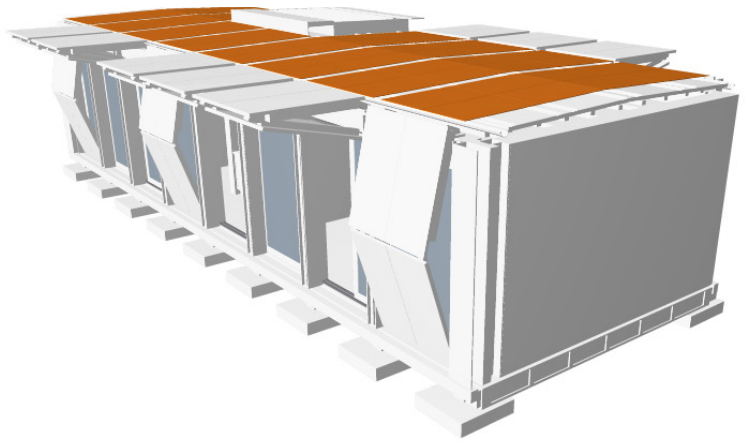
	Three phase AC 400 V inverters	Single phase AC 230 V inverters
Line supply characteristics		
Voltage range	380 V to 480 V AC (tolerance: -15 % to +10 %) 47 Hz to 63 Hz Current derating exists at the input voltages / switching frequencies higher than 400 V / 4kHz. *	200 V to 240 V AC (tolerance: -10 % to +10 %) 47 Hz to 63 Hz Current derating exists at the input voltages / switching frequencies higher than 230 V / 8kHz. *
Overvoltage category	EN 60664-1 Category III	
Permissible supply configuration	TN, TT, IT **, TT earthed line	TN, TT
Supply environment	Second environment (private power network) *	
Environmental conditions		
Surrounding air temperature	0 °C to 40 °C: without derating 40 °C to 60 °C: with derating *	
Storage temperature	- 40 °C to + 70 °C	
Protection class	IP 20	
Maximum humidity level	95% (non-condensing)	
Shock and vibration	Long-term storage in the transport packaging according to EN 60721-3-1 Class 1M2	
	Transport in the transport packaging according to EN 60721-3-2 Class 2M3	
	Vibration during operation according to EN 60721-3-3 Class 3M2	
Operating altitude	Up to 4000 m above sea level 1000 m to 4000 m: output current derating * 2000 m to 4000 m: input voltage derating *	
Environmental classes	Pollution class: 3S2 Gas class: 3C2 (SO_2, H_2S) Climate class: 3K3	

* For more information, refer to the SINAMICS V20 Inverter Operating Instructions.

** Note that only unfiltered inverters can be operated on IT power system.

12.2.5 SOLAR SYSTEMS — PHOTOVOLTAIC AND SOLAR THERMAL

PHOTOVOLTAIC SYSTEMS ON ROOF



Rooftintegrated thin film modules on the top of our building (coulored here orange)

The electrical systems on the roof contain for the competition 41 CIGS modules or 4920 W. After the competition we will raise the active number of modules upt to 84 modules or 10080 W.

The modules are mounted on a flat fast mountable substructure of K2-Systems. We are in close contact with this manufacturer and have got a detailed statical analysis of the loading conditions occuring on the roof.

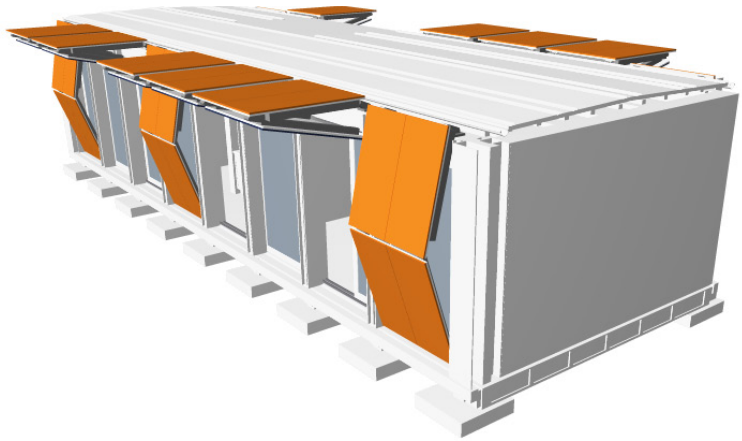
The Rooftop strings are connected withsunways AT 3000 inverters to the grid. This inveter provides a negative potetntial free performance so there is no need for a funcitional grounding. In technical questions we are in close contact with the modules and inverters manufacturers.

Our modules on the roof are integrated within the architectonical concept. They are not loose add-ons to the building rather melting with the buildings optic with is immanent to raise the acceptance for the residants in the city for these form of energy production. In this synergie of engineering and architecture we knowingly accept variations of common PV building standards for open space or classical plants.

See for further technical information chapter 5.3.5.

On the following pages we have got a summary of datasheets and certificates for the used appliances.

PHOTOVOLTAIC SYSTEMS ON FAÇADE



Our innovative façade elements are both architectural and engineering eycatcher

The façade modules are one of our most prominent elements in the building concept.

For the competition we will have 8 pairs of modules on the southern façade with a peak power of 1920 K. After the competition we will upgrade the façade system up to 28 modules and 3360 W.

We maximize the PV output with an one axial tracking system integrated in the HVAC systems. due to individual angles and orientations of each façade module we will use Power optimizer for each pair of modules.

For a detailed description of the façades mechanical system is in chapter 5.3.8.

On the following pages we have got a summary of datasheets and certificates for the used appliances.

String 1: façade string with 8x2modules

Each string consists of 2modules connected in parallel. The Solaredge power optimizers have their own MPP-performance. So the modules MPP-performance is not the calculation base here. We will intentionally oversize our Façade inverter for the competition with the plan to connect after the competition the north façade's modules to the same string. This is agreed by the technical support of Solaredge.

- The total PV output is 8x2x120Wp = 1920Wp

Compliance with Solaredge Inverter-> no. of strings 1

Compliance with Inverter-> P= 1920< 2200; lies without range of 0.9-1.1

BUT: We are going to install 6 more Poweroptimizers to the same string after the competition.

- The current of the string = Istring= IOP400EV = 5A

String max guaranteed by Power optimizer: 400W

Maximum Voltage of the circuit (Considering VOP400EV) = 60 V

Compiance with inverter -> 60V < 350 Vmax

Compliance with Inverter-> Istring=5<8.5A (Max input current) Compliance with Inverter-> 350 V is within the maximum Voltage of the inverter

- Number of POs in series: 8<#PO<25:

This is guaranteed with 8 POs in Series during the competition and after the com petition with 14 POs as well.

See **Figure 280** of the Solaredge calculation Software to proof the systems configuration.

Location:

Paris, France

System data:

Installed power: 1,92 kWp

Max achieved DC power: 1,88 kW

Inverters AC power: 2,20 kVA

PV Array # 6: PV Array # South

Tilt	Azimuth	Mounting
30°	180°	Co-planar with roof

Solibro, SL2-120, 120,00 W

Inverter design

Inverter 1: SE2200

String 1: PV Array # South: 8 x OP400-EV (2 parallel / 1 series)

Power optimizer extreme operating conditions

OP400-EV (2 parallel / 1 series)

	Calculated	Limit
Max input power	240 W	400 W
Min input voltage	114 V	15 V
Max input voltage	83 V	125 V
Max input current	3 A	7 A
Max output current	5 A	15 A

Figure 276: **Extract of the Calculations with the SolarEdge Calculation tool**

String 2: Rooftop string with 5x5 modules

Each string consists of 5 modules connected in series.

The total PV output is 5x5x120Wp = 3000Wp

Compliance with Sunways AT 3000 Inverter-> no. of strings 1 < 2

Compliance with Inverter-> P =3000 = 3000; can lie within range of 0.9-1.1

The current of the string = Istring=5x Isc= 8.45 A

The voltage of the string = Ustring=5xUoc= 485 V

Compliance with Inverter-> Istring=8.45< 15A (Max input current)

And Ustring within the Operation Voltage of 180V-600V

See the extract of PVSyst for this strings simulation.

Array Characteristics

module	CIS Model	SL2-120		
	Manufacturer	Solibro		
nber of PV modules	In series	5 modules	In parallel	5 strings
al number of PV modules	Nb. modules	25	Unit Nom. Power	120 Wp
ay global power	Nominal (STC)	3000 Wp	At operating cond.	2726 Wp (50°C)
ay operating characteristics (50°C)	U mpp	360 V	I mpp	7.6 A
al area	Module area	23.5 m²		
erter	Model	AT 3000		
	Manufacturer	Sunways		
aracteristics	Operating Voltage	203-600 V	Unit Nom. Power	3.00 kW AC

Array loss factors

rmal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind=1 m/s.)			NOCT	56 °C
ing Ohmic Loss	Global array res.	776 mOhm	Loss Fraction	1.5 % at STC
dule Quality Loss			Loss Fraction	0.0 %
dule Mismatch Losses			Loss Fraction	1.0 % at MPP
idence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

Figure 277: **Extract of the strincalculation using PVSyst**

Properties at different temperatures (-10°C to +70°C):

String 1: façade string with 8x2modules

Formulae: Uoc(temp)= Uoc + (ΔT* Uoc *(Tcoeff of Uoc at STC[%]))

Isc(temp)= Isc + (ΔT* Isc *(Tcoeff of Isc at STC[%]))

P(temp)= P + (ΔT* P *(Tcoeff of P at STC[%]))

- Uoc(-10)= 97.6 + (-35*97.6*(-0.0029)) = 107.50 V

Compliance with PO->107.5V < 125 V

- Uoc(70)= 97.6 + (45*97.6*(-0.0029)) = 84.86 V

Compliance with PO -> 84.86V <125 V

- Isc(-10)= 1.69+ (-35*1.69(+0.00)) = 1.69 A

Compliance with PO-> 2*1.69 = 3.38< 7 A

- Isc(70)= 1.69 + (40*1.69(+0.00)) = 1.69 A

Compliance with PO->2*1.69= 3.38 < 7 A

- P(-10)= 120 + (-35* 120*(-0.38)) = 135.96W

Compliance with PO -> 135.96*2 = 271< 400 W

- P(70)= 120 + (40*120*(-0.38)) = 101.76W

Compliance with PO -> 101.76*2= 203.52< 400 W

Therefore the PO complies with the modules in a 2x1 configuration. The Inverter is concerted for an opertaion with the POs and doesn't need to be calculated in Voltage and Current.

String 2: Rooftop string with 5x5 modules

- Uoc(-10)= 97.6 + (-35*97.6*(-0.0029)) = 107.50 V
- UOC(-10)string=5*107.50V =537.50V

Compliance with Sunways AT 3000 -> 537.50V<600 V

- Uoc(70)= 97.6 + (45*97.6*(-0.0029)) = 84.86 V
- Uoc(70)string= 84.86*5 =424.3 V

Compliance with Sunways AT 3000-> 424.3V < 600 V

- Isc(-10)= 1.69+ (-35*1.69(+0.00)) = 1.69 A
- Isc(-10)string= 1.69 *5 = 8,4 A

Compliance with Sunways AT 3000-> 8.4 A<15 A

- Isc(70)= 1.69 + (40*1.69(+0.00)) = 1.69 A
- Isc(70)= 1.69A*5 = 8,45 A

Compliance with Sunways At 3000-> 8.45 A< 15 A

- P(-10)= 120 + (-35* 120*(-0.38)) = 135.96W
- P(-10)string= 25* 135.96W= 3399W

Compliance with Sunways At 3000 -> 3399W < 1.2*3000W

- P(70)= 120 + (40*120*(-0.38)) = 101.76W
- P(70)string= 101.76 W*25=2544

Compliance with Sunways At 3000-> 2544< 3000 W

Dimensioning of the DC string cables Sunways

For the sunways before the junctionbox we have 1,69 A in each string the voltage for each string from the software is going to be 360 V. (5 solar panels in Series)

Cross section string lines in mm2: Astring=2 x Lm x Istring / (v x Umpp x K)

where, v-accepted loss = 1%

Lm-length of wire for one string = 30 m

K- Electrical conductivity, KCU – 43.5m/(mm2Ω) at 70°C,

Therefore: Astring (mm2) =2 x 30 x 1.69 / (0.01 x 360 x 43.5) = 0.65 mm2

and then after junction box we need 8.45A

Cross section string lines in mm2: Astring=2 x Lm x Istring / (v x Umpp x K)

where, v-accepted loss = 1%

Lm-length of wire for one string = 10 m

K- Electrical conductivity, KCU – 43.5m/(mm2Ω) at 70°C,

Therefore: Astring (mm2) =2 x 10 x 8.45 / (0.01 x 384 x 43.5) = 1.08 mm2

Dimensioning of the AC string cables Sunways

We have got 3000 W peak power installed on the roof. If we asume 100% efficiency and a voltage of 230V we have got a current of 13.04 A on the AC cables after the inverter.

cross section for AC cables in mm2: Astring=1 x Lm x Icable/ (v x 230Vx K)

where, v-accepted loss = 1%

Lm-length of wire for AC connection= 5 m

K- Electrical conductivity, KCU – 43.5m/(mm2Ω) at 70°C (worst case szenario),

Therefore: Astring (mm2) =1 x 5 x 13.04/ (0.01 x 230 x 43.5) = 0.65 mm2

Thus using 2.5 mm² cables is sufficient.

Dimensioning of the DC string cables SolarEdge

Cross section string lines in mm2: Astring=2 x Lm x Istring / (v x Umpp x K)

where, v-accepted loss = 1%

Lm-length of wire for one string = 40 m

K- Electrical conductivity, KCU – 43.5m/(mm2Ω) at 70°C,

IPOmax= 15 A

UPOmax= 60 V

the maximum output current from the Solaredge software is 5A and by dividing it by the total power of the solar panels the voltage of the string is going to be 384 V

Therefore: Astring (mm2) =2 x 40 x 5 / (0.01 x 384 x 43.5) = 2,39 mm2

Hence to reduce the losses as much as possible we selected 6 mm2cross-section for the wire for all the DC side of the circuit.

Hence selecting 6 mm2 cross-section wire for the DC side of the circuit. This matches with the output wire of the SE PO in the datasheet. We will use 6mm² for all connecting lines between strings and inverters and for the powerline of the façade modules. The MC4 connectors are compatible between this different crosssections. According to their product manager.

Minimal Power losses for the whole cabling:

Pm = 2 x Lm x IPOwork(60V)2/(AST x k)

= 2 x 150m x 6.66²A²/(6mm² x 56)

= 39.6W

Dimensioning of the AC string cables SolarEdge

We have got 1680W peak power installed on the roof. If we asume 100% efficiency and a voltage of 230V we have got a current of 7.34 A on the AC cables after the inverter.

cross section for AC cables in mm2: Astring=1 x Lm x Icable/ (v x 230Vx K)

where, v-accepted loss = 1%

Lm-length of wire for AC connection= 5 m

K- Electrical conductivity, KCU – 43.5m/(mm2Ω) at 70°C (worst case szenario),

Therefore: Astring (mm2) =1 x 5 x 7.34 (0.01 x 230 x 43.5) = 0.36mm2

Thus using 2.5 mm² cables is sufficient.

DC Isolator/Circuit Breaker for Solar Edge

DC-Isolator must be able to switch at:

VOC = 400 V and 1.25 x IPO= 1.25x 5 A= 6.25 A

Cable ampere capacity IA ≥ IF (Fusing current of the string fuse)

Fusing current of the string fuse: 2xIsc string>Ifuse ≥ 1.4x Isc string

2x 5 > I fuse ≥ 1.4 x 6.25

10 A > I fuse ≥ 7 A

DC Isolator/Circuit Breaker for Sunway Inverter

DC-Isolator must be able to switch at:

VOC = 488 V and 1.25 x IPO= 1.25x 8.45 A= 10.56 A

Cable ampere capacity IA ≥ IF (Fusing current of the string fuse)

Fusing current of the string fuse: 2xIsc string>Ifuse ≥ 1.4x Isc string

2x 8.45 > I fuse ≥ 1.4 x 8.45

16.9> I fuse ≥ 11.83 A

Comformity of the Inverters

See the certificates of the Inverters in the appendix.

Studer Xtender	**Sunways AT 3000**	**Solaredge SE 2200**	**Solaredge OP 300**
Low voltage directive 2006/95/EC DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02	DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02	EN 50178:1997	EN 6100-6-2:2005
- EN 50178:1997	VDE-AR-N 4105:2011-08	DIN EN 50178:1998	EN 6100-6-3:2007/A1:2011
- EN 62040-1:2008	EN 61000-3-3:2006	IEC 62103:2003	EN 6100-6-4:207/A1:2011
EMC directive 2004/108/EC	EN 61000-3-3:2006	IEC 62109-1:2010	FCC CFR 47 Part 15 Subpart B
- EN 61000-6-2:2005	EN 61000-3-12:2005	IEC 62109-2:2011	EN 6100-4-2:2008
- EN 61000-6-3:2007	EN 61000-6-2 :2006	UTE C15-712-1, Juilliet 2010	EN 6100-4-3:2008
- EN 61000-3-2:2006	EN 61000-6-3:2005	DIN V VDE V 0126-1-1: 2006-02	EN 6100-4-6:2008
- EN 61000-3-12:2005	EN 61000-6-4:2007	ERDF-NOI-RES_13E	EN 6100-4-8:2001
- EN 62040-2:2006		VDE-AR-N-4105:2011-08	IEC 62109-1:2010, EN 62109-1:2010, DIN EN 62109-1:2011
RoHS directive 2002/95/EC	EN 50178:1997	DIN VDE V 0124-100: 2012-07	
-VDE-AR-N 4105:2011-08	IEC 62103:2003	EN 6100-6-3:2007	
	IEC 62109-1:2010	EN 6100-6-2:2005	
	EN 62109-1:2011	FCC CFR 47 Part 15 Subpart B	
		EN 50178:1997	
		DIN EN 50178:1998	
		IEC 62103:2003	

Grid-Connected System: Simulation parameters

Project : **Grid-Connected Project at Paris Versailles**

Geographical Site	**Paris Versailles**		**Country**	**France**
Situation	Latitude	48.8°N	Longitude	2.1°E
Time defined as	Legal Time	Time zone UT+1	Altitude	141 m
	Albedo	0.20		

Meteo data : Paris Versailles , Synthetic Hourly data

Simulation variant : **New simulation variant**

Simulation date 23/04/14 11h48

Simulation parameters

Collector Plane Orientation	Tilt	3°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	CIS Model	**SL2-120**		
	Manufacturer	Solibro		
Number of PV modules	In series	5 modules	In parallel	5 strings
Total number of PV modules	Nb. modules	25	Unit Nom. Power	120 Wp
Array global power	Nominal (STC)	**3000 Wp**	At operating cond.	2726 Wp (50°C)
Array operating characteristics (50°C)	U mpp	360 V	I mpp	7.6 A
Total area	Module area	**23.5 m²**		
Inverter	Model	**AT 3000**		
	Manufacturer	Sunways		
Characteristics	Operating Voltage	203-600 V	Unit Nom. Power	3.00 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind=1 m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	776 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	0.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Evaluation Mode

Grid-Connected System: Main results

Project : **Grid-Connected Project at Paris Versailles**

Simulation variant : **New simulation variant**

Main system parameters				
System type		**Grid-Connected**		
PV Field Orientation	tilt	3°	azimuth	0°
PV modules	Model	SL2-120	Pnom	120 Wp
PV Array	Nb. of modules	25	Pnom total	**3000 Wp**
Inverter	Model	AT 3000	Pnom	3000 W ac
User's needs	Unlimited load (grid)			

Main simulation results

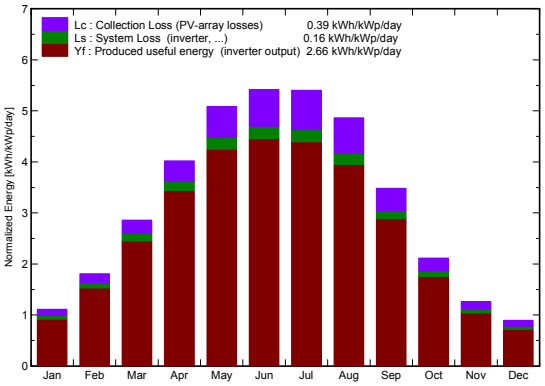
System Production

Produced Energy **2908 kWh/year** Specific prod. 969 kWh/kWp/year

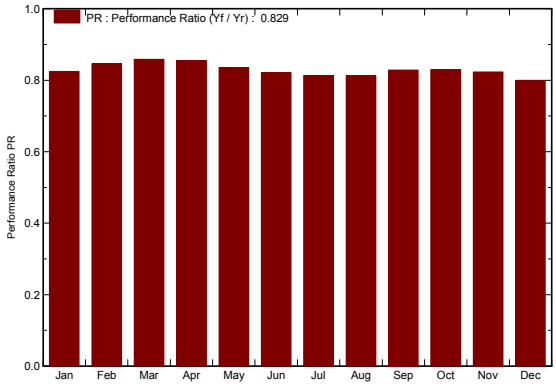
Performance Ratio PR 82.9 %

Non Mode

Normalized productions (per installed kWp): Nominal power 3000 Wp



Performance Ratio PR



New simulation variant

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	32.2	3.80	34.5	31.9	92.0	85.3	11.35	10.52
February	48.4	4.30	50.7	47.7	137.3	128.7	11.52	10.80
March	86.2	7.10	88.7	84.3	241.9	228.4	11.61	10.96
April	118.5	9.50	120.7	115.6	326.7	309.5	11.52	10.91
May	156.3	14.20	157.7	151.7	416.4	395.0	11.23	10.66
June	161.7	17.80	162.6	156.5	422.7	400.8	11.06	10.49
July	166.2	20.40	167.6	161.4	430.9	408.7	10.94	10.38
August	148.5	20.60	150.9	144.8	387.6	367.6	10.93	10.37
September	101.7	16.90	104.5	99.8	274.4	259.7	11.17	10.57
October	63.2	12.90	65.7	62.1	173.8	163.3	11.26	10.58
November	36.0	7.30	38.0	35.6	100.9	93.8	11.31	10.50
December	25.7	4.80	27.8	25.6	72.8	66.8	11.12	10.21
Year	1144.6	11.68	1169.3	1117.1	3077.5	2907.7	11.20	10.58

Legends:

GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

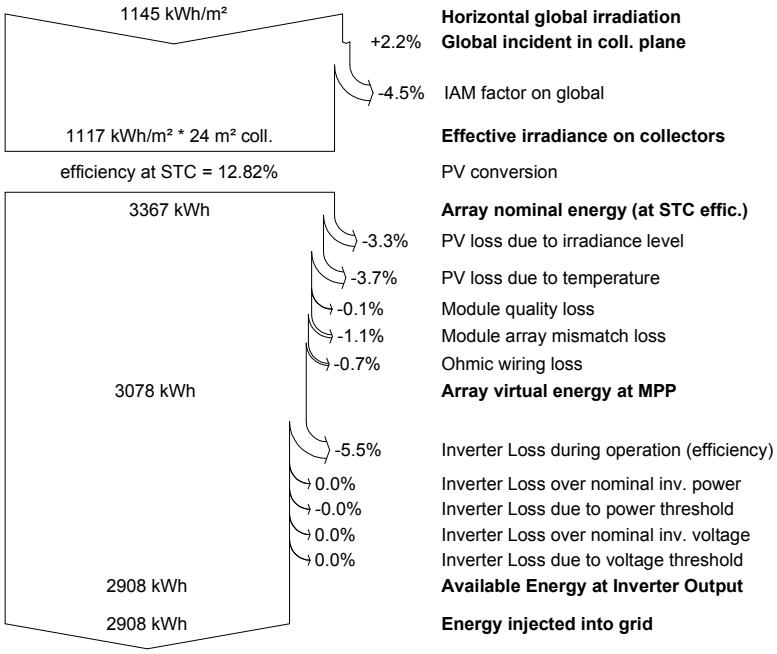
Grid-Connected System: Loss diagram

Project : **Grid-Connected Project at Paris Versailles**

Simulation variant : **New simulation variant**

Main system parameters				
System type		**Grid-Connected**		
PV Field Orientation	tilt	3°	azimuth	0°
PV modules	Model	SL2-120	Pnom	120 Wp
PV Array	Nb. of modules	25	Pnom total	**3000 Wp**
Inverter	Model	AT 3000	Pnom	3000 W ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Email: cwengert@web.de

solaredge

Project:

Rooftop

Mittwoch, 23. April 2014 11:42

Location:

Paris, France

System data:

Installed power: 1,92 kWp

Max achieved DC power: 1,88 kW

Inverters AC power: 2,20 kVA

PV Array # 6: PV Array # South

Tilt	Azimuth	Mounting
30°	180°	Co-planar with roof

Solibro, SL2-120, 120,00 W

Inverter design

Inverter 1: SE2200

String 1: PV Array # South: 8 x OP400-EV (2 parallel / 1 series)

Power optimizer extreme operating conditions

OP400-EV (2 parallel / 1 series)

	Calculated	Limit	
Max input power	240 W	400 W	✓
Min input voltage	114 V	15 V	✓
Max input voltage	83 V	125 V	✓
Max input current	3 A	7 A	✓
Max output current	5 A	15 A	✓

* Calculated values are the absolute min/max of all arrays using this power optimizer configuration.

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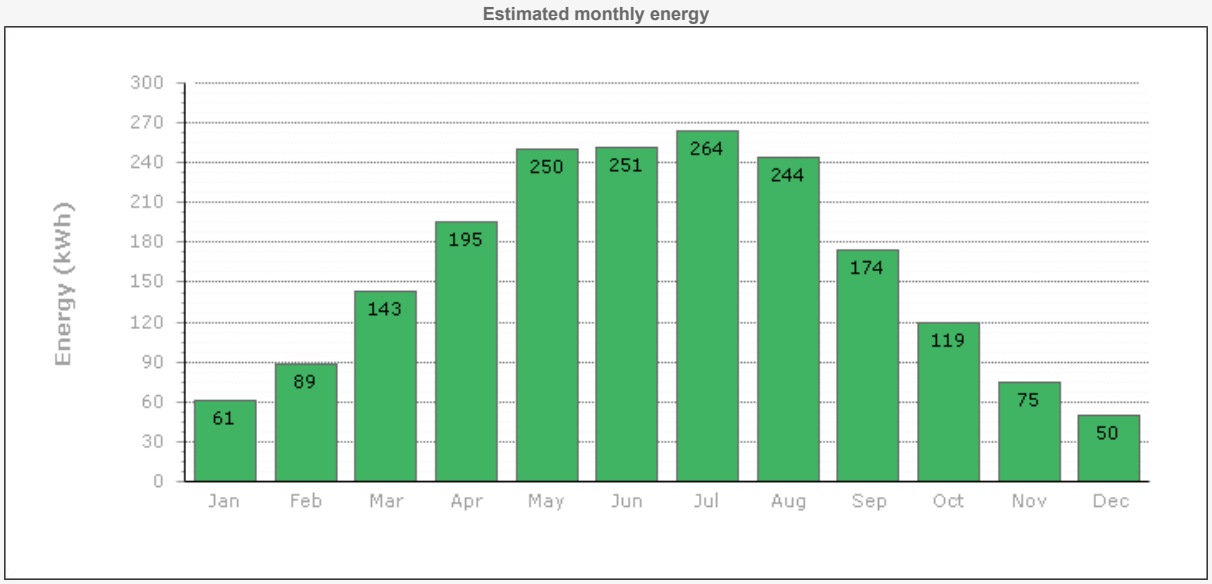
Energy estimation



Estimated yearly energy: 1,91 MWh

Energy yields are an approximation; they are not guaranteed by SolarEdge.

Bill of Materials

Inverters:	SE2200-ER-01-FRA, quantity: 1
Optimizers:	OP400-EV-MC4SM-4U, quantity: 8
Branch cables:	MC4 male: Contact SolarEdge, quantity: 8 MC4 female: Contact SolarEdge, quantity: 8

SMA PV OFFSET BOX



Economical
- Low power consumption
- Maintainance of performance capability
- Regeneration of PV modules affected by PID

Flexible
- Different operating modes, as night operation, continuous operation
- Ideal for transformerless inverters

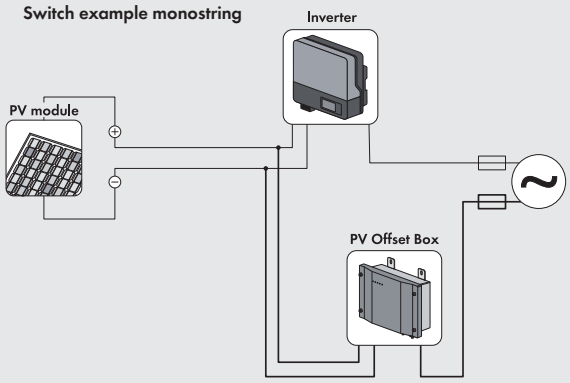
Simple
- Fully automatic operation
- Integrated function control

SMA PV OFFSET BOX

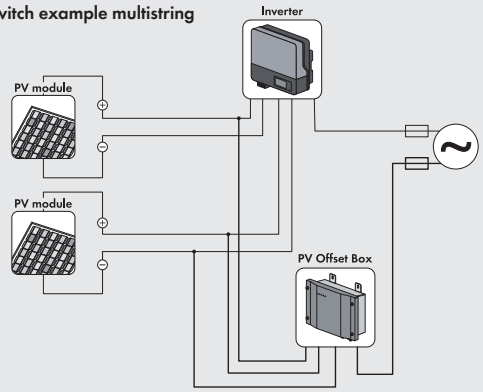
Automatic Night-Time Discharging of PV Modules

Certain kinds of PV modules are subject to power degradation when exposed to negative voltage to ground (polarization). The PV Offset Box maintains the performance capability of these modules even if they have inverters that cannot be grounded. If the degradation has already started, the device helps to regenerate the modules. The PV Offset Box is designed for inverters up to 1,000 V. Operation with all PV array components (PV modules, cables, inverters) has to be released by the respective manufacturer.

Switch example monostring



Switch example multistring



Technical data	PV Offset Box
PV array / inverter input	
Max. PV voltage	1000 V
Min. MPP voltage (in feed-in operation of the inverter)	75 V
Max. PV voltage (in offset operation)	50 V
Min. system voltage (V) of all components	400 V
Min. insulation resistance	200 kΩ
Output voltage to ground	400 V to 1000 V
Max. output current	3.3 mA
Grid (AC)	
Nominal AC voltage	100 V to 240 V
Nominal AC grid frequency	50 Hz to 60 Hz
Power consumption in standby operation	< 0.5 W
Typical power consumption in operation	3 W
General data	
Dimensions (W / H / D)	270 / 230 / 100 mm (10.6 / 9.0 / 3.9 inches)
Weight	1.4 kg (3.08 lb)
Operating temperature range	–25 °C to +60 °C (–13 °F to +140 °F)
Indoor / outdoor installation (IP65)	● / ●
Features	
PV connection (spring clamp terminal for cables up to 6 mm²)	PV (–) / PVA (+) / PVB (+)
AC-connection (spring clamp terminal for cables up to 1.5 mm²)	IN: N / L / FE OUT: N / L / FE
LED display: operation	green
LED display: failure	red
Warranty	5 years
Certificates and approvals	www.SMA.de
Approvals	
The PV OFFSET BOX has been approved by SMA for the following string inverters:	STP5000TL-20 STP6000TL-20 STP7000TL-20 STP8000TL-20 STP9000TL-20 STP8000TL-10 STP10000TL-10 STP12000TL-10 STP15000TL-10 STP17000TL-10
Status February 2013	
Type designation	PVO-N-20

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WECHSELRICHTER

solaredge

SolarEdge Einphasen-Wechselrichter

SE2200 - SE5000



Die optimale Wahl für SolarEdge-Systeme

- Einzigartiger Wirkungsgrad (97,6%)
- Klein, geringes Gewicht und einfache Installation
- Integrierte Überwachung auf Modulebene
- Internetverbindung via Ethernet oder Wireless
- IP65 – Installation im Freien und in Gebäuden

USA - DEUTSCHLAND - ITALIEN - FRANKREICH - JAPAN - CHINA - AUSTRALIEN - ISRAEL www.solaredge.de

SolarEdge Einphasen-Wechselrichter

SE2200 - SE5000

	SE2200	SE3000	SE3500	SE4000	SE5000	
AUSGANG						
AC-Nennleistung	2200	3000	3500	4000	4600	VA
Maximale AC-Leistung	2200	3000	3500	4000	4600	VA
AC-Ausgangsspannung (Nennspannung)	220 / 230					Vac
AC-Ausgangsspannungsbereich	184 - 264,5					Vac
AC-Frequenz (Nennfrequenz)	50 / 60 ± 5					Hz
Maximaler Dauerausgangsstrom	12	16,5*	19,5*	22*	25	A
Fehlerstromüberwachung / Fehlerstrom-Schutzschalter	300 / 30					mA
Netzüberwachung, Schutz vor Inselbildung, konfigurierbare landesspezifische Schwellenwerte	Ja					
EINGANG						
Empfohlene Maximale DC-Leistung** (Modul STC)	2400	3300	3900	4400	5100	W
OhneTransformator, ungeerdet	Ja					
Maximale Eingangsspannung	500					Vdc
DC-Nenneingangsspannung	350					Vdc
Maximaler Eingangsstrom	8,5	11,5	13,5	15,5	17,5	Adc
Verpolungsschutz	Ja					
Erdschlusserkennung	Empfindlichkeit 600 kΩ					
Maximaler Wirkungsgrad des Wechselrichters	97,6					%
Europäischer (gewichteter) Wirkungsgrad	97,6	97,6	97,5	97,5	97,4	%
Energieverbrauch nachts	< 2,5					W
WEITERE FUNKTIONEN						
Mögliche Kommunikationsinterfaces	RS485, RS232, Ethernet, ZigBee (optional)					
ERFÜLLTE NORMEN						
Sicherheit	IEC-62103 (EN50178), IEC-62109					
Netzanschluss	VDE-AR-N-4105, AS-4777, RD-1663 , DK 5940					
EMV	IEC61000-6-2, IEC61000-6-3, IEC61000-3-11, IEC61000-3-12, FCC Teil15 Klasse B					
RoHS	Ja					
MECHANISCHE SPEZIFIKATIONEN						
AC-Ausgang	Kabelverschraubung – Durchmesser 9-16					mm
DC-Eingang	1 MC4 Paar			2 MC4 Paare		
Abmessungen (H x B x T)	540 x 315 x 172			540 x 315 x 191		mm
Gewicht	20,2			21,7		kg
Kühlung	Eigenkonvektion					
Geräuschemission	< 50					dBA
Betriebstemperaturbereich	-20 - +50 (M40 Version -40 - +50)					˚C
Schutzklasse	IP65 – im Freien und in Gebäuden					
Montage an Halterung (Halterung wird mitgeliefert)						

* Um Information über Wechselrichter mit einer Begrenzung des AC Stroms auf 16A zu erhalten, sehen Sie bitte das Datenblatt "SE3000-4000-16A Inverter" ein.
** Die maximale DC-Leistung kann jeh nach tatsächlicher AC-Leistung erhöht werden.

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SOLAR INVERTER

Sunways Solar Inverter AT 2700, AT 3000, AT 3600, AT 4500 and AT 5000

Thanks to HERIC® topology with innovative FP switching, the new AT Solar Inverters from Sunways achieve a constant yield at changing irradiation levels and temperatures. And that even across technological limits.



Flexible system planning – thin-film and silicon technology
Thanks to its expanded input voltage range from 150 to 680 V, solar inverters of the AT series offer the greatest possible flexibility for planning solar systems. Due to their innovative technology (without a transformer), AT Solar Inverters achieve a constant, consistently high efficiency even with fluctuating DC voltages and different power levels. Negative voltages, which are particularly undesirable with thin-film modules, are eliminated by the HERIC® topology with FP switching.

All-in-one – standard equipment

- Integrated DC load break cut-out
- Lighted graphic display and keypad
- Extensive internal 128 MB data logger
- Inverter networking via CAN bus
- Ethernet interface for integration in networks
- Active email alerting in case of system faults
- Voltageless alarm relay for the connection of external alarm devices
- S0 pulse output for controlling the Sunways display
- Integrated web server for display and configuration via a web browser



Simple, fast and safe installation with plug-in connectors and weatherproof connection box.

Information and Sales
Sunways AG · Photovoltaic Technology · Macairestraße 3-5
D-78467 Konstanz · Telephone +49 (0)7531 996 77-0
Fax +49 (0)7531 996 77-444 · E-Mail info@sunways.de
www.sunways.de

sunways
Photovoltaic Technology

Technical Data of Sunways Solar Inverter AT

	AT 2700	AT 3000	AT 3600	AT 4500	AT 5000
DC Input					
Rated DC power	2850 W	3150 W	3800 W	4750 W	5250 W
Maximum DC current	15.5 A	15.5 A	15.5 A	22.0 A	22.0 A
Nominal DC voltage	350 V				
MPP voltage range	181 V...600 V	203 V...600 V	242 V...600 V	214 V...600 V	236 V...600 V
Maximum voltage DC	680 V				
Number of inputs per MPP tracker	2 x Tyco Solarlok				
Number of MPP trackers	1				
AC output					
Rated AC output power	2700 W	3000 W	3600 W	4500 W	4600 W
Maximum AC power	2700 W	3000 W	3600 W	4500 W	5000 W
Nominal AC current	11.7 A	13.0 A	15.7 A	19.6 A	20.0 A
Maximum AC current	12.5 A	14.0 A	17.0 A	21.0 A	23.0 A
Nominal frequency	50 Hz				
Frequency tolerance range	47.5 Hz ... 51.5 Hz (according to VDE-AR-N 4105:2011-08)				
Grid voltage	230 V				
AC voltage range	-20% ... +15% (according to DIN VDE 0126-1-1)				
Distortion factor at Pn	< 4%				
Reactive power factor (cos phi)	ca. 1 or adjustable from –0.9 to +0.9				
Grid voltage monitoring	single-phase (according to DIN VDE 0126-1-1)				
Earth fault protection	RCD (according to DIN VDE 0126-1-1)				
Insulation, frequency and DC current monitoring	integrated according to DIN VDE 0126-1-1				
Required phases, number of grid connections	1 (L, N, PE)				
Number of feed-in phases (230 V single-phase)	1				
Performance					
Stand-by consumption	6.5 W				
Night-time consumption	< 0.06 W				
Maximum efficiency	95,5%	95,5%	95,5%	95,5%	95,5%
European efficiency	94,7%	94,8%	94,9%	95,0%	95,0%
MPP efficiency (static)	> 99%	> 99%	> 99%	> 99%	> 99%
Switching concept	HERIC® / FP topology, transformerless				
Other					
DC switch	internal, mechanical				
Grid-connection fuse layout	16 A	16 A	25 A	25 A	25 A
Data interfaces	Ethernet, CAN, RS485, voltageless alarm relay, S0 pulse output				
Sensor interfaces	irradiation, temperature				
Display	LCD, backlit, 128 x 64 pixels				
Plant supervision	active alarm via e-mail, Sunways Browser, Sunways Portal				
IP degree of protection according to IEC 60529	IP 54				
Max. relative humidity	95%				
Cooling	free convection				
Ambient temperature	-25°C ... 40°C (at full load)				
Overload behaviour	working point adjustment				
Dimensions (height x width x depth)	59 x 35 x 21 cm				
Weight	29 kg				
Type of installation	wall installation				
Noise development	< 35 dB (A)				
Warranty					
Standard warranty	5 years				
Extension of warranty to 10 years (article no.)	SV101000A	SV101000A	SV101000A	SV101010A	SV101010A
Extension of warranty to 15 years (article no.)	SV101030A	SV101030A	SV101030A	SV101040A	SV101040A
Extension of warranty to 20 years (article no.)	SV101060A	SV101060A	SV101060A	SV101070A	SV101070A
Extension of warranty to 25 years (article no.)	SV101090A	SV101090A	SV101090A	SV101100A	SV101100A
Certificates	CE, DIN VDE 0126-1-1, VDE-AR-N 4105:2011-08, G59-2, G83-1 Further certificates under www.sunways.eu				

Values based on 230 V mains voltage

Subject to technical changes, as at 02/2012

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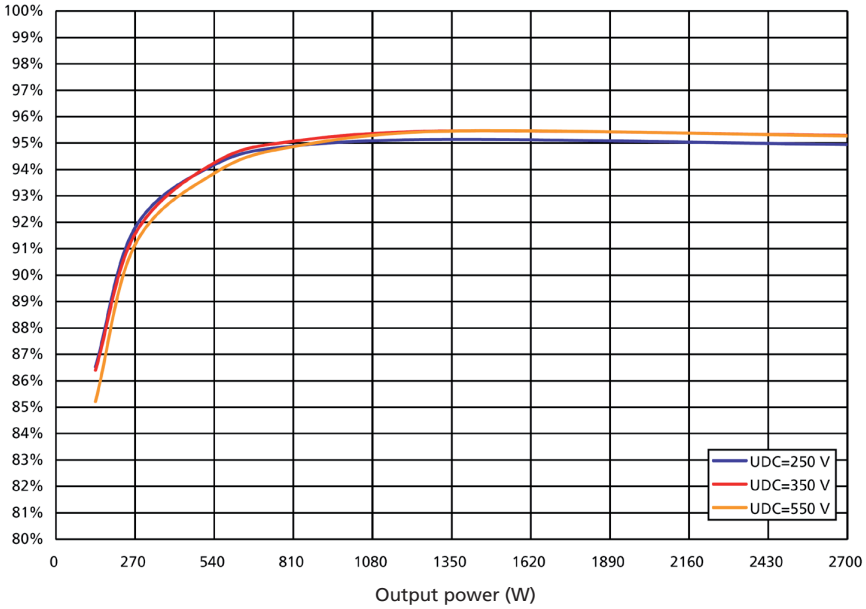
Efficiency curve for Sunways Solar Inverter AT

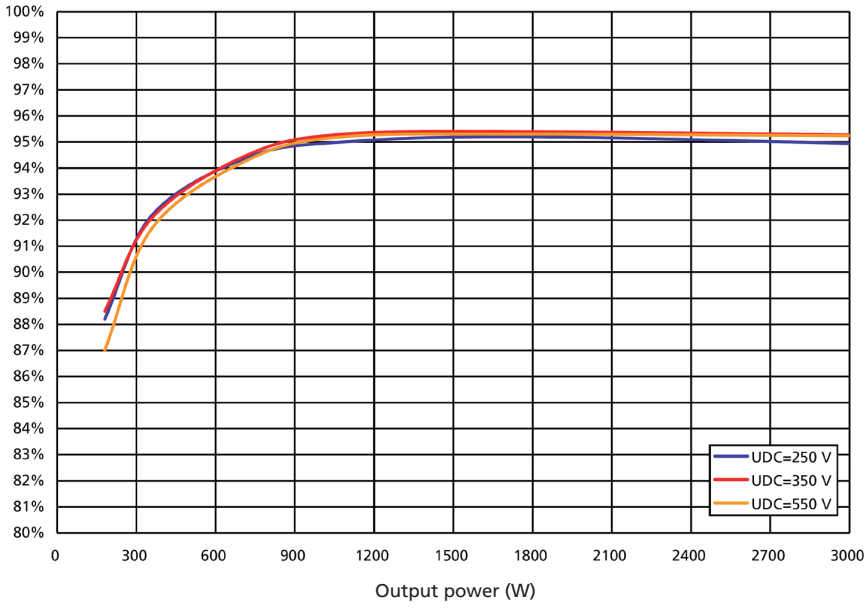
Efficiency curve AT 2700



Output power (%)		5.0	10.0	20.0	30.0	50.0	100.0	Max	Euro
Efficiency	250 V	86.5	91.8	94.2	94.9	95.1	94.9	95.3	94.5
	350 V	86.4	91.6	94.3	95.1	95.5	95.3	95.5	94.7
	550 V	85.2	91.2	93.9	94.9	95.5	95.3	95.5	94.6

Values based on 230 V mains voltage, cos phi = 1 and an ambient temperature of 25°C.

Efficiency curve AT 3000



Ausgangsleistung (%)		5,0	10,0	20,0	30,0	50,0	100,0	Max	Euro
Wirkungsgrad	250 V	88.2	92.2	94.4	95.0	95.2	94.8	95.3	94.6
	350 V	88.5	92.1	94.5	95.3	95.4	95.2	95.5	94.8
	550 V	85.2	91.2	93.9	94.9	95.5	95.3	95.5	94.6

Values based on 230 V mains voltage, cos phi = 1 and an ambient temperature of 25°C.

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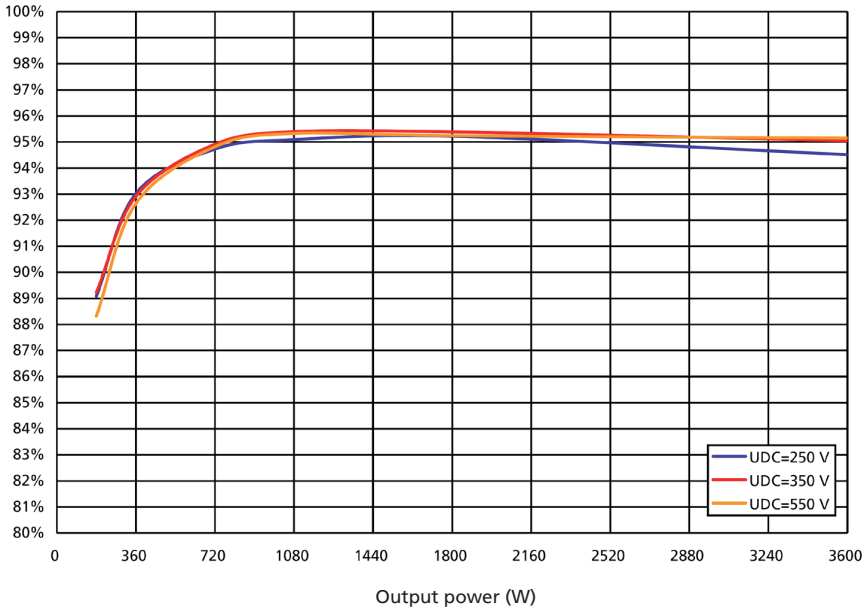
Efficiency curve for Sunways Solar Inverter AT

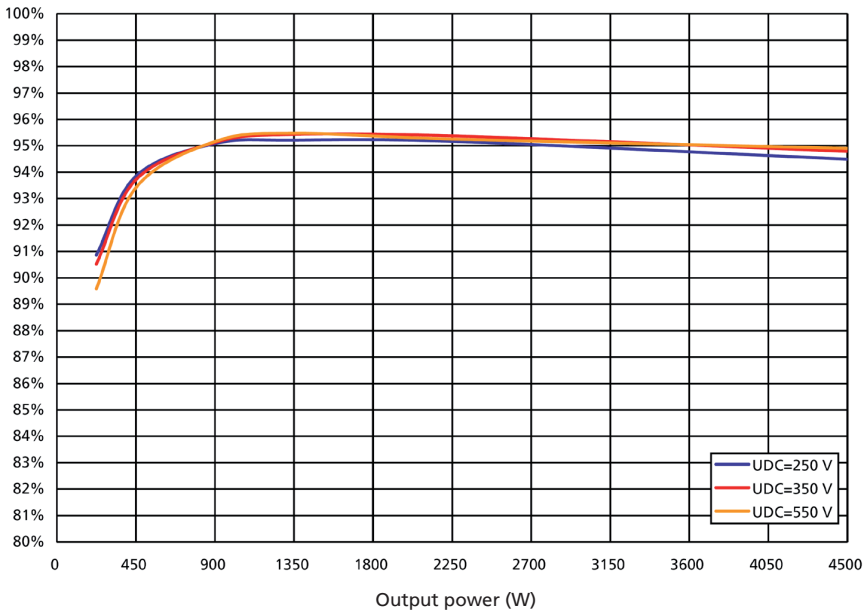
Efficiency curve AT 3600



Output power (%)		5.0	10.0	20.0	30.0	50.0	100.0	Max	Euro
Efficiency	250 V	89.1	93.0	94.7	95.1	95.2	94.5	95.3	94.7
	350 V	89.2	92.9	94.9	95.4	95.4	95.1	95.5	94.9
	550 V	88.3	92.6	94.8	95.3	95.2	95.1	95.5	94.8

Values based on 230 V mains voltage, cos phi = 1 and an ambient temperature of 25°C.

Efficiency curve AT 4500



Output power (%)		5.0	10.0	20.0	30.0	50.0	100.0	Max	Euro
Efficiency	250 V	90.9	93.9	95.1	95.2	95.2	94.5	95.4	94.8
	350 V	90.5	93.7	95.1	95.4	95.4	94.8	95.5	95.0
	550 V	89.6	93.4	95.2	95.5	95.3	94.9	95.5	94.9

Values based on 230 V mains voltage, cos phi = 1 and an ambient temperature of 25°C.

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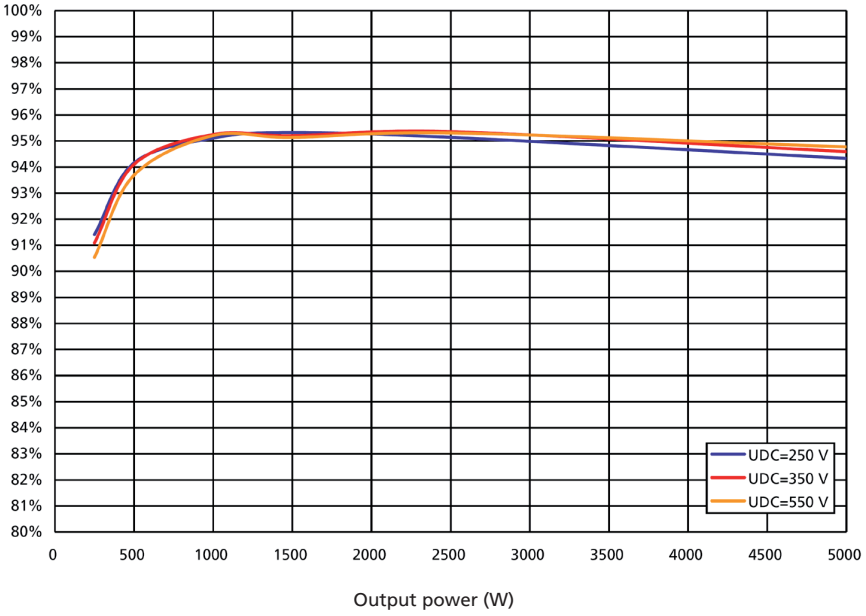
Efficiency curve for Sunways Solar Inverter AT

Efficiency curve AT 5000



Output power (%)		5.0	10.0	20.0	30.0	50.0	100.0	Max	Euro
Efficiency	250 V	91.4	94.2	95.1	95.3	95.1	94.3	95.4	94.8
	350 V	91.1	94.1	95.3	95.2	95.4	94.6	95.5	95.0
	550 V	90.5	93.7	95.2	95.1	95.3	94.8	95.5	94.9

Values based on 230 V mains voltage, cos phi = 1 and an ambient temperature of 25°C.

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Xtender series







	Model	XTS 900-12	XTS 1200-24	XTS 1400-48	XTM 1500-12	XTM 2000-12	XTM 2400-24	XTM 2600-48	XTM 3500-24	XTM 4000-48	XTH 3000-12	XTH 5000-24	XTH 6000-48	XTH 8000-48
	Inverter													
	Nominal battery voltage	12Vdc	24Vdc	48Vdc	12Vdc		24Vdc	48Vdc	24Vdc	48Vdc	12Vdc	24Vdc	48Vdc	
	Input voltage range	9.5 - 17Vdc	19 - 34Vdc	38 - 68Vdc	9.5 - 17Vdc		19 - 34Vdc	38 - 68Vdc	19 - 34Vdc	38 - 68Vdc	9.5 - 17Vdc	19 - 34Vdc	38 - 68Vdc	
	Continuous power @ 25°C	650**/500VA	800**/650VA	900**/750VA	1500VA	2000VA	2000VA	2000VA	3000VA	3500VA	2500VA	4500VA	5000VA	7000VA
	Power 30 min. @ 25°C	900**/700VA	1200**/1000VA	1400**/1200VA	1500VA	2000VA	2400VA	2600VA	3500VA	4000VA	3000VA	5000VA	6000VA	8000VA
	Power 5 sec. @ 25°C	2.3kVA	2.5kVA	2.8kVA	3.4kVA	4.8kVA	6kVA	6.5kVA	9kVA	10.5kVA	7.5kVA	12kVA	15kVA	21kVA
	Maximum load	Up to short-circuit												
	Maximum asymmetric load	Up to Pcont.												
*	Load detection (stand-by)	2 to 25 W												
	Cos φ	0.1-1												
	Maximum efficiency	93%	93%	93%	93%		94%	96%	94%	96%	93%	94%	96%	
	Consumption OFF/Stand-by/ON	1.1W/1.4W/7W	1.2W/1.5W/8W	1.3W/1.6W/8W	1.2W/1.4W/8W	1.2W/1.4W/10W	1.4W/1.6W/9W	1.8W/2W/10W	1.4W/1.6W/12W	1.8W/2.1W/14W	1.2W/1.4W/14W	1.4W/1.8W/18W	1.8W/2.2W/22W	1.8W/2.4W/30W
*	Output voltage	Pure sine wave 230Vac (±2%) / 120Vac (1)												
*	Output frequency	45Hz - 60Hz (1) ± 0.05% (crystal controlled)												
	Harmonic distortion	<2%												
	Overload and short-circuit protection	Automatic disconnection with 3 time restart attempt												
	Overheat protection	Warning before shut-off - with automatic restart												
	Battery charger													
*	Charge Characteristic	6 steps : Bulk-Absorption-Floating-Equalization-reduced floating-periodic absorption Number of steps, thresholds, end current and times completely adjustable with the RCC-02/-03												
*	Maximum charging current	35A	25A	12A	70A	100A	55A	30A	90A	50A	160A	140A	100A	120A
*	Temperature compensation	With BTS-01 or BSP 500/1200												
	Power Factor Correction (PFC)	EN 61000-3-2												
	General data	**XTS 900-12**	**XTS 1200-24**	**XTS 1400-48**	**XTM 1500-12**	**XTM 2000-12**	**XTM 2400-24**	**XTM 2600-48**	**XTM 3500-24**	**XTM 4000-48**	**XTH 3000-12**	**XTH 5000-24**	**XTH 6000-48**	**XTH 8000-48**
*	Input voltage range	150 to 265Vac / 50 to 140Vac (1)												
	Input frequency	45 to 65Hz												
	Input current max. (transfer relay) / Output current max.	16Aac/20Aac			50Aac/56Aac									50Aac/80Aac
	Transfer time	<15ms												
	Multifunction contacts	Module ARM-02 with 2 contacts, in option			2 independent contacts (potential free 3 points, 16Aac/5Adc)									
	Weight	8.2 kg	9 kg	9.3 kg	15 kg	18.5 kg	16.2 kg		21.2 kg	22.9 kg	34 kg	40 kg	42 kg	46 kg
	Dimension hxwxl [mm]	110x210x310			133x322x466						230x300x500			
	Protection index	IP54			IP20									
	Conformity	Directive EMC 2004/108/EC : EN 61000-6-1, EN 61000-6-3, EN 55014, EN 55022, EN 61000-3-2, 62040-2 Low voltage directive 2006/95/EC : EN 62040-1-1, EN 50091-2, EN 60950-1												
	Operating temperature range	-20 to 55°C												
	Relative humidity in operation	100%			95% without condensation									
	Ventilation	Optional cooling module ECF-01			Forced from 55°C									
	Acoustic level	<40dB / <45dB (without/with ventilation)												
	Warranty	5 years												
	Accessoires													
	Remote control RCC-02 or RCC-03	•	•	•	•	•	•	•	•	•	•	•	•	•
	Module XCOM-232i	•	•	•	•	•	•	•	•	•	•	•	•	•
	Internet based communication sets Xcom-LAN, Xcom-GSM	•	•	•	•	•	•	•	•	•	•	•	•	•
	Remote Control Module RCM-10 (3 m)	•	•	•	•	•	•	•	•	•				
	2 aux. contacts module ARM-02	•	•	•										
	Cooling Module ECF-01	•	•	•										
	Battery temp. sensor BTS-01 (3 m)	•	•	•	•	•	•	•	•	•	•	•	•	•
	Communication cable for 3ph and // CAB-RJ45-8-2	•	•	•	•	•	•	•	•	•	•	•	•	•
	Mounting frame X-Connect										•	•	•	•

* Adjustable with the RCC-02/-03

** These features are valid only when using the cooling module ECF-01.

(1) With -01 at the end of the reference, means 120V/60Hz. Available for all Xtenders except XTH 8000-48

Data may change without any notice.

Xtender series







	Model	XTS 900-12	XTS 1200-24	XTS 1400-48	XTM 1500-12	XTM 2000-12	XTM 2400-24	XTM 2600-48	XTM 3500-24	XTM 4000-48	XTH 3000-12	XTH 5000-24	XTH 6000-48	XTH 8000-48
	Inverter													
	Nominal battery voltage	12Vdc	24Vdc	48Vdc	12Vdc		24Vdc	48Vdc	24Vdc	48Vdc	12Vdc	24Vdc	48Vdc	
	Input voltage range	9.5 - 17Vdc	19 - 34Vdc	38 - 68Vdc	9.5 - 17Vdc		19 - 34Vdc	38 - 68Vdc	19 - 34Vdc	38 - 68Vdc	9.5 - 17Vdc	19 - 34Vdc	38 - 68Vdc	
	Continuous power @ 25°C	650**/500VA	800**/650VA	900**/750VA	1500VA	2000VA	2000VA	2000VA	3000VA	3500VA	2500VA	4500VA	5000VA	7000VA
	Power 30 min. @ 25°C	900**/700VA	1200**/1000VA	1400**/1200VA	1500VA	2000VA	2400VA	2600VA	3500VA	4000VA	3000VA	5000VA	6000VA	8000VA
	Power 5 sec. @ 25°C	2.3kVA	2.5kVA	2.8kVA	3.4kVA	4.8kVA	6kVA	6.5kVA	9kVA	10.5kVA	7.5kVA	12kVA	15kVA	21kVA
	Maximum load	Up to short-circuit												
	Maximum asymmetric load	Up to Pcont.												
*	Load detection (stand-by)	2 to 25 W												
	Cos φ	0.1-1												
	Maximum efficiency	93%	93%	93%	93%		94%	96%	94%	96%	93%	94%	96%	
	Consumption OFF/Stand-by/ON	1.1W/1.4W/7W	1.2W/1.5W/8W	1.3W/1.6W/8W	1.2W/1.4W/8W	1.2W/1.4W/10W	1.4W/1.6W/9W	1.8W/2W/10W	1.4W/1.6W/12W	1.8W/2.1W/14W	1.2W/1.4W/14W	1.4W/1.8W/18W	1.8W/2.2W/22W	1.8W/2.4W/30W
*	Output voltage	Pure sine wave 230Vac (±2%) / 120Vac (1)												
*	Output frequency	45Hz - 60Hz (1) ± 0.05% (crystal controlled)												
	Harmonic distortion	<2%												
	Overload and short-circuit protection	Automatic disconnection with 3 time restart attempt												
	Overheat protection	Warning before shut-off - with automatic restart												
	Battery charger													
*	Charge Characteristic	6 steps : Bulk-Absorption-Floating-Equalization-reduced floating-periodic absorption Number of steps, thresholds, end current and times completely adjustable with the RCC-02/-03												
*	Maximum charging current	35A	25A	12A	70A	100A	55A	30A	90A	50A	160A	140A	100A	120A
*	Temperature compensation	With BTS-01 or BSP 500/1200												
	Power Factor Correction (PFC)	EN 61000-3-2												
	General data	**XTS 900-12**	**XTS 1200-24**	**XTS 1400-48**	**XTM 1500-12**	**XTM 2000-12**	**XTM 2400-24**	**XTM 2600-48**	**XTM 3500-24**	**XTM 4000-48**	**XTH 3000-12**	**XTH 5000-24**	**XTH 6000-48**	**XTH 8000-48**
*	Input voltage range	150 to 265Vac / 50 to 140Vac (1)												
	Input frequency	45 to 65Hz												
	Input current max. (transfer relay) / Output current max.	16Aac/20Aac			50Aac/56Aac									50Aac/80Aac
	Transfer time	<15ms												
	Multifunction contacts	Module ARM-02 with 2 contacts, in option			2 independent contacts (potential free 3 points, 16Aac/5Adc)									
	Weight	8.2 kg	9 kg	9.3 kg	15 kg	18.5 kg	16.2 kg		21.2 kg	22.9 kg	34 kg	40 kg	42 kg	46 kg
	Dimension hxwxl [mm]	110x210x310			133x322x466						230x300x500			
	Protection index	IP54			IP20									
	Conformity	Directive EMC 2004/108/EC : EN 61000-6-1, EN 61000-6-3, EN 55014, EN 55022, EN 61000-3-2, 62040-2 Low voltage directive 2006/95/EC : EN 62040-1-1, EN 50091-2, EN 60950-1												
	Operating temperature range	-20 to 55°C												
	Relative humidity in operation	100%			95% without condensation									
	Ventilation	Optional cooling module ECF-01			Forced from 55°C									
	Acoustic level	<40dB / <45dB (without/with ventilation)												
	Warranty	5 years												
	Accessoires													
	Remote control RCC-02 or RCC-03	•	•	•	•	•	•	•	•	•	•	•	•	•
	Module XCOM-232i	•	•	•	•	•	•	•	•	•	•	•	•	•
	Internet based communication sets Xcom-LAN, Xcom-GSM	•	•	•	•	•	•	•	•	•	•	•	•	•
	Remote Control Module RCM-10 (3 m)	•	•	•	•	•	•	•	•	•				
	2 aux. contacts module ARM-02	•	•	•										
	Cooling Module ECF-01	•	•	•										
	Battery temp. sensor BTS-01 (3 m)	•	•	•	•	•	•	•	•	•	•	•	•	•
	Communication cable for 3ph and // CAB-RJ45-8-2	•	•	•	•	•	•	•	•	•	•	•	•	•
	Mounting frame X-Connect										•	•	•	•

* Adjustable with the RCC-02/-03

** These features are valid only when using the cooling module ECF-01.

(1) With -01 at the end of the reference, means 120V/60Hz. Available for all Xtenders except XTH 8000-48

Data may change without any notice.

SOLIBRO SL2 CIGS THIN-FILM MODULE

Generation 1.4 - Efficiency and aesthetics have a new name



Solibro's SL2 thin-film modules offer efficiencies up to 13.2 % in serial production. The modules are especially suited for roof-parallel installations on flat rooftops. This allows minimal shadowing with maximal energy yield. Due to their frameless design, SL2 modules possess excellent self-cleaning properties and require minimal maintenance. All SL2 modules are "Made in Germany" and are tested according to very high standards in order to insure a long lifetime and stable module performance.



MAXIMIZE YOUR ENERGY YIELD

Additional power through positive lightsoaking: In contrast to ordinary solar cells, our CIGS modules increase in power under illumination. Combined with our strict positive sorting, you get up to 15 % more power for your money.

Our modules deliver top performance even at very high temperatures: With a temperature coefficient of -0.38 %/K, the Solibro CIGS modules are a long way ahead of their crystalline competitors, producing high yields even under critical climatic conditions.

Excellent usage of sunlight: Our modules allow PV installations regardless of whether the roof faces to the south, east or west. SL2 modules generate high energy yields even when installed parallel to the roof.

ONE MORE ADVANTAGE FOR YOU

Aesthetic appearance: The uniformly black SL2 solar modules are ideal for architecturally demanding photovoltaic installations.

Controlled quality: Solibro's SL2 modules are certified according to IEC 61646, IEC 61730 and UL 1703. A multitude of additional quality checks ensure that each single module fulfills the same high standards guaranteeing your long-term energy yields.

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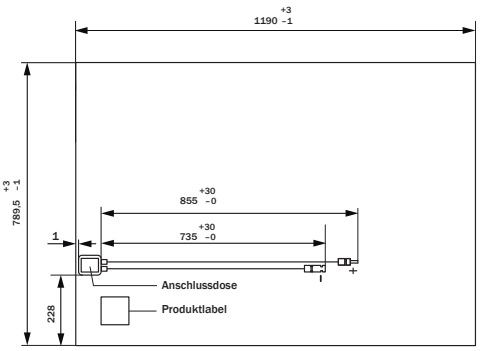
MECHANICAL SPECIFICATION	
Length	1190 (+3/-1) mm
Width	789.5 (+3/-1) mm
Height	7.3 mm (+ Junction box, 15 mm)
Weight	16.5 kg
Front cover	4 mm tempered low iron glass (ESG)
Back cover	3 mm float glass
Frame	None
Cell type	CIGS [Cu(In, Ga) Se_2]
Junction box	Protection class IP 65, with 1 bypass diode (3A) 66 x 54 x 15 mm³
Cable type	Solar cable 2.5 mm²; (+) 855 (+30/-0) mm; (–) 735 (+30/-0) mm
Connector	MC4

TECHNICAL DRAWING



ELECTRICAL CHARACTERISTICS

PERFORMANCE AT STANDARD TEST CONDITIONS (STC: 1000 W/m2, 25 °C, AM 1.5 G SPECTRUM)[1]

POWER CLASS (+5/-0 W)		[W]	100	105	110	115	120
Minimum Power	P_{MPP}	[W]	100.0	105.0	110.0	115.0	120,0
Short Circuit Current	I_{SC}	[A]	1.68	1.68	1.69	1.69	1.69
Open Circuit Voltage	U_{OC}	[V]	90.1	91.6	93.3	95.1	97.6
Current at P_{MPP}	I_{MPP}	[A]	1.46	1.49	1.52	1.54	1.56
Voltage at P_{MPP}	U_{MPP}	[V]	68.5	70.5	72.4	74.7	76.9
Nominal efficiency	η	[%]	≥10.6	≥11.2	≥11.7	≥12.2	≥12.8

PERFORMANCE AT NORMAL OPERATING CELL TEMPERATURE (NOCT: 800 W/M2, 51 ± 2 °C, AM 1.5 G SPECTRUM)[1]

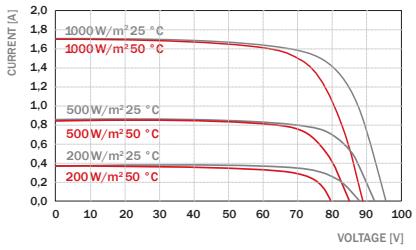
POWER CLASS (+5/-0 W)		[W]	100	105	110	115	120
Minimum Power	P_{MPP}	[W]	72.3	75.9	79.5	83.1	86.7
Short Circuit Current	I_{SC}	[A]	1.34	1.34	1.35	1.35	1.35
Open Circuit Voltage	U_{OC}	[V]	82.0	83.4	84.9	86.5	88.8
Current at P_{MPP}	I_{MPP}	[A]	1.16	1.18	1.21	1.22	1.24
Voltage at P_{MPP}	U_{MPP}	[V]	62.1	64.0	65.7	67.8	69.8

[1] Measurement accuracy PMPP: ± 5 %; measurement accuracy ISC, VOC, IMPP, VMPP: ± 10 %. All STC measurements are based on a pre-treatement of modules with 43 kWh/m² of light soaking (43 hours at 1000 W/m² and MPP) followed by a cool down to 25 °C. For system conception, please take into account the typical relative VOC and VMPP power increase of 2.5 % after 215 kWh/m² of light soaking.This power boost is not included in the nominal values of this data sheet.

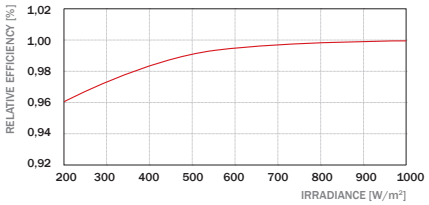
TEMPERATURE COEFFICIENTS (AT 1000 W/M2, AM 1.5 G SPECTRUM)

Temperature Coefficient of I_{SC}	α	[%/K]	+ 0.00 ± 0.04	Temperature Coefficient of U_{OC}	β	[%/K]	− 0.29 ± 0.04
Temperature Coefficient of P_{MPP}	γ	[%/K]	− 0.38 ± 0.04				

I-V CURVES AT VARIOUS TEMPERATURES AND IRRADIANCE LEVELS



PERFORMANCE AT LOW IRRADIANCE



The typical relative change in module efficiency (at nominal power) at an irradiance of 200 W/m² in relation to 1000 W/m² (both at 25 °C and AM 1.5 G spectrum) is -4.0 % rel.

PROPERTIES FOR SYSTEM DESIGN

Maximum System Voltage V_{SYS}	[V]	1000 (IEC) / 600 (UL 1703)
Maximum Reverse Current I_R	[A]	4
Wind / Snow Load	[Pa]	2400
Safety Class	II	
Fire Rating	C	
Permitted module temperature on continous duty	-40 °C bis +85 °C	

QUALIFICATIONS AND CERTIFICATES

IEC 61646 (Ed. 2), IEC 61730 (Ed.1) application class A, UL 1703
The production site is certified according to ISO 9001 for Quality Management.

Safety Class II

C Zertifiziert US
UL 1703

The content of this data sheet is according to DIN EN 50380.

Note: See the installation and operating manual or contact the technical service for further information on approved installation and use of this product.

Specifications subject to technical changes © Solibro GmbH. Data sheet_SL2_G1.4_Rev02_EN_2013-03

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Super B Lithium batteries to perform better



SB12V160E-ZC

Lightweight Lithium Ion Traction battery, 62.4 lb / 28.3 kg.
This newly developed battery is designed to replace the much heavier 250 to 320 Ah lead-acid battery.

Features

- Traction battery
- Lithium Iron Phosphate (LiFePO4)
- Most safe lithium technology today
- Superior abuse tolerance
- Integrated BMS (Battery Management System)
- Glass fibre reinforced plastic (GRFP) Casing, Aluminium / PE sandwich side panels
- 2 x 95mm2 wire connection per terminal
- Integrated fuse, 32V / 500A
- CANOpen interface for battery monitoring
- Battery monitoring / History Storage
- Adaptive cell balancing
- Serial string equalisation

Performance

- High capacity
- Low weight
- High cycle count
- Low maintenance
- One on One replaceable with AGM/GEL lead acid batteries
- High discharge current, 3C continuous, 5C pulse
- Can be charged with regular AGM charger
- Fast charging, 1C

- Serial string connection up to 1150V DC

Safety

super B batteries are based on Lithium Iron Phosphate technology (LiFePO4). This Lithium Ion technology used in super B batteries is the safest Lithium Ion technology available today. On top of that our bespoke casing and electronics further increase safety and durability.

Recharges much faster

Longer service life

Only 1/3 of the size

Weighs less

Low self discharge

High temperature starting

Applications for SB12V160E-ZC

Super B Lithium batteries to perform better

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The Netherlands

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F +31 (0)74 8200011
E info@super-b.com

Super B Lithium batteries to perform better

Marine

Technical specifications SB12V160E-ZC

SKU/EAN13	8718531360198
Battery Designation	4IFP227/415/315
Height (mm)	313,00 / 314,00
Diameter (mm)	NA
Width (mm)	413,50 / 414,50
Thickness (mm)	225,00 / 226,00
Nominal voltage (V)	13,2V
Charge method	CCCV
End of charge voltage (V)	15,4V
End of charge voltage (V) for endurance (cycle life)	14,6V
Charge current (A)	160A (1C)
Charge current (A) for endurance (cycle life)	52,8A (C/3)
End-of-discharge voltage (V)	8V
?End-of-discharge voltage (V) for endurance (cycle life)	10V
Discharge current (A)	480A (3C)
Discharge current (A) for endurance (cycle life)	52,8A (C/3)
Discharge pulse current (A) (10 seconds)	1280A (8C)
Discharge pulse current (A) (60 second)	800A (5C)
Discharge performance at 20 °C (rated capacity)	160Ah / 2112Wh
Discharge performance at –20 °C (capacity)	104Ah / 1372,8Wh
High rate discharge performance at 20 °C (capacity)	144Ah / 1841,4Wh
EqPb (Equals Lead acid battery)	320Ah
Weight	28.3kg
Operating temperature range (Charge)	0°C to 45°C

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Operating temperature range (Discharge)	-20°C to +60°C
Storage temperature range	-20°C to +60°C

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MATERIAL SAFETY DATA SHEET

super B batteries

FILE NO.: MSD_190_004_2
MSDS DATE: 15 June 2013

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: SB12V50E-MC / SB12V100E-NC / SB12V160E-ZC
SYNONYMS: Lithium Iron Phosphate Battery, High Power/Energy Lithium Ion Battery Cells, Phosphate Based
PRODUCT CODES: 8718531360174 / 8718531360181 / 8718531360198

MANUFACTURER: super B b.v.
ADDRESS: Diamantstraat 1e
7554 TA Hengelo
The Netherlands

EMERGENCY PHONE: +31 (0)74 8200010

CHEMICAL NAME: Lithium Iron Phosphate
CHEMICAL FAMILY: Lithium Ion
CHEMICAL FORMULA: LiFePO4

PRODUCT USE: Automotive starter battery / Traction batteries
PREPARED BY: super B b.v.

SECTION 1 NOTES:

SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS

Under normal use, this battery is not expected to expose user to hazardous ingredients. USA: This battery is an article pursuant to 29 CFR 1910.1200 and, as such, is not subject to the OSHA Hazard Communication Standard requirement. The information contained in this Material Safety Data Sheet contains valuable information critical to the safe handling and proper use of the product. This MSDS should be retained and available for employees and other users of this product.
Canada: This is not a controlled product under WHMIS. This product meets the definition of a “manufactured article” and is not subject to the regulations of the Hazardous Products Act.

SECTION 2 NOTES:

SECTION 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:
Not dangerous with normal use. The battery should not be disassembled or incinerated. Exposure to the ingredients contained within or their combustion products could be harmful.

APPEARANCE, COLOR, and ODOR:
Solid object, no odor.

ROUTES OF ENTRY:
Risk of exposure will only occur if the battery cell is mechanically, thermally, or electrically abused and the enclosure is compromised. If this occurs, exposure to electrolyte solutions contained within the battery cell may occur by inhalation, eye contact, skin contact and ingestion.

POTENTIAL HEALTH EFFECTS

EYES: Contact between the battery and eye will not cause any harm. Eye contact with the contents of a ruptured battery can cause severe irritation to the eye.

SKIN: Contact between the battery and skin will not cause any harm. Skin contact with positive and negative terminals of high voltages may cause burns to the skin. Skin contact with a ruptured battery can cause skin irritation.

INGESTION: Swallowing of material from a sealed battery is not an expected route of exposure. Swallowing mists from a ruptured battery may cause respiratory irritation, chemical burns of the mouth and gastrointestinal tract irritation.

INHALATION: Inhalation of material from a sealed battery is not an expected route of exposure. Vapors or mists from a ruptured battery may cause respiratory irritation.

MATERIAL SAFETY DATA SHEET

super B batteries

FILE NO.: MSD_190_004_2
MSDS DATE: 15 June 2013

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: Not Available

SECTION 4: FIRST AID MEASURES

EYES: Wash affected eye with lukewarm water for at least 30 minutes. Rinse with saline solution if possible. Seek medical attention.

SKIN: Wash affected area with lukewarm water for at least 30 minutes. If irritation or pain persists, seek medical attention.

INGESTION: Move victim to fresh air and remove source of contamination from area. Seek medical attention.

INHALATION: Move victim to fresh air and remove source of contamination from area. Seek medical attention.

CAUTION: In all cases if irritation persists, seek medical assistance at once.

SECTION 4 NOTES:

SECTION 5: FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIA: Water, carbon dioxide, dry chemical powder and foam are most effective means to extinguish a battery fire

FIRE FIGHTING PROCEDURE: Put on fully protective gear, including self-contained breathing apparatus, goggles, fireproofing jacket and gloves.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Exposing battery cell to excessive heat, fire or over voltage condition may cause a leak, fire, hazardous vapors and hazardous decomposition products. Damaged or opened cells or batteries can result in rapid heating and the release of flammable vapors.

SECTION 5 NOTES:

SECTION 6: ACCIDENTAL RELEASE MEASURES

ACCIDENTAL RELEASE MEASURES:
The material contained within the batteries cells is only expelled under abusive conditions. Use a shovel and cover battery with sand or vermiculite, place in an approved container and dispose in accordance with section 13.

SECTION 6 NOTES:

SECTION 7: HANDLING AND STORAGE

HANDLING: Do not expose battery or cell to extreme temperatures or fire. Do not disassemble, crush or puncture battery.

STORAGE: Insulate positive and negative terminals to avoid short circuit. Store in a cool and well ventilated area and avoid direct sunlight. Elevated temperatures can result in reduced battery life.

SECTION 7 NOTES:

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

RESPIRATORY PROTECTION: Not necessary under normal use. In case of battery or cell rupture, use a self contained full face respiratory mask.

EYE PROTECTION: Not necessary under normal use. Wear safety goggles if handling a ruptured or leaking battery cell.

HAND PROTECTION: Not necessary under normal use. Wear Viton rubber gloves if handling a ruptured or leaking battery cell.

SKIN PROTECTION: Not necessary under normal use. Wear rubber apron and Viton rubber gloves if handling a ruptured or leaking battery cell.

MATERIAL SAFETY DATA SHEET

super B batteries

FILE NO.: MSD_190_004_2
MSDS DATE: 15 June 2013

SECTION 8 NOTES:

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid	**Odor Type:**	Odorless
Appearance:	Battery	**Odor Threshold:**	Not Applicable
pH:	Not Applicable	**Evaporative Rate: (n-Butyl Acetate = 1)**	Not Applicable
Relative Density:	Not Applicable	**Auto Ignition Temperature (°C):**	Not Applicable
Boiling Point:	Not Applicable	**Flammability Limits (%):**	Not Applicable
Melting Point:	Not Applicable	**Vapor Pressure: (mm Hg @ 20 °C)**	Not Applicable
Viscosity:	Not Applicable	**Vapor Density: (Air = 1)**	Not Applicable
Oxidizing Properties:	Not Applicable	**Solubility in Water:**	Insoluble
Flash Point and Method (°C)	Not Applicable	**Water/ Oil distribution coefficient:**	Not Applicable

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable

Conditions to Avoid: Avoid exposing battery to high temperatures. Do not incinerate, deform, mutilate, crush, pierce, short circuit or disassemble.

Materials to Avoid: Not Applicable

Hazardous Decomposition Products: Combustible vapors may be released if exposed to fire.

Possibility of Hazardous Reactions: Not available.

SECTION 10 NOTES:

SECTION 11: TOXICOLOGICAL INFORMATION

Irritation: Risk of irritation only occurs if battery cells are mechanically, thermally or electrically abused and the enclosure is compromised.

Neurological Effects: Not applicable.

Sensitization: Not applicable.

Teratogenicity: Not applicable.

Reproductive Toxicity: Not applicable.

Mutagenicity (Genetic Effects): Not applicable.

Toxicologically Synergistic Materials: Not available

SECTION 11 NOTES:

SECTION 12: ECOLOGICAL INFORMATION

Bioaccumulative potential: Not available.

Persistence and degradability: Not available.

Mobility: Not available.

MATERIAL SAFETY DATA SHEET

super B batteries

FILE NO.: MSD_190_004_2
MSDS DATE: 15 June 2013

Ecotoxicity: Not available.

Other adverse effects: Not available.

SECTION 12 NOTES:

SECTION 13: DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD: Recycling is encouraged. Dispose of in accordance with local, state and federal laws and regulations.

USA: Dispose of in accordance with local, state and federal laws and regulations.

Canada: Dispose of in accordance with local, state and federal laws and regulations.

EC: Dispose of in accordance with relevant EC Directives.

SECTION 14: TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION

PROPER SHIPPING NAME:	Lithium Ion batteries
HAZARD CLASS:	UN3480
ID NUMBER:	Not applicable
PACKING GROUP:	PI965 Section I
LABEL STATEMENT:	See note

WATER TRANSPORTATION

PROPER SHIPPING NAME:	Lithium Ion batteries
HAZARD CLASS:	UN3480
ID NUMBER:	Not applicable
PACKING GROUP:	PI965 Section I
LABEL STATEMENT:	See note

AIR TRANSPORTATION

PROPER SHIPPING NAME:	Lithium Ion batteries
HAZARD CLASS:	UN3480
ID NUMBER:	Not applicable
PACKING GROUP:	PI965 Section I
LABEL STATEMENT:	See note

OTHER AGENCIES:

SECTION 14 NOTES:

ATERIAL SAFETY DATA SHEET

ɔer B batteries

FILE NO.: MSD_190_004_2
MSDS DATE: 15 June 2013



Class 9 Miscellaneous Dangerous Goods and UN Identification labels for transportation of lithium ion batteries which are assigned Class
efer to relevant transportation documents. Lithium and lithium ion cells and batteries are regulated in the U.S. in accordance with Part 49
ıe Code of Federal Regulations, (49 CFR Sections 105-180) of the U.S. Hazardous Materials Regulations.

CTION 15: REGULATORY INFORMATION

TSCA Status: All ingredients in the product are listed on the TSCA inventory.

SARA Title III: Sec. 302/304: None
Sec. 311/312: None
Sec. 313: None
CERCLA RQ: None

California Prop 65: This product does not contain chemicals know to the State of California to cause cancer or reproductive toxicity.

ıada

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contair all the information required by the Controlled Products Regulations.

WHMIS Classification: Not Controlled

New Substance Notification Regulations: All ingredients in the product are listed, as required, on Canada's Domestic Substance List.

NPRI Substances (National Pollutant Release Inventory): This product does not contain any NPRI chemicals.

Classification for the Substance/ Preparation

Symbol: This product is not classified as dangerous according to Directive 1999/45/EC and it's amendments.

Risk Phrases: None

Safety Phrases: S2: Keep out of the reach of children.

CTION 15 NOTES:

CTION 16: OTHER INFORMATION

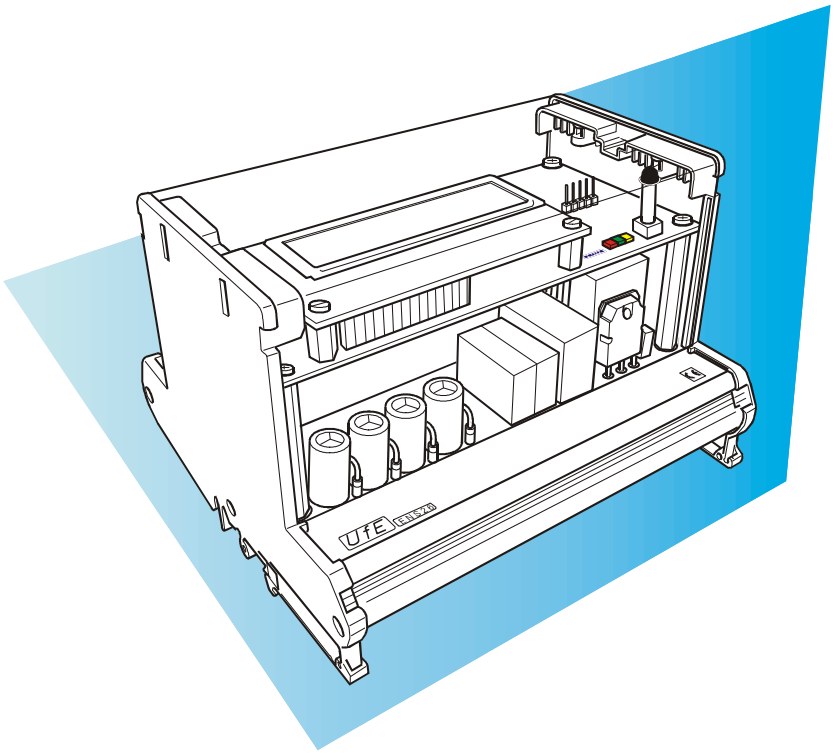
MATERIAL SAFETY DATA SHEET

super B batteries

FILE NO.: MSD_190_004_2
MSDS DATE: 15 June 2013

Preparation Date: 7 Nov 2012
Revision Date: 15 June 2013
Revision Summary: Released.
Prepared by: super B b.v.
Diamantstraat 1e
7554 TA Hengelo
the Netherlands
Phone: +31 (0)74-8200010

Disclaimer: The information and recommendations set forth are made in good faith and accurate at the date of preparation. Super B b.v. makes no warranty expressed or implied with respect to this information and recommendations and disclaims all liability from reliance on it.



ENS26NA
Network and System Protection complying with regulation VDE AR-N-4105 and Automatic Isolation Unit complying with standard DIN V VDE V 0126-1-1/A1

Installation and Operating Manual

Declaration of Conformity

We

UfE Umweltfreundliche Energieanlagen GmbH
Joachim-Jungius-Straße 9
18059 Rostock
Deutschland/Germany

declare in sole responsibility that the product

Type: NA-Protection ENS26NA

fulfils the applicable health and safety requirements in the EU Directives

89/336/EEC (Electromagnetic Compatibility EMC) and
73/23/EEC (low voltage guidelines)

and the law reorganising the safety of technical apparatus and consumer products (law on equipment and product safety),
as well as the requirements stipulated in other applicable, harmonised European Norms.

In addition, the following directives are also fulfilled:

89/391/EEC (employee safety and health protection)
VDE-AR-N-4105 (Generators connected to the low-voltage distribution network)
DIN V VDE V 0126-1-1/A1 (Automatic disconnection device between a generator and the public low-voltage grid)

Klaus-Wilhelm Köln
Manager

Umweltfreundliche Energieanlagen

UfE GmbH Joachim-Jungius-Str. 9 18059 Rostock

Declaration concerning the Requirements

of the VDE-AR-N 4105 „Generators connected to the low-voltage distribution network“
NA protection, type: ENS26NA

The above mentioned grid and system protection meets the requirements of the VDE-AR-N-4105.

The setup values and switch off times are according to item 6.5 of the VDE-AR-N-4105.

The functional safety has been checked and meets at least the requirements according annex A „to 6.1 General requirements, single fault safety“ of the VDE-AR-N-4105.

The software version in use is: ENS 26_6.

Rostock, 07.09.2011

Klaus-Wilhelm Köln
Manager



Manager: Klaus Köln
J.-Jungius-Str. 9, 18059 Rostock
HRB 8987, AG Rostock
Ust.-IdNr: DE 173735470
St.-Nr.: 11 079 121 04502

9 Technical Data

Switched power	max. 5.750 W
Own consumption	1.5 W
Housing	Plastic, suitable for assembly on the top hat rail
Overall dimensions (W x H x D)	146 mm x 99 mm x 125,4 mm
Cut-out dimensions (W x H)	146 mm x 73 mm
Ambient conditions	- 20 °C to + 40 °C, 10 to 90 % relative humidity, non-condensating
Nominal current of power feeder	25 A
The unit disconnects the mains under the following defined conditions (complying with regulation VDE-AR-N-4105 and standard DIN V VDE V 0126-1-1/A1):	
Overvoltage (fast shutdown)	> 300 V (response time 20 ms)
Overvoltage	> 264 V (response time < 200 ms)
Overvoltage	230 V + 10% over 10 minutes
Undervoltage	< 184 V (response time < 200 ms)
Frequency deviation	- 2.5 Hz / + 1.5 Hz (response time < 200 ms) optional: + 0.3 Hz to + 1.5 Hz statistically distributed (response time < 200 ms)
Impedance jump detection	> 0.5 Ohm (response time 500 ms)

https://www.phoenixcontact.com/ch/products/2800627

Type 2 surge protection device - VAL-MS 1000DC-PV/2+V-FM - 2800627

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Surge arrester for 2-pos. isolated 1000 V DC voltage systems, for DIN rail mounting, 3-pos. base element with remote indication contact, three plug-in temperature-monitored protective elements, status message on each plug.

Why buy this product

- Increased safety, thanks to compliance with standard EN 50539-11
- Reliable contact, thanks to integrated rotating latch
- Easy replacement, thanks to plug-in arresters
- Optimum inverter protection, thanks to low protection level
- Efficient replacement of defective plugs, thanks to visual status indicator
- Optimized maintenance planning, thanks to remote signaling
- Protection against mismatching, thanks to keyed plugs and base elements
- Always the right arrester, thanks to universal type 1/type 2 protective components



Key commercial data

Packing unit	1 pc
GTIN	4 046356 615075
Weight per Piece (excluding packing)	333.4 g
Custom tariff number	85363030
Country of origin	Germany

Technical data

Dimensions

Height	99 mm
Width	53.4 mm
Depth	65.5 mm
Horizontal pitch	3 Div.

Ambient conditions

Degree of protection	IP20
Ambient temperature (operation)	-40 °C ... 80 °C

Type 2 surge protection device - VAL-MS 1000DC-PV/2+V-FM - 2800627

Technical data

Ambient conditions

Ambient temperature (storage/transport)	-40 °C ... 80 °C
Altitude	≤ 2000 m (amsl (above mean sea level))
Permissible humidity (operation)	5 % ... 95 %
Shock (operation)	60g (Half sine/11 ms/3x #X#Y#Z)
Vibration (operation)	7,5g (5-500 Hz/2.5 h/XYZ)

General

Standards/specifications	EN 50539-11 2013
IEC test classification	PV T2
Number of ports	One
SPD failure behavior	Open circuit mode (OCM)
Connection configuration	Y configuration
SPD design	Voltage-limiting type
Installation location	Inside
Accessibility	Accessible
Installation location of the disconnect device	Internal
Mounting type	DIN rail: 35 mm
Color	jet black RAL 9005
Housing material	PBT / PA
Pollution degree	2
Distance between live and grounded parts	8 mm
Inflammability class according to UL 94	V-0
Surge protection fault message	Optical, remote indicator contact

Additional descriptions

Note	The device is intended for touch proof installation in a housing. Ensure that there is a gap of at least 8 mm between the active and grounded parts in the connection area.

Protective circuit DC voltage side (DC)

Maximum continuous operating voltage U_{CPV}	1170 V DC
Open circuit voltage U_{OCSTC}	≤ 970 V DC
Short-circuit current rating I_{SCPV}	300 A
Continuous operating current I_{CPV}	< 20 µA
Rated load current I_L	80 A
Residual current I_{PE}	≤ 20 µA DC
	≤ 250 µA AC
Standby power consumption P_C	≤ 25 mVA
Nominal discharge current I_n (8/20) µs (L+) - (L-)	15 kA
Nominal discharge current I_n (8/20) µs (L+) - PE	15 kA
Nominal discharge current I_n (8/20) µs (L-) - PE	15 kA
Maximum discharge current I_{max} (8/20) µs (L+) - (L-)	40 kA

Type 2 surge protection device - VAL-MS 1000DC-PV/2+V-FM - 2800627

Technical data

Protective circuit DC voltage side (DC)

Maximum discharge current I_{max} (8/20) µs (L+) - PE	40 kA
Maximum discharge current I_{max} (8/20) µs (L-) - PE	40 kA
Total discharge current I_{Total} (8/20)µs	40 kA
Voltage protection level U_p (L+) - (L-)	≤ 3.7 kV
Voltage protection level U_p (L+) - PE	≤ 3.7 kV
Voltage protection level U_p (L-) - PE	≤ 3.7 kV
Residual voltage U_{res} (L+) - (L-)	≤ 3.7 kV (at I_n)
	≤ 3.1 kV (at 5 kA)
	≤ 3.5 kV (at 10 kA)
	≤ 4 kV (at 20 kA)
	≤ 4.6 kV (at 30 kA)
	≤ 5 kV (at 40 kA)
Residual voltage U_{res} (L+) - PE	≤ 3.7 kV (at I_n)
	≤ 3.1 kV (at 5 kA)
	≤ 3.5 kV (at 10 kA)
	≤ 4 kV (at 20 kA)
	≤ 4.6 kV (at 30 kA)
	≤ 5 kV (at 40 kA)
Residual voltage U_{res} (L-) - PE	≤ 3.7 kV (at I_n)
	≤ 3.1 kV (at 5 kA)
	≤ 3.5 kV (at 10 kA)
	≤ 4 kV (at 20 kA)
	≤ 4.6 kV (at 30 kA)
	≤ 5 kV (at 40 kA)
Response time t_A (L+) - (L-)	≤ 25 ns
Response time t_A (L+) - PE	≤ 25 ns
Response time t_A (L-) -PE	≤ 25 ns
Insulation resistance R_{iso}	> 5 GΩ (at 500 V DC)
Max. required backup fuse with branch wiring	Not required
Recommended backup fuse maximum	Not required

Indicator/remote signaling

Switching function	PDT, 1-pos.
Operating voltage	5 V AC ... 250 V AC
	30 V DC
Operating current	5 mA AC ... 1.5 A AC
	1.5 A DC
Connection method	MC 1,5/3
Screw thread	M2
Tightening torque	0.25 Nm

Type 2 surge protection device - VAL-MS 1000DC-PV/2+V-FM - 2800627

Technical data

Indicator/remote signaling

	2 lb in ... 4 lb in
Stripping length	7 mm
Conductor cross section stranded min.	0.14 mm²
Conductor cross section stranded max.	1.5 mm²
Conductor cross section solid min.	0.14 mm²
Conductor cross section solid max.	1.5 mm²
Conductor cross section AWG/kcmil min.	30
Conductor cross section AWG/kcmil max	16

Connection data

Connection method	Screw connection
Conductor cross section stranded min.	1.5 mm²
Conductor cross section stranded max.	25 mm²
Conductor cross section solid min.	1.5 mm²
Conductor cross section solid max.	35 mm²
Screw thread	M5
Tightening torque	4.5 Nm
Stripping length	16 mm
Connection method	Biconnect terminal blocks
Conductor cross section stranded min.	1.5 mm²
Conductor cross section stranded max.	16 mm²
Screw thread	M6

Classifications

eCl@ss

eCl@ss 4.0	27140201
eCl@ss 4.1	27130801
eCl@ss 5.0	27130801
eCl@ss 5.1	27130801
eCl@ss 6.0	27130805
eCl@ss 7.0	27130805
eCl@ss 8.0	27130805

ETIM

ETIM 3.0	EC000941
ETIM 4.0	EC000941
ETIM 5.0	EC000941

UNSPSC

UNSPSC 6.01	30212010
UNSPSC 7.0901	39121610

Type 2 surge protection device - VAL-MS 1000DC-PV/2+V-FM - 2800627

Classifications

UNSPSC

UNSPSC 11	39121610
UNSPSC 12.01	39121610
UNSPSC 13.2	39121620

Approvals

Approvals

Approvals

UL Recognized / KEMA-KEUR / cUL Recognized / cULus Recognized

Ex Approvals

Approvals submitted

Approval details

UL Recognized

KEMA-KEUR

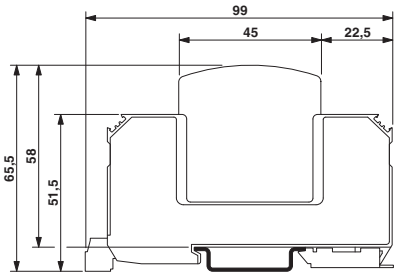
cUL Recognized

cULus Recognized

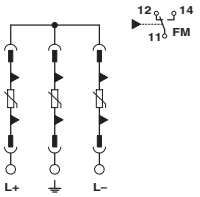
Drawings

Type 2 surge protection device - VAL-MS 1000DC-PV/2+V-FM - 2800627

Dimensioned drawing



Circuit diagram



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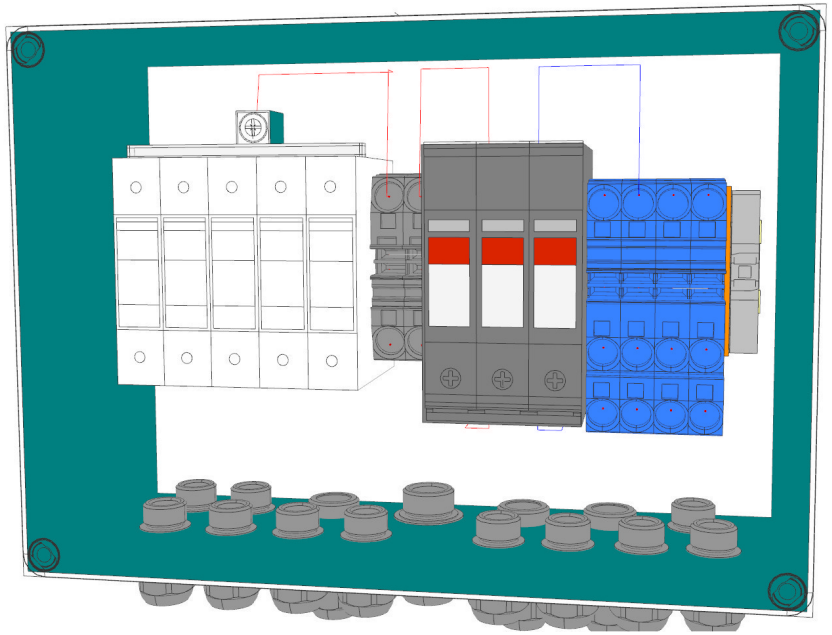
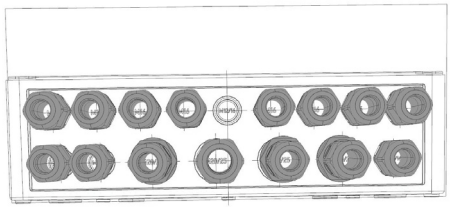
Artikelnummer HIS-50-10039





HISbox Combiner 5 Strings
Überspannungsschutz Typ 2

Max. Uoc: 1000V DC
Max. Isc (Σ): 70A
Max Isc String: 14A

Zugang:
5x Sicherungshalter 1 - 10 mm² (+)
5x Federzugklemme 1 - 16 mm² (-)

PV-Sicherung 10x38 mm 1000V DC
inklusive. Stromstärke [A] ist anzugeben.

Abgang:
2x Federzugklemme 1 - 16 mm² (+)
2x Federzugklemme 1 - 16 mm² (-)

Gehäuse:
Polycarbonatgehäuse/-deckel, grau,
H254xB180xT111mm, IP 65, UV beständig

Überspannungsableiter Typ 2 1000V DC:
Kurzschlussfestigkeit ISCPV 300 A
Dauerbetriebsstrom ICPV < 20 µA
Nennlaststrom IL 80 A
Schutzleiterstrom IPE ≤ 20 µA DC ≤ 250 µA AC
Standby-Leistungsaufnahme PC ≤ 25 mVA
Gesamtableitstoßstrom ITotal (8/20)µs 40 kA
Schutzpegel Up (L+) - (L-) ≤ 3,7 kV

Kabelverschraubungen montiert - Klemmbereich:
14x M16 = 4,5 - 10,0 mm
01x M20 = 6,0 - 13,0 mm

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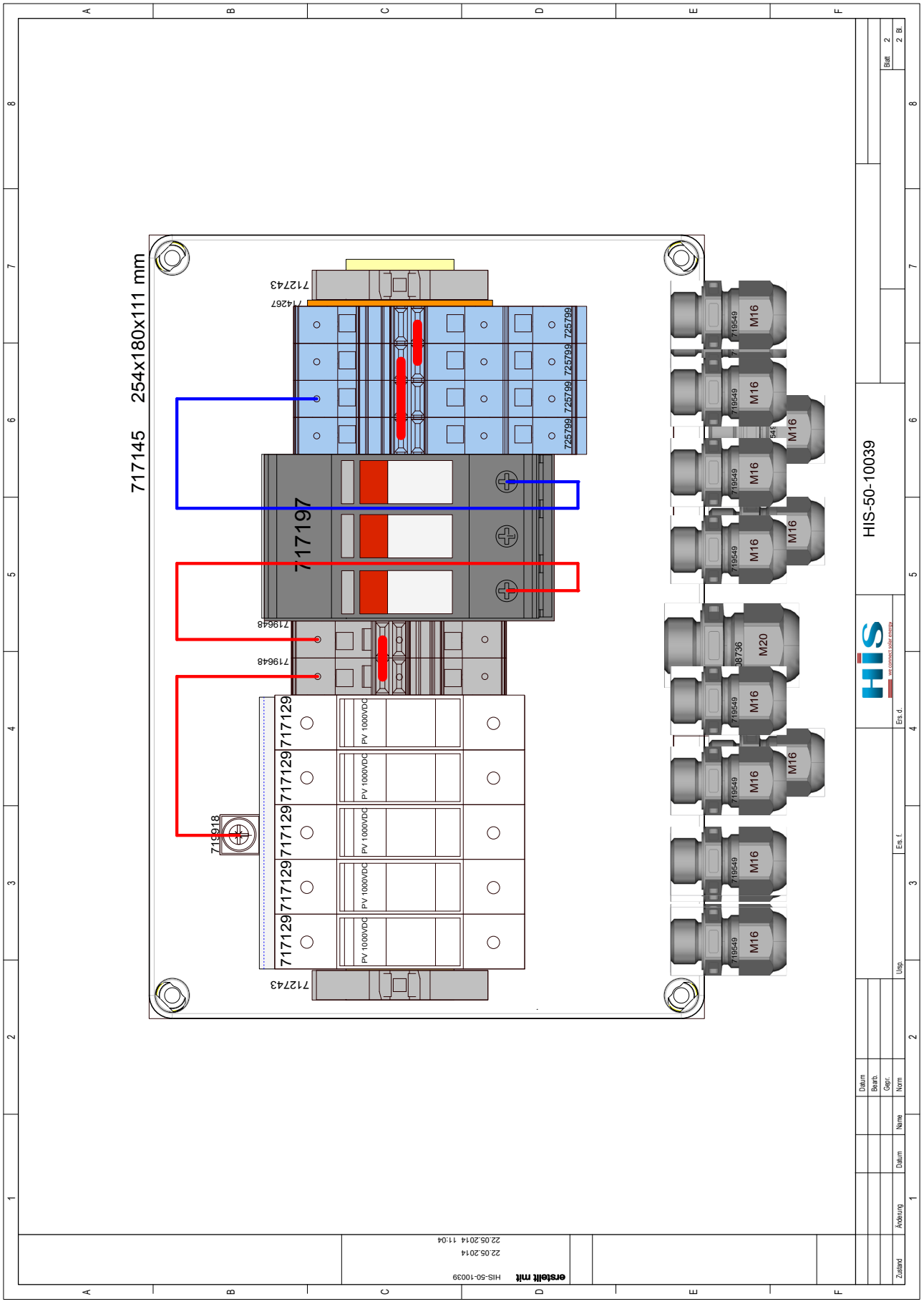
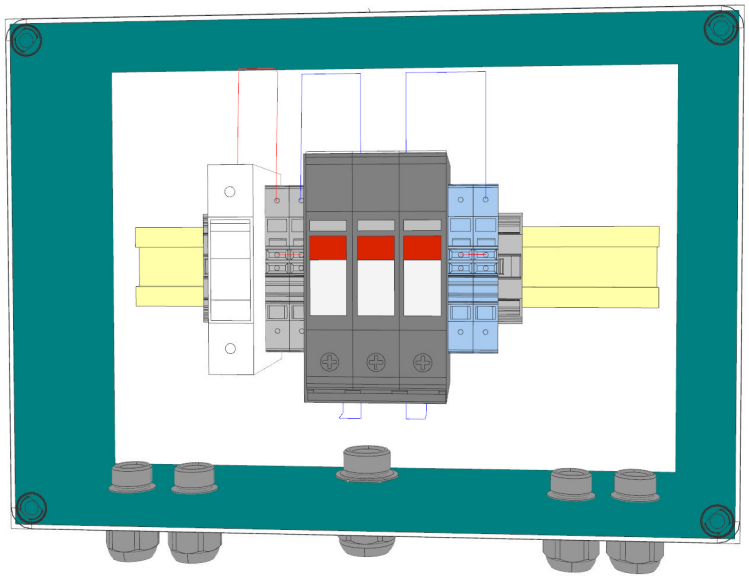
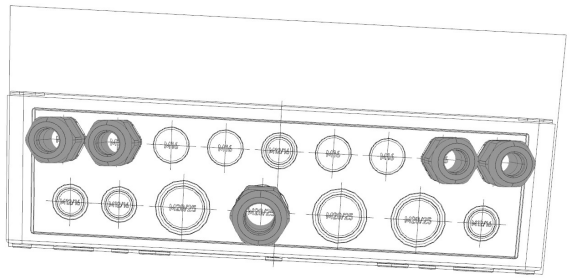
				Datum	05.09.2013			HIS-50-10039		
				Bearb.	Christian Sunkel					
				Gepr.						
Zustand	Änderung	Datum	Name	Norm	DIN EN 61439-1	Ursp.	Ers. f.	Ers. d.		Blatt 1 / 2 Bl.

ROOFTOP


717145 254x180x111 mm
712743
714267
725799
717197
719648
719918
717129
PV 1000VDC
719549
M16
M20
HIS-50-10039
erstellt mit
HIS-50-10039
22.05.2014
22.05.2014 11:04

Artikelnummer HIS-51-02806





HISbox Combiner 1 String
Überspannungsschutz Typ 2

Max. Uoc: 1000V DC
Max. Isc (Σ): 50A
Max. Isc (Strang): 50A

Zugang:
1x Sicherungshalter 1 - 10 mm² (+)
1x Federzugklemme 1 - 10 mm² (-)

Absicherung (+):
PV-Sicherung 10x38 mm 1000V DC

Abgang:
1x Federzugklemme 1 - 10 mm² (+)
1x Federzugklemme 1 - 10 mm² (-)

Gehäuse:
Polycarbonatgehäuse/-deckel, grau,
H254xB180xT111mm, IP 65, UV beständig

Überspannungsableiter Typ 2 1000V DC:
Kurzschlussfestigkeit ISCPV 300 A
Dauerbetriebsstrom ICPV < 20 µA
Nennlaststrom IL 80 A
Schutzleiterstrom IPE ≤ 20 µA DC ≤ 250 µA AC
Standby-Leistungsaufnahme PC ≤ 25 mVA
Gesamtableitstoßstrom ITotal (8/20)µs 40 kA
Schutzpegel Up (L+) - (L-) ≤ 3,7 kV

Kabelverschraubungen montiert - Klemmbereich:
4x M16 = 4,5 - 10,0 mm
1x M20 = 6,0 - 13,0 mm

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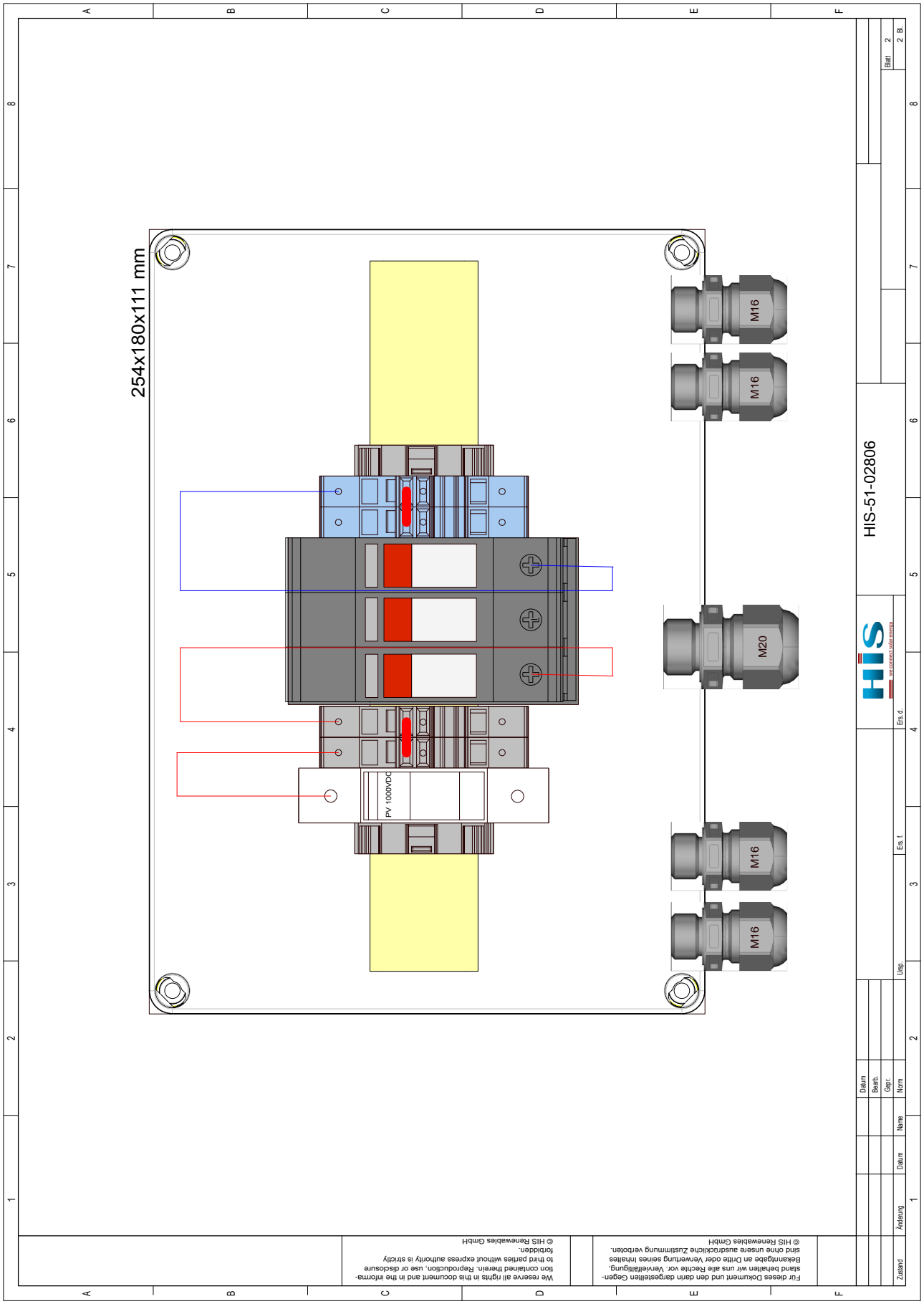
				Bearb.	Christian Sunkel				
				Gepr.					Blatt 1
Zustand	Änderung	Datum	Name	Norm	DIN EN 61439-1	Ursp.	Ers. f.	Ers. d.	2 Bl.


254x180x111 mm
M16
M16
M20
M16
M16
PV 1000VDC
HIS-51-02806
HIS
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Zertifikat *Certificate*

TÜVRheinland®

Zertifikat Nr. *Certificate No.*
R 60028286

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0001

Ihr Zeichen *Client Reference*	Unser Zeichen *Our Reference*	Ausstellungsdatum	*Date of Issue (day/mo/yr)*
	0010-- 21120907 006	16.04.2010	

Genehmigungsinhaber *License Holder*
Multi-Contact AG Basel
Stockbrunnenrain 8
4123 Allschwil 1
Schweiz

Fertigungsstätte *Manufacturing Plant*
Multi-Contact AG Basel
Stockbrunnenrain 8
4123 Allschwil 1
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Prüfzeichen *Test Mark*

www.tuv.com TÜVRheinland® ID:2000000000
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EN 50521:2008

Zertifiziertes Produkt (Geräteidentifikation)
Certified Product *(Product Identification)*

Lizenzentgelte - Einheit
License Fee - Unit

PV-Connector

Designation:	a) PV-KST4/xy ; PV-KBT4/xy b) PV-ADSP4/z ; PV-ADBP4/z	12
Rated voltage:	DC 1000V	
Rated current:	17A (90°C ; 1,5mm²) 22,5A (90°C ; 2,5mm²) 30A (90°C ; 4,0 - 6,0mm²) 43A (90°C ; 10mm²) only a)	
Ambient temperature range:	-40°C to +90°C	
Upper limit temperature:	105°C	
Protection degree:	IP 67 (1m; 30min) , IP65	
Application class:	A	

Hint: connector a) for free installation, connector b) explicit for build-in installation
x= cross section of cable (2, 5, 6, 10)
y= cable gland (I, II, IA, IIA, IIIA)
z= cross section of cable (2, 5, 6)
Replaces certificate R_60017180

12

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Zertifizierungsstelle

TÜV Rheinland LGA Products GmbH Zertifizierungsstelle

Dipl.-Ing. F. Esdohr

TÜV Rheinland LGA Products GmbH, Tillystraße 2, 90431 Nürnberg
Tel.: +49 221 806-1371 e-mail: cert-validity@de.tuv.com
Fax: +49 221 806-3935 http://www.tuv.com/safety

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0002

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Certified Product *(Product Identification)*

Lizenzentgelte - Einheit
License Fee - Unit

PV-Steckverbinder

wie Blatt / as page 0001

Ergänzung / supplement:

Hinweis / hint:
Nur zur Verwendung mit TRLP Bauart zertifizierten Gegenstücken der Multi-Contact MC4 Produktfamilie.
'Exclusively to be used with TRLP Bauart certified mated connectors from the Multi-Contact MC4 product family.

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Tel.: +49 221 806-1371 e-mail: cert-validity@de.tuv.com
Fax: +49 221 806-3935 http://www.tuv.com/safety

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0003

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4123 Allschwil 1
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PV-Steckverbinder			
wie Blatt / as page 0001-0002			
Ergänzung / supplement:			
Bemessungsstrom:	39A	(85°C ; 4mm²)	1
/rated current	45A	(85°C ; 6mm²)	

1

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Zertifikat *Certificate*

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Zertifikat Nr. *Certificate No.*
R 60028286

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0004

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4123 Allschwil 1
Schweiz

Fertigungsstätte *Manufacturing Plant*
Multi-Contact AG Basel
Stockbrunnenrain 8
4123 Allschwil 1
Schweiz

Prüfzeichen *Test Mark*

www.tuv.com TÜVRheinland® ID:2000000000
• BAUART GEPRÜFT
• TYPE APPROVED

Geprüft nach *Tested acc. to*
EN 50521:2008

Zertifiziertes Produkt (Geräteidentifikation)
Certified Product *(Product Identification)*

Lizenzentgelte - Einheit
License Fee - Unit

PV-Steckverbinder

wie Blatt/as page 0001-0003

Änderung / modification:

Schutzart/protection degree: IP 65 / IP 68(1m; 60min)

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Zertifizierungsstelle

TÜV Rheinland LGA Products GmbH Zertifizierungsstelle

Dipl.-Ing. F. Esdohr

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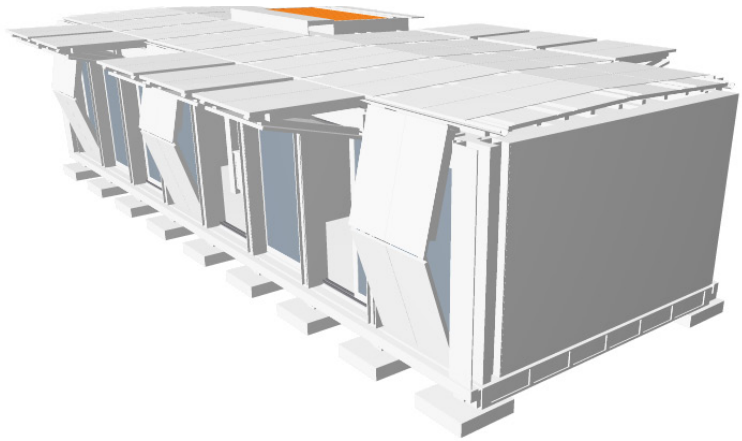
SOLARTHERMAL INSTALLATIONS



Location of our solar thermal plant

augusta solar
Innovative Solartechnik



Wir fertigen MADE IN GERMANY in Deutschland

SPF Solartechnik Prüfung Forschung

Hochvakuum Röhrenkollektor DF 6

Hochvakuum Röhren

- ✓ Extrem langlebig
- ✓ Kompakt
- ✓ Hocheffizient
- ✓ Wartungsfrei
- ✓ Einfache Montage

Vakuum-Röhrenkollektoren direkt durchströmt – überzeugend in Funktion und Leistung

Es gibt keinen besseren Schutz gegen Wärmeverluste als das Hochvakuum. Diese Wärmedämmung unterliegt keinem Alterungsprozess, ist umweltfreundlich und schützt den Solarabsorber und seine hochselektive Beschichtung vor Korrosion und Beschädigung.

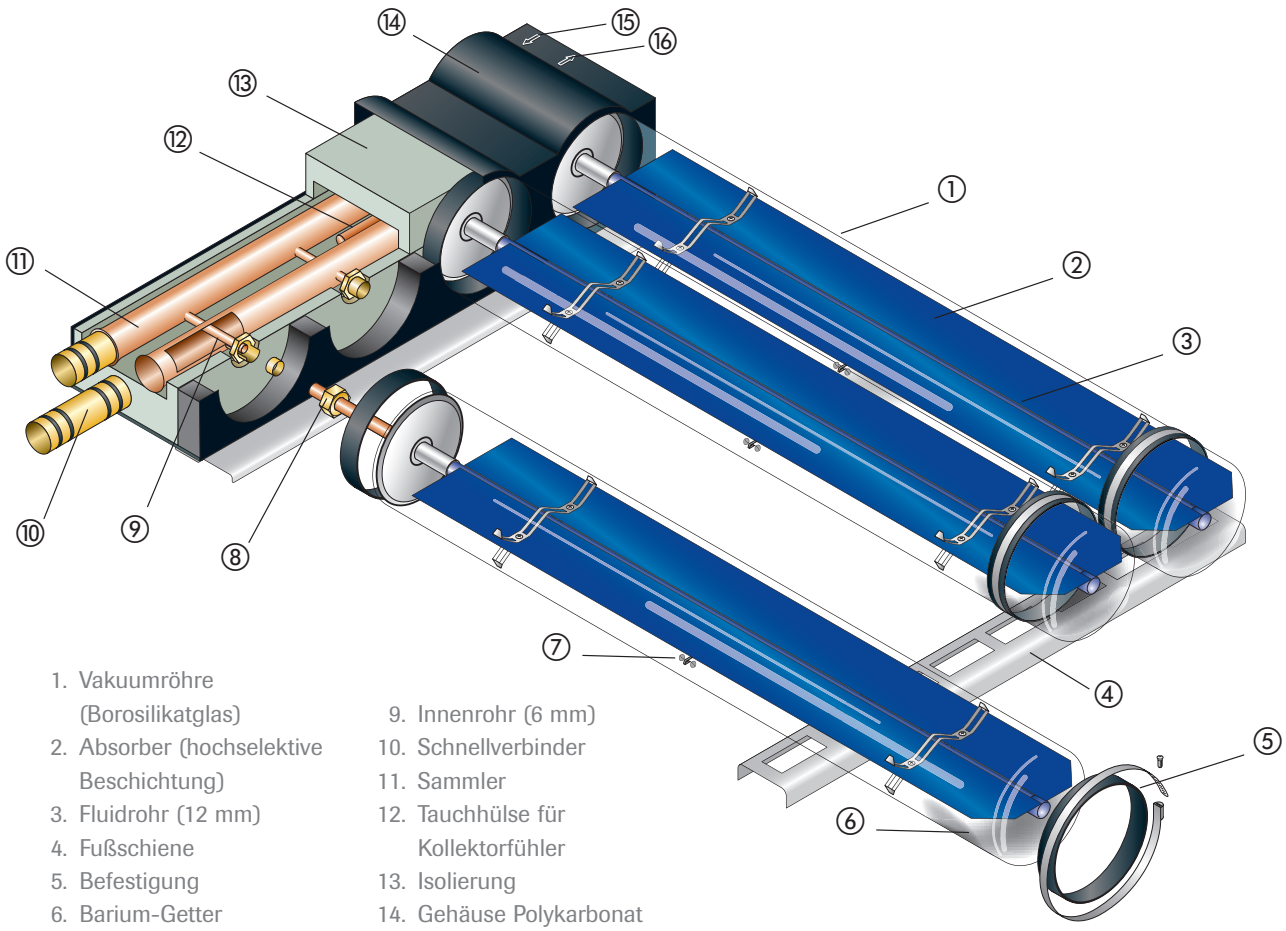
Sparen in Zeiten der Energieverteuerung

Die Sonne scheint kostenlos und liefert über das ganze Jahr Solarenergie frei Haus zum Nulltarif auch in unseren Breiten. Dazu bietet **augusta-solar** ein höchst effizientes System von Kollektoren, das über 70 % des jährlichen Energiebedarfs für die Brauchwassererwärmung für Küche und Bad von Ein- und Zweifamilienhäusern decken kann. Im Sommer reicht die Energieausbeute sogar, um die Warmwasserbereitung völlig zu übernehmen. Während der übrigen Jahreszeiten sorgt die Solarenergie für kostengünstige Vorerwärmung des Wassers im Brauchwasser- und Heizungskreislauf eines Hauses. Das senkt den Öl- und Gasverbrauch und entlastet den Geldbeutel.

Aus Verantwortung gegenüber der Umwelt

Mit den Hochvakuum-Kollektoren von **augusta-solar** kann die Umwelt bei einem Einfamilienhaus pro Jahr um eine drei Viertel Tonne Kohlendioxid (CO_2) entlastet werden. Die Langlebigkeit unserer Anlagen und die hohe Betriebssicherheit wird durch die ausschließliche Verwendung von korrosionsbeständigen Materialien garantiert.

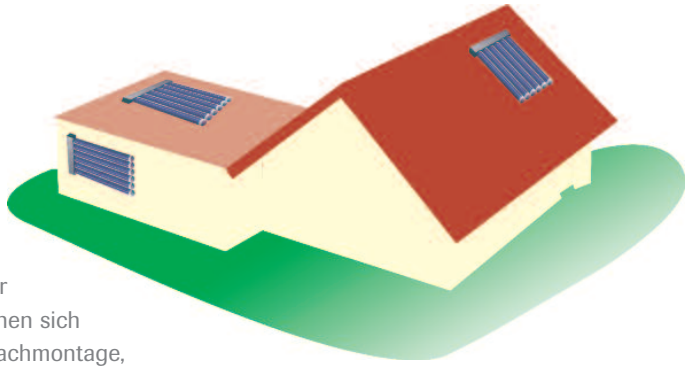
Durch die überdurchschnittlich hohe Nutzungsdauer unserer Solaranlagen tragen wir auch zur Sicherung der Rohstoff-Ressourcen bei.



1. Vakuumröhre (Borosilikatglas)
2. Absorber (hochselektive Beschichtung)
3. Fluidrohr (12 mm)
4. Fußschiene
5. Befestigung
6. Barium-Getter
7. Zirkonium-Getter
8. Verschraubung
9. Innenrohr (6 mm)
10. Schnellverbinder
11. Sammler
12. Tauchhülse für Kollektorfühler
13. Isolierung
14. Gehäuse Polykarbonat
15. Kollektor-Eingang
16. Kollektor-Ausgang

Für anspruchsvolle Architektur

augusta-solar DF 6
Durch das ansprechende Kollektordesign und den flexiblen Montagemöglichkeiten lassen sich die Kollektormodule harmonisch in verschiedene Gebäude integrieren. Sie verbinden den gestalterischen Anspruch mit der Funktionalität solarer Versorgungskonzepte. **augusta-solar DF 6** Solarkollektoren gewährleisten je nach Bauvorhaben und der entsprechenden Einstellung der Absorber zur Sonne immer eine optimale Energieausbeute. Sie eignen sich bei gleichbleibender Leistungsstärke für die Schrägdachmontage, die horizontale Flachdachmontage und der vertikalen Fassadenmontage.



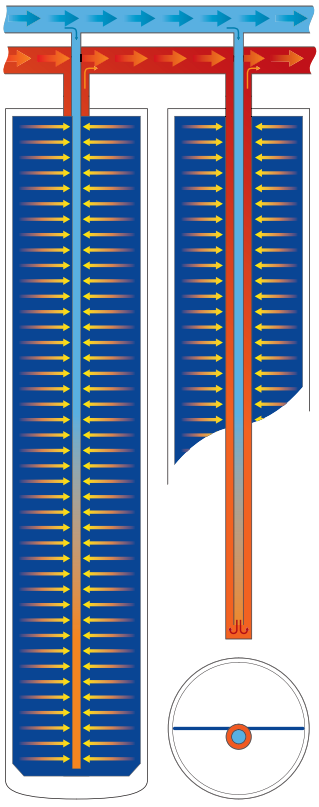
Die entscheidenden Vorteile:

Aufstellvarianten
Die **augusta-solar DF 6** Vakuum-Röhren-Kollektoren werden allen Einbauwünschen des Bauherrn gerecht. Ob Flachdach oder Schrägdach, ob Fassade oder freie Aufstellung – sämtliche Varianten sind möglich (Neigungswinkel 0–90°).

Montage
Werkseitig vorgefertigte Module mit 6 Röhren sind einfach zu montieren. Mit einem patentierten Stecksystem werden die Module miteinander verbunden. Die patentierte Steckverbindung ermöglicht eine sehr einfache und schnelle Montage der einzelnen Kollektoren. Mehrere Module können lückenlos nebeneinander montiert werden, auch nachträglich ist das Kollektorfeld beliebig erweiterbar. Somit entsteht ein optisch ansprechendes Gesamtbild der Anlage.

Leistung
Die hochselektive Beschichtung garantiert eine optimale Energieausnutzung bei unterschiedlicher Witterung, vor allem auch bei bedecktem Himmel.

Qualität
Die 2,8 mm starken und hochtransparenten Borosilicatglasröhren sichern eine gleichbleibend hohe Lichtdurchlässigkeit. Die Form und die extrem glatte Oberfläche verleihen den Röhren eine selbstreinigende Wirkung.
Die patentierte Glas-Metallverbindung von Röhre und Edelstahlverschluss im Thermokompressionsverfahren verschließt die Röhren dauerhaft vakuumdicht.
Die speziellen Getter wirken als chemische Vakuumpumpen und sichern die Vakuum-Wärmedämmung bei ca. 10^{-8} bar über die gesamte Lebensdauer. Alle innenliegenden Komponenten sind durch das Vakuum vor beeinträchtigenden Witterungs- und Korrosionseinflüssen geschützt.



Fließschema
augusta-solar Kollektor DF 6

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Hochvakuum Röhrenkollektor DF 6

Hochvakuum Röhren

- ✓ Extrem langlebig
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- ✓ Hocheffizient
- ✓ Wartungsfrei
- ✓ Einfache Montage

12.2.6 TELECOMMUNICATIONS AND BUILDING AUTOMATION

12.3. SAFETY INFORMATION

12.3.1 FIRE SAFETY TABLE

INTERIOR PROPAGATION SPREADING (RULES 51.3)

type of material	class	location in specification in PD and PM
covering (see rule 51.3 Note 1)		
outer layer: trapezoidal sheet (steel plate)	A1	PM: 5.3.2
ceiling (see rule 51.3 Note 2)		
inner layer: fire protection plasterboard	A2-s1, d0	PM: 5.3.2
walls (see rule 51.3 Note 2)		
inner layer: fire protection plasterboard	A2-s1, d0	PM: 5.3.2
flooring		
timber boards	D_fl s1	PM: 5.3.2
rubber boards	D_fl s1	PD: AR-321, AR-322
corc plates	D_fl s1	
pipes and ducts (running through flooring, walls, ceilings)		
floor (exept technical room): polyethylene pipes on aluminum heat conducting strips	A2-s1,d0	PM: 5.3.7
installations – water systems: multi-layer composite pipe (polyethylene – aluminum-polyethylene) with rockwool insulation	A2-s1,d0	PM: 5.3.3
installations – ventilation: aluminum ducts	A1	PM: 5.3.4
installations – cables: cables in fire protection cable ducts	A2-s1,d0	PM: 5.3.5
Textile cover elements integrated into building		
-		

Thermal screen of thermal and acoustic insulation products	Fire resistance time	Location in Specifications in PD and PM
wood fibre insulation (envelope)	30min	PM: 3.5.2
rock wool insulation (technical room)	60min	PM: 3.5.2

EVACUATION OF OCCUPANTS

evacuation element	width (m)	specifications in PD and PM
doors and doorways		
door (entrance)	0,90	PD: footprint
movable glass elements	1,55	PD: footprint
doorway	1,40	PD: footprint
hallways and ramps		
hallway	2,62	PD: footprint
ramp	1,40	PD: footprint
stairs	1,12	PD: footprint

12.3.2 SAFETY IN USE TABLE

SAFETY AGAINST FALLS

Floor Class Slipperiness

Type of Floors	Where (Location in the project)	Floor Classification - Specifications in PD and PM
Dry interior area: Surface's slope less than 5%	living room, sleeping room, entrée	R 10 (IN-001)
Dry interior area: Surface's slope equal or greater than 5%. Stairs included	---	
Humid interior area: Surface's slope less than 5%	bathroom, kitchen, extensions	R 10 (IN-501)
Humid interior area: Surface's slope equal or greater than 5%. Stairs included	---	
Exterior areas	terraces, Treppenhaus mock-up	R 12 (AR-321)

Differences in the floor level, holes and opening (limit the risks of falling)

Where (in the project) and difference in floor level, holes and opening that represent a risk of falling	Type of protective barriers	Height of protective barriers where the difference in the floor level are more than 400mm - Specifications in PD and PM
main terrace, privat terrace	handrail with expanded metal filling	1 m (AR-002, AR-211)
gardening terrace	bench	0,4 x 0,4 m (AR-211)
ramp resting landing	handrail with expanded metal filling	1 m (AR-002)

Restricted Areas Stairs

	Value	Specifications in PD and PM
Width of the tread	---	
Height of the riser	---	
Depth of the tread	---	
Height of handrails	---	

Public Areas Staircases

	Value	Specifications in PD and PM
Width of the tread	1,4 m	AR-002
Height of the riser	0,15 m	AR-002
Depth of the tread	0,33 m	AR-002
Height of handrails	1 m	AR-002

Ramps

	Value	Specifications in PD and PM
% slope value	5 %	AR-002
Length of Ramp	16,37 m	AR-002
Width of Ramp	1,4 m	AR-002
Height of Handrails	1 m	AR-002
Size of the Resting Landings	2,38 x 1,4 m	AR-002

SAFETY FOR AVOIDING TRAPPING AND IMPACT RISK

Impact due to fixed elements (House Tours area)

	Minimum Value	Specifications in PD and PM
Clearance height in house	2,39 m	AR-211
Height of the doors threshold	0,00 m	AR-212
Height of fixed elements projecting from façades	2,61 m	AR-211
Projection of fixed elements in the walls that do not which do not start from the ground	1,6 m	AR-211

Impact due to opening elements (public tours areas)

	Value (circular freespace)	Specifications in PD and PM
Sweep of the doors on the sides of the hallway	---	PT-001, PT-101

Impact due to fragile elements and not very perceptible elements

Location in the Project	Type of Glazing (safety)	Specifications in PD and PM
Glassfaçades	3-layer isolation glazing P4A	AR-301

Trapping

	Value (distance)	Specifications in PD and PM
Distance of manual sliding door to the nearest fixed element	---	during public tours are all sliding doors fixed! PT-001

SAFETY AGAINST THE RISK OF INADEQUATE LIGHTING

	Where- min. illumination level	Specifications in PD and PM
Light fittings for exterior areas	20 lux	
Light fittings for interior areas	200 lux	

Appliances and Home Electronic Equipment Specifications and User Manuals

This section must be submitted from Deliverable #4 and onwards, and must include:

a). The “Appliances and Home Electronic Equipment Tables” (filled out by the Team). In these tables, teams will include all the appliances and equipment that they plan to use for the Contest 6 House Functioning, indicating the compliance with the requirements stated on Rule 20.5. Template of these tables will be available on the SDE WAT.

b). Appliances specifications and user manuals. With the technical specifications, Teams will justify the rules compliances related with capacity, volume, as well as other important information as their energy consumption and energy class (label). The user manual help to know the appliances general characteristic and cycles options.

C). Home electronic equipment basic specifications and user manuals. With the technical specifications, Teams will justify the rules compliances related display sizes, as well as other important information as their energy consumption and energy class (label). The user manual help to know the appliances general characteristic and display brightness setting (Rule 20.5 Sub-contest 6.9c).

Notes:

1. Only include the sections of the appliances’ user manuals related with the appliances general characteristics, cycles and energy consumption.

2. From the TV and Computer display user manuals, only include the sections related with their general characteristics, energy consumption and display brightness setting.

3. If there are not English versions of the manuals or specifications, Teams must include copy of the documents in the original language and an English translation of the parts that justified the Rules compliance.
4. Teams intending to use energy saving programs during the Final Phase of the SDE 2014 Competition must communicate it to the SDE 2014 Organization.

5. As stated in Rule 20.5, SDE organisers will define the appliances’ cycles that will be used during the competition.

ROOFTOP

STRUCTURAL CALCULATIONS

ROOFTOP

Structural Calculations

Promoter: Solar Decathlon 2014

Building project: rooftop house

Editor: Team rooftop

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1 Overview of the structure

We have divided the house into parts from top to bottom for better understanding.

1 Roof: including ceiling

2 Bracing Walls: W1, W2 and W3

3 Facades and Pillars: the lift-up facade and windows on the long sides of the building and the pillars

4 Floor: the floor area of the house

5 Core Module: bathroom, technical installations room and kitchen

6 Footings

7 Terrace: the terrace space around the house

8 Surroundings: the access ramp and the buildings representing the Berliner Altbau

The following illustration shows the division on the floor level, ***figure 1: parts of the house***.

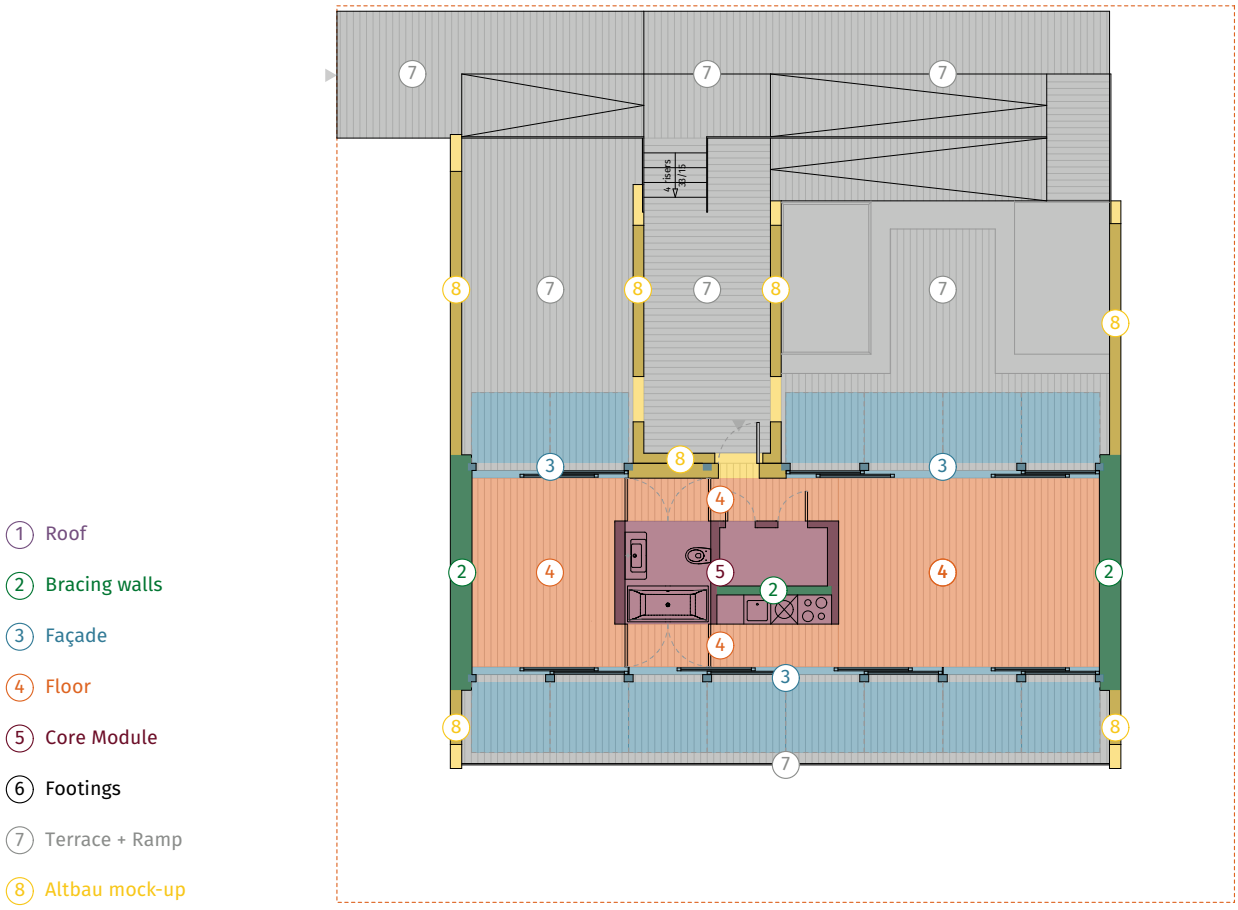


figure 1: parts of the house

All structurally important parts of the house (1, 2, 3, 4, 5, 7) are highlighted in the structural blowup of our building, ***figure 2: structural blow-up of the house***.

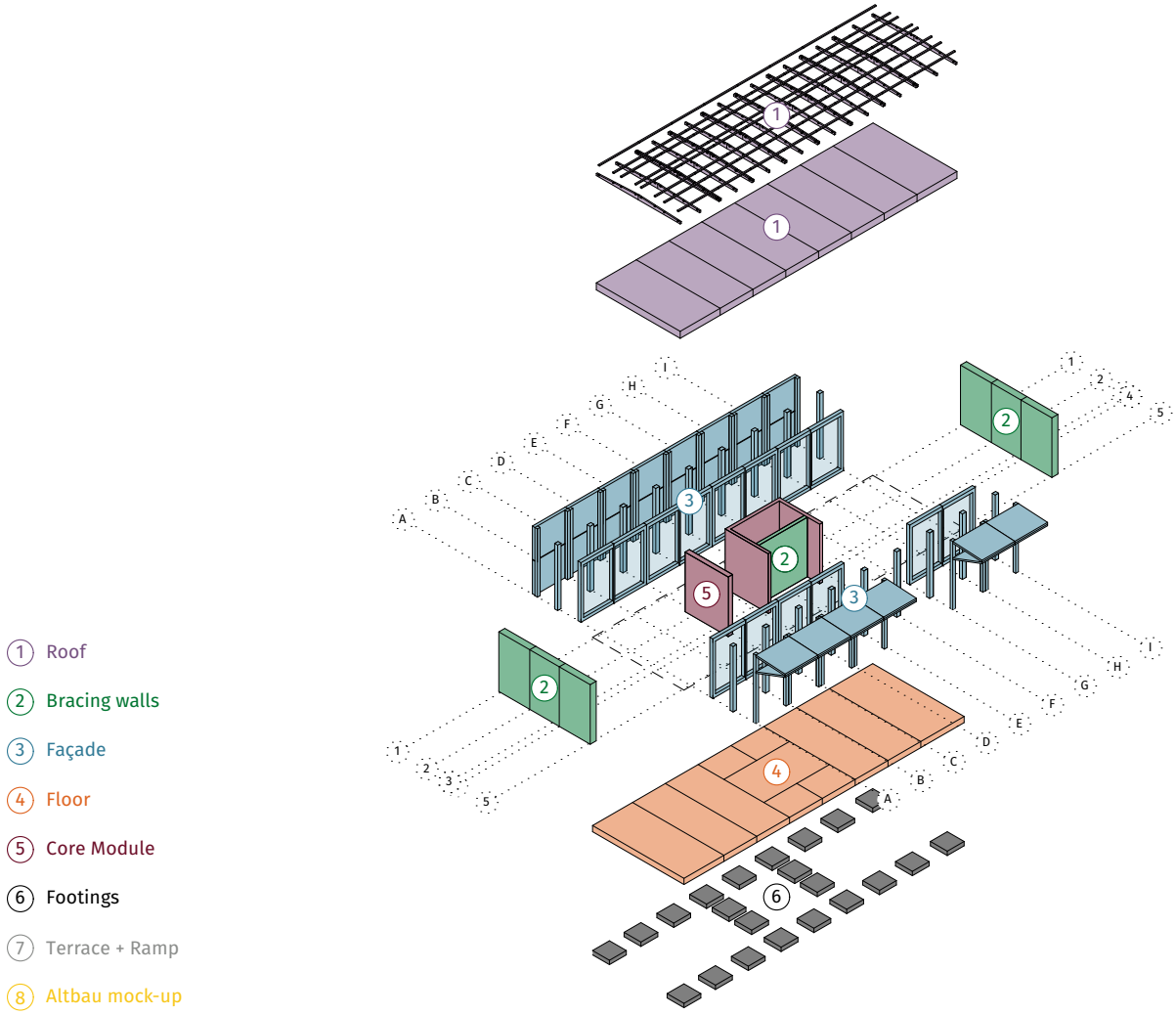


figure 2: structural blow-up of the house

1 Roof:

The area load (own weight, snow, wind) is collected by the roof structure and borne by 9 purlins every 1.75 m. Whereas each purlin is actually divided into two, in order to enhance a modular construction.

2 Bracing Walls:

The walls carry their own load and are necessary for bracing, but are not responsible for bearing the roof load.

3 Facades and pillars

On each side, the loads from the 8 dynamic lift-up facade panels (1.75 m wide) such as wind and own weight are introduced into the 9 pillars and the roof construction. The pillars bear the load

from the roof. In the long direction 1.75 m long beams connect the pillars

4 Floor

The floor, apart from live loads, collects the loads from the pillars, walls.

5 Core module

The Core module is a part of the floor construction, yet it contains the main technical devices and the kitchen and will be designed separately. Due to the own weight of the devices additional load assumptions will be made and we also use additional footings for its construction.

6 Footings:

The footings will be made out of two components; an in height-adjustable steel column base grounded on a wooden load distribution plate.

7 Terrace:

The terrace is also made out of wood and set together in modules using special wooden dovetail connections. In height adjustable recyclable column bases out of plastic transmit the vertical loads into the ground, whereas horizontal stability is given by connecting the terrace modules to heavy structures as the house, the outside walls and the settling basin.

8 Surroundings:

As one of our main focuses of attention is to illustrate that our house is placed on the roof of a typical Berliner Altbau, we reconstructed the situation in setting up high walls on the east and the west of our building and the terrace and designing the entrance as a fiction staircase.

2 Load assumptions

2.1 Roof

To assume the loadings of the roof it is separated into two areas as shown in *figure 3: areas of the roof*:

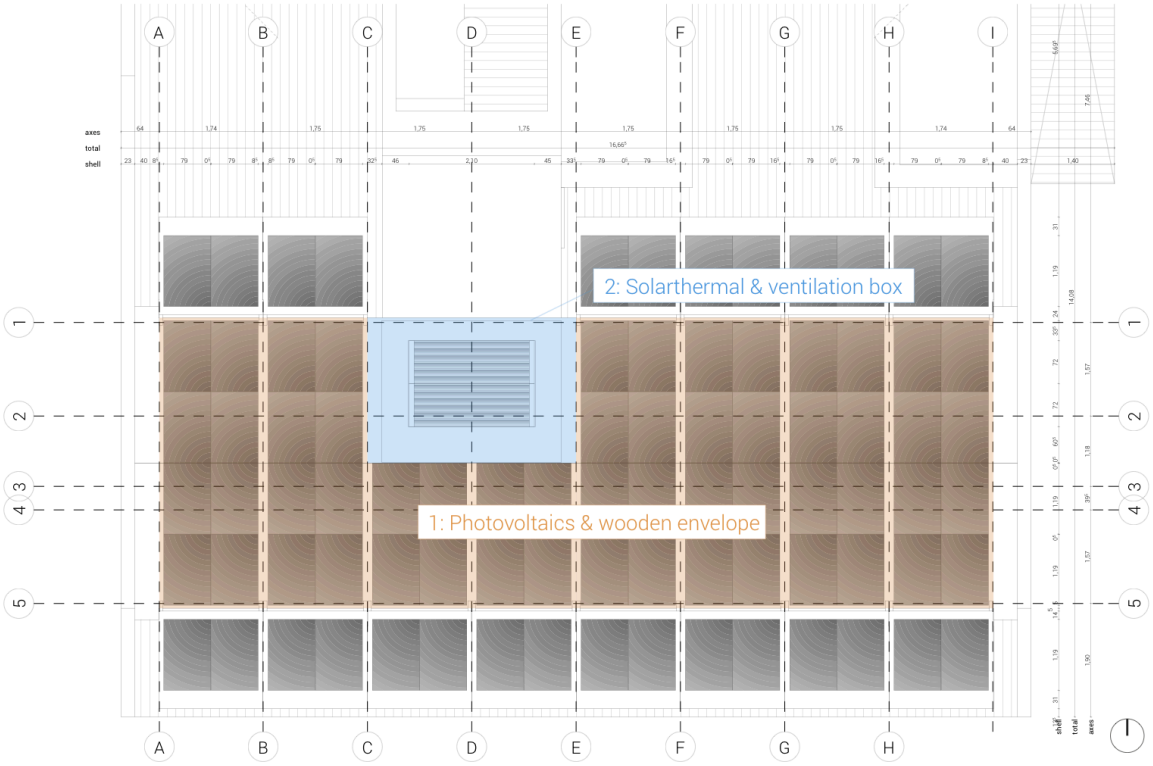


figure 3: areas of the roof

Overview of roof layers area 1 and 2,*figure 4: roof layers of area 1 and 2*:

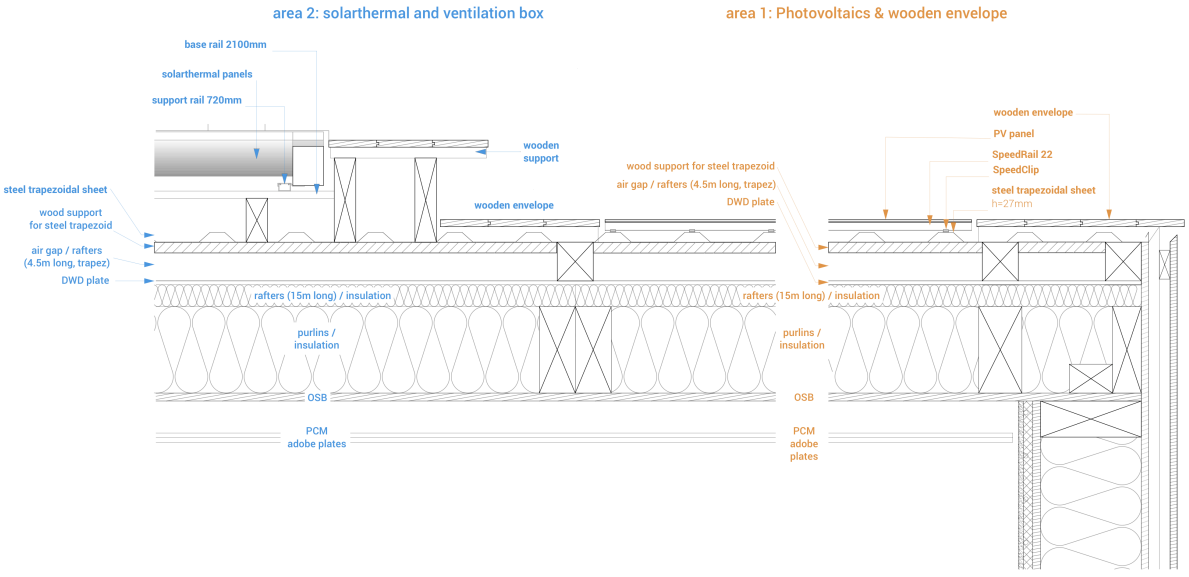


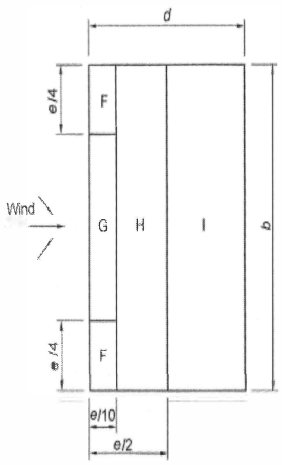
figure 4: roof layers of area 1 and 2

table of load assumptions:

ROOF DIMENSIONS					
length [m]	15		all calculations in z-direction – vertical,		
width [m]	4,5		direction of gravity is positive direction of forces		
area 1 [qm]	59,0625				
area 2 [qm]	8,4375				
area [qm]	67,5				
LOADS		force of gravity g	10		
own weight per square meter, area 1	Factor 1 type		Factor 2 type		weight [kg/qm]
Photovoltaic panel Solibro	area, m2	0,94	weight, kg	16,5	17,56
wooden envelope around PV panels	height, m	0,01	density, kg/m3	500	5,00
air gap					0,00
steel trapezoid sheet	according to manufacturer (Flexton)				5,00
wood support for steel trapezoid, all wood C24	volume, m3	0,36	density, kg/m3	420	2,24
air gap					0,00
Trapezoid wood rafters 4.5m long in air gap	volume, m3	0,30	density, kg/m3	420	1,84
DWD plate (diffusion open)	height, m	0,016	density, kg/m3	565	9,04
cellulose insulation	height, m	0,06	density, kg/m3	50	3,00
rafters 15m long in insulation	volume, m3	0,72	density, kg/m3	420	4,48
cellulose insulation	height, m	0,24	density, kg/m3	50	12,00
rafters at short ends of modules	volume, m3	0,576	density, kg/m3	420	3,58
connections (assume 10% of above)					5,52
sum, above purlins					64,26
main support purlins 4.5m long in insulation	volume, m3	1,944	density, kg/m3	420	12,10
connections (assume 10% of above)					1,21
sum, purlins					13,31
wooden support for underconstruction C24	volume, m3	0,288	density, kg/m3	420	1,79
OSB3 board	height, m	0,022	density, kg/m3	650	14,30
plasterboard	height, m	0,0125	density, kg/m3	680	8,50
PCM adobe ceiling	according to manufacturer (Lehmorange)				23,00
connections (assume 10% of above)					4,76
sum, below purlins					52,35
own weight per square meter, area 2	Factor 1 type		Factor 2 type		weight [kg/qm]
solarthermal panels	area, m2	1,5141	weight, kg	35	23,12
ventilation outlets	weigh next to nothing compared to solarthermal				
electrics: lightning protection, junction box	located besides solarthermal panels, don't exceed that weight				
wooden construction of roof area 2	area, m2	6,9			
wooden support of solarthermal box, area 2	volume, m3	0,05	density, kg/m3	420	2,74
wooden box construction	volume, m3	0,07	density, kg/m3	420	4,26
wood around ventilation outlets	located besides solarthermal wood support, don't exceed that weight				
---					
same as in area 1 from steel trapezoid down					46,70
sum, above purlins					76,81
sum, purlins					13,31
sum, below purlins					52,35

snow (area load)	
according to EC 3	
Berlin, northern German lowlands – snow zone 2	
snow load on the ground s(k) [kN/qm]	0,85
roof gradient [°]	0,00
factor myu1	0,80
factor c(e)	1,00
factor c(t)	1,00
factor c(extraordinary)	2,30
snow load on the roof [kN/qm]	
usual load [kN/qm]	0,68
extraordinary load [kN/qm]	1,56

wind (area load)					
Berlin – wind zone 2, Geländekategorie/topographical category IV (cities)					
building (roof) is not subject to oscillations (building not higher than 25m) – Basisgeschwindigkeitsdruck q(b) not relevant					
Because the building is lower than 25m, according to DIN EN 1991-1-4/NA the simplified process is used					
height [m]	18-25m				
Böen- oder Spitzengeschwindigkeitsdruck q(p) [kN/qm]	0,9				
q(p) is not diminished because of temporary states					
interior wind pressure w(i) doesn't have to be considered, as building is closed on all sides					
exterior wind pressure w(e) is calculated according to w(e) = q(p)[z(e)]*c(pe); aerodynamic factor für exterior pressure c(pe); height z(e)					
the roof is a flat roof as the gradient is below 5°					
the edge is sharp (scharfkantiger Traufbereich)					
division of the roof in F, G, H, I acc. to figure [1]	area [qm]	c(pe,10)	c(pe,1)	c(pe)	w(e)
load area – Lasteinzugsfläche [qm]		> 10	≤ 1	9,00	
width of load area	2,00				
height of structure h (without attica)	3,50				
b	15,00				
d	4,50				
e = b or 2h – lower number	7,00				
F (twice)	1,23	-1,80	-2,50	-1,83	-1,65
G	8,05	-1,20	-2,00	-1,24	-1,11
H	42,00	-0,70	-1,20	-0,72	-0,65
I auf Sog	15,00	-0,60	-0,60	-0,60	-0,54
I auf Druck		0,20	0,20	0,20	0,18
control area	ok				
sum of loads [kN/qm]					
w(e,Sog,F,G)	-1,24				
w(e,Sog)	-0,72				
w(e,Druck)	0,04				



LOAD COMBINATIONS					
load combination #1	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	s	w (Druck)		
security factor	1,35	1,5	1,5		
combination factor		1	0,6		
result [kN/qm]	1,75	1,02	0,036		2,81
load combination #2	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	w (Druck)	s		
security factor	1,35	1,5	1,5		
combination factor		1	0,5		
result [kN/qm]	1,75	0,06	0,51		2,32
load combination #3	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	q	w (Druck)	s	
security factor	1,35	1,5	1,5	1,5	
combination factor		1	0,6	0,5	
result [kN/qm]	1,75	0	0,036	0,51	2,30
load combination #4	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	q	s		
security factor	1,35	1,5	1,5		
combination factor		1	0,5		
result [kN/qm]	1,75	0	0,51		2,26
load combination #5	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	q	w (Druck)		
security factor	1,35	1,5	1,5		
combination factor		1	0,6		
result [kN/qm]	1,75	0	0,036		1,79
load combination #6	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	w (Druck)			
security factor	1,35	1,5			
combination factor		1			
result [kN/qm]	1,75	0,06			1,81
load combination #7	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	s			
security factor	1,35	1,5			
combination factor		1			
result [kN/qm]	1,75	1,02			2,77
load combination #8	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	q			
security factor	1,35	1,5			
combination factor		1			
result [kN/qm]	1,75	0			1,75
extraordinary situation / AS 1	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	s (extraordinary)	w (Druck)		
security factor	1	1	0,2		
combination factor		1	1		
result [kN/qm]	1,30	1,564	0,008		2,87
normative load combination for roof	#8				
distributed load [kN/qm]	2,87				

for other structural members, other load cases might be normative. Therefore we will refer to this page later on again. Also to calculate the deformations under limited design state of usage characteristical loadvalues need to be taken into account

above beams					
extraordinary situation / AS 1	steady load	variable load 1	variable load 2	variable load 3	result
load type	g	s (extraordinary)	w (Druck)		
security factor	1	1	0,2		
combination factor		1	1		
result [kN/qm]	0,64	1,564	0,008		2,21

According to the structural parts defined above, we sum all characteristic loads on the respective part in the following diagram, ***figure 5: overview loads of the roof***. The source for each assumption is specified above the diagrams. Where calculations were necessary they are attached and named as sources.

Source for live loads (wind and snow) as well as dead loads (own weight and beams), calculation see table of load assumptions on page 6.

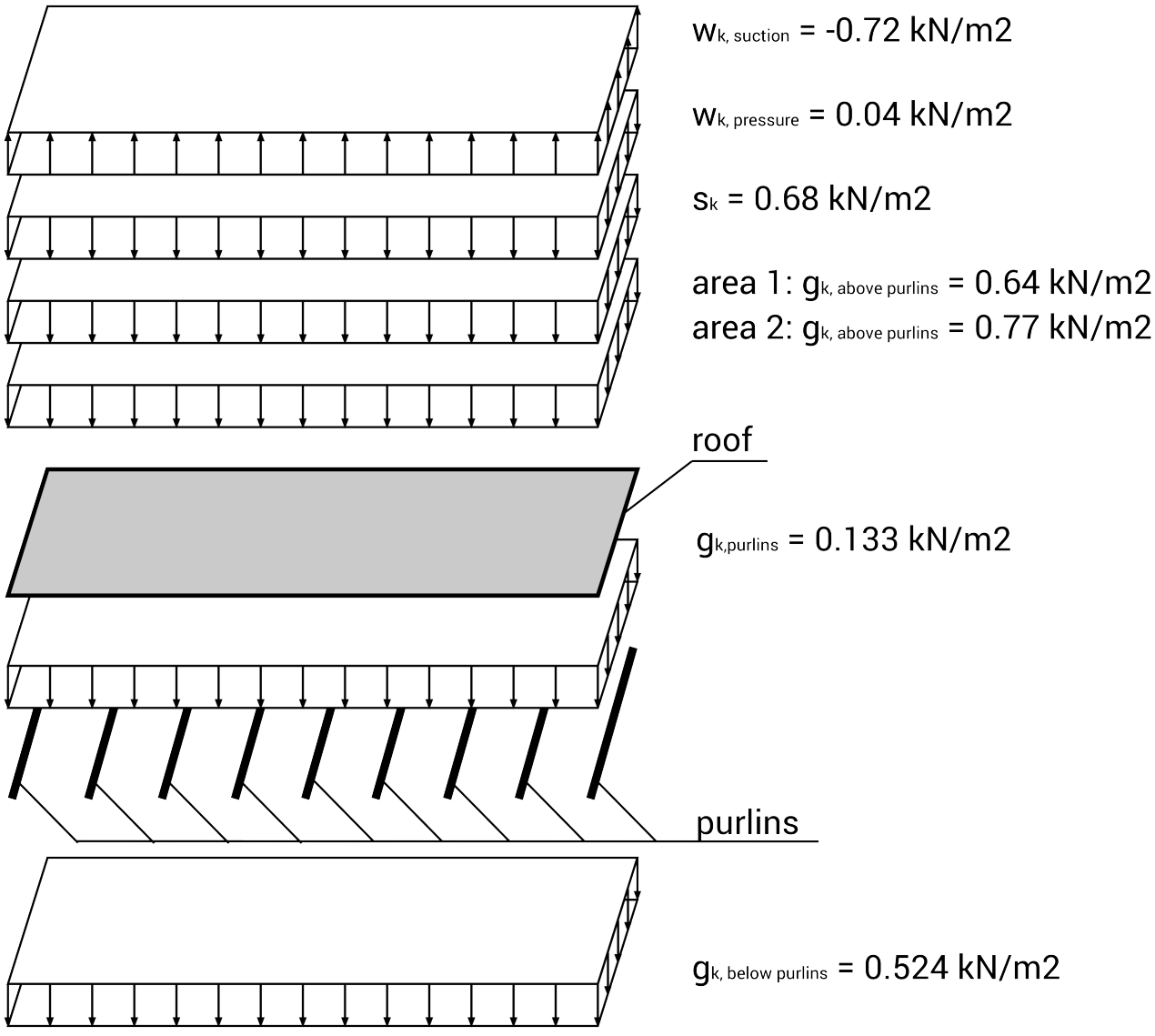


figure 5: overview loads of the roof

Own weight of standard roof module. Members are high-lighted with colours for explanation reasons:

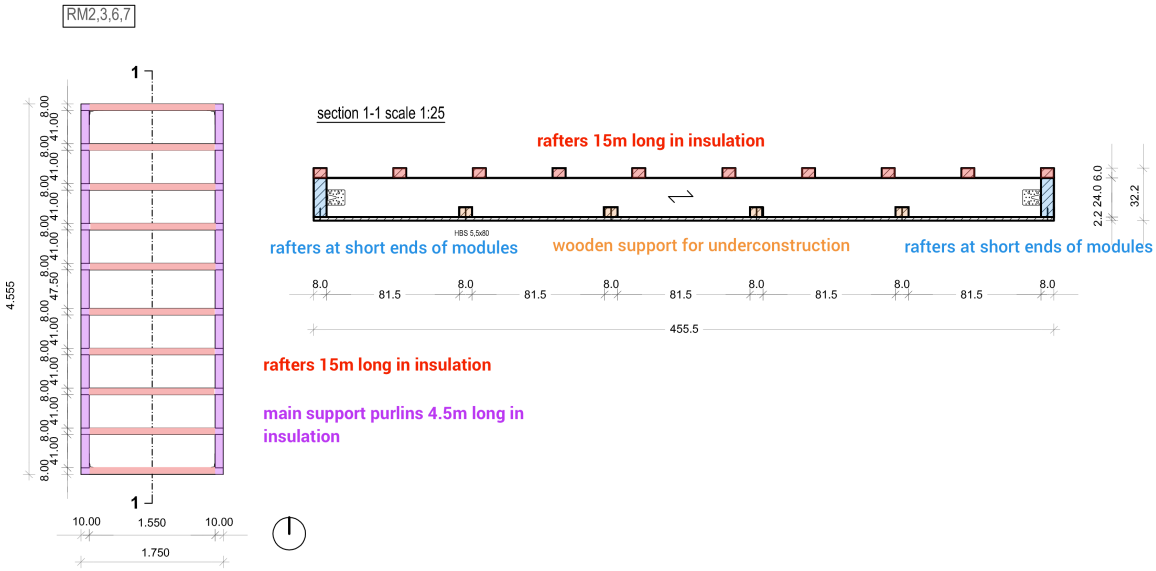


figure 6: members of standard roof module

additional structure roof area 2:

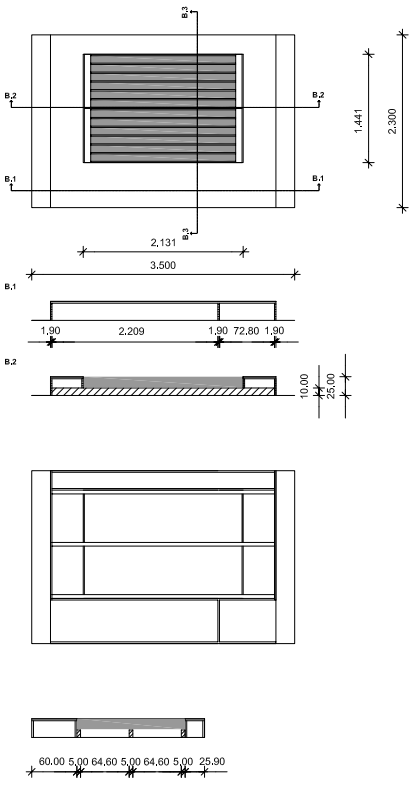


figure 7: roof box for solar thermal modules

2.2 Bracing walls

Wind loads on longitudinal flank. Decisive for construction of wall W1 and W2.

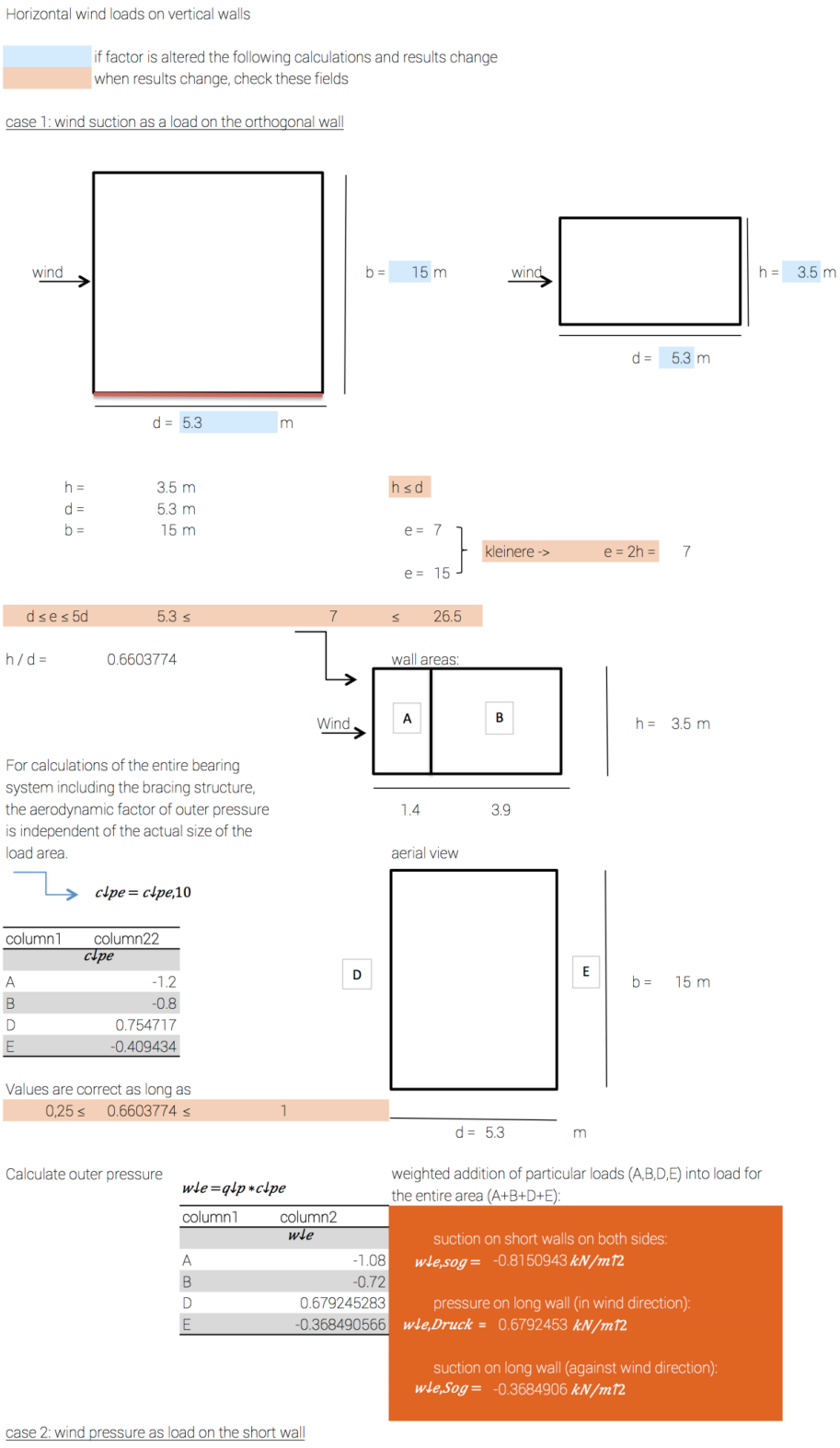


figure 8: wind on longitudinal flank, calculation sheet

visualized wind loads on closed façade.

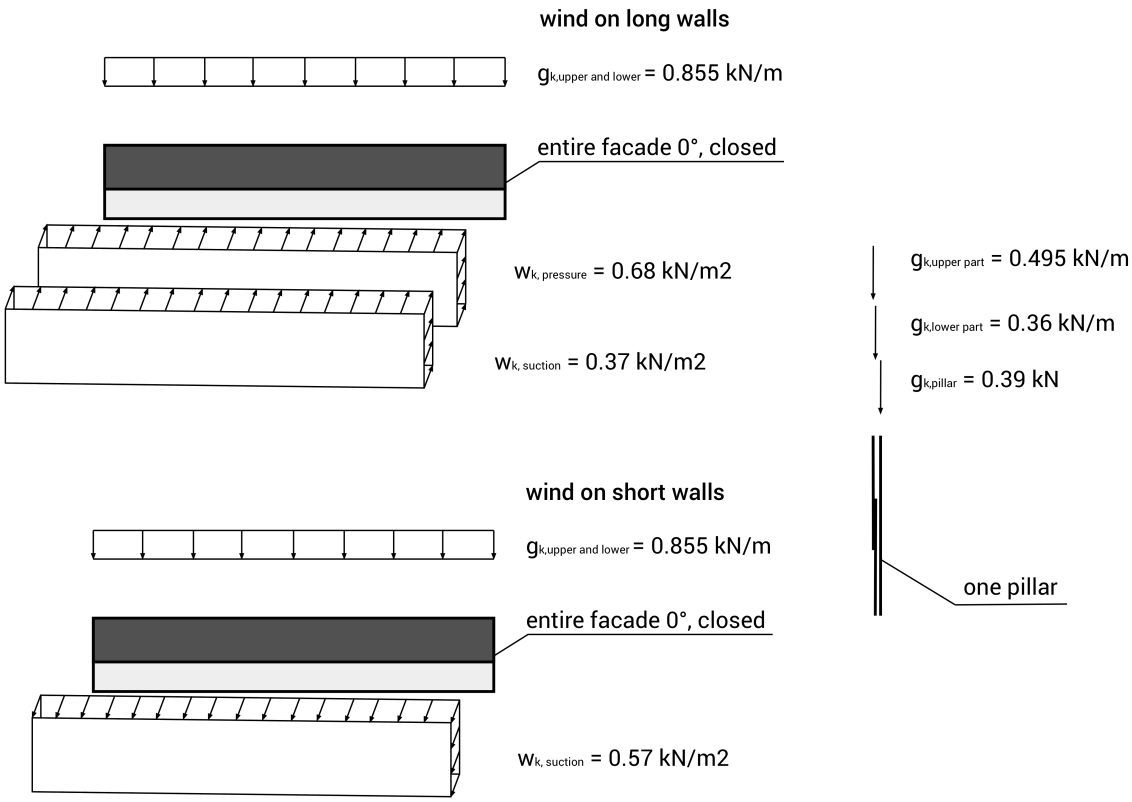
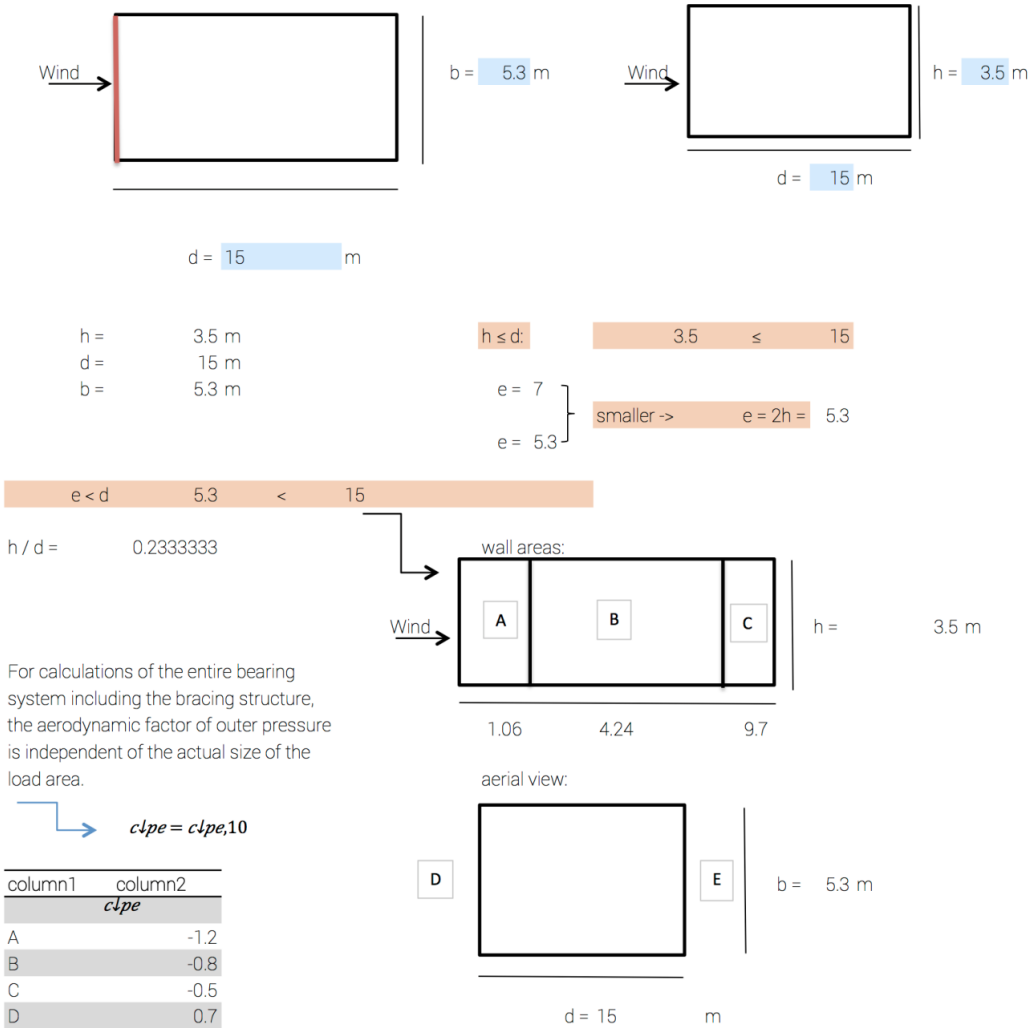


figure 9 :wind on longitudinal flank, overview of wind loads

Wind loads on transverial flank, wind calculation sheet part 2.



column1	column2
	cl*pe
A	-1.2
B	-0.8
C	-0.5
D	0.7
E	-0.3

column1	column2
	w*le
A	-1.08
B	-0.72
C	-0.45
D	0.63
E	-0.27

figure 10: wind on transversal flank, calculation sheet part 2

Loads visualized.

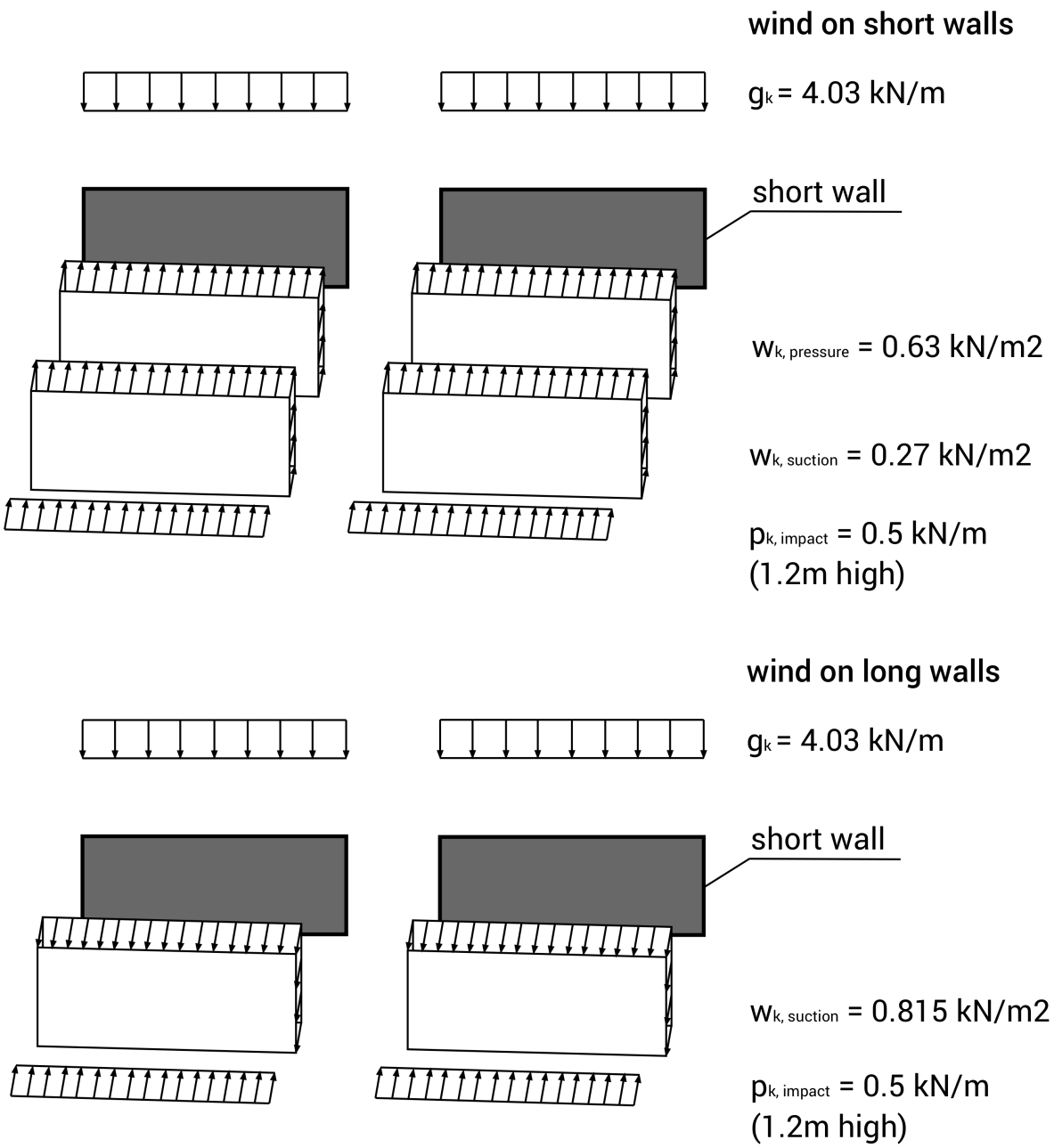


figure 11: wind on transversal flank, overview of horizontal loads

Dead load W1/W2 (short walls), calculation sheet:

#	material	width [m]	height [m]	area [m²]	thickness [m]	specific weight [kN/m³]	total load [kN]	area load [kN/m²]	knife-edge load on top [kN/m]
	construction wood								
5	C24 10x28cm; eight pieces vertically, two horizontally	11.00	25.60			4.60	4.714	0.268	0.86
	other materials								
1	plasterboard				0.015	14.00		0.210	0.67
2	rigid wood fiber insulation				0.040	1.10		0.044	0.14
3	OSB				0.022	6.20		0.136	0.44
4	flexible wood fiber insulation				0.280	0.50		0.140	0.45
6	soft fiberboard				0.040	1.40		0.056	0.18
7	lathing				0.030	5.20		0.156	0.50
8	counter lathing				0.030	5.20		0.156	0.50
9	wood panels				0.020	4.60		0.092	0.29
	installations (assumption)								
	Σ	**5.50**	**3.20**	**17.60**	**0.477**			**1.258**	**4.03**

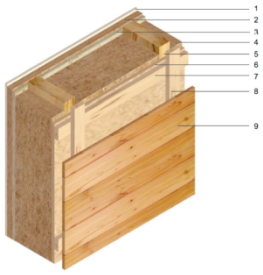


figure 12: dead load W1/W2 , calculation sheet

Dead load W3, calculation sheet:

material	dimension x [m]	dimension y [m]	length [z]	area [m²]	thickness [m]	specific weight [kN/m³]	load [kN]	knife-edge load on top [kN/m]
construction wood C24 12x12cm	0.12	0.12	15.04			4.2	0.9096192	0.32
OSB3 to kitchen	2.4	2.8		6.72	0.022	6.5	0.96096	0.34
OSB3 to technical room	2.4	2.8		6.72	0.022	6.5	0.96096	0.34
installations								0.1
Σ								1.11

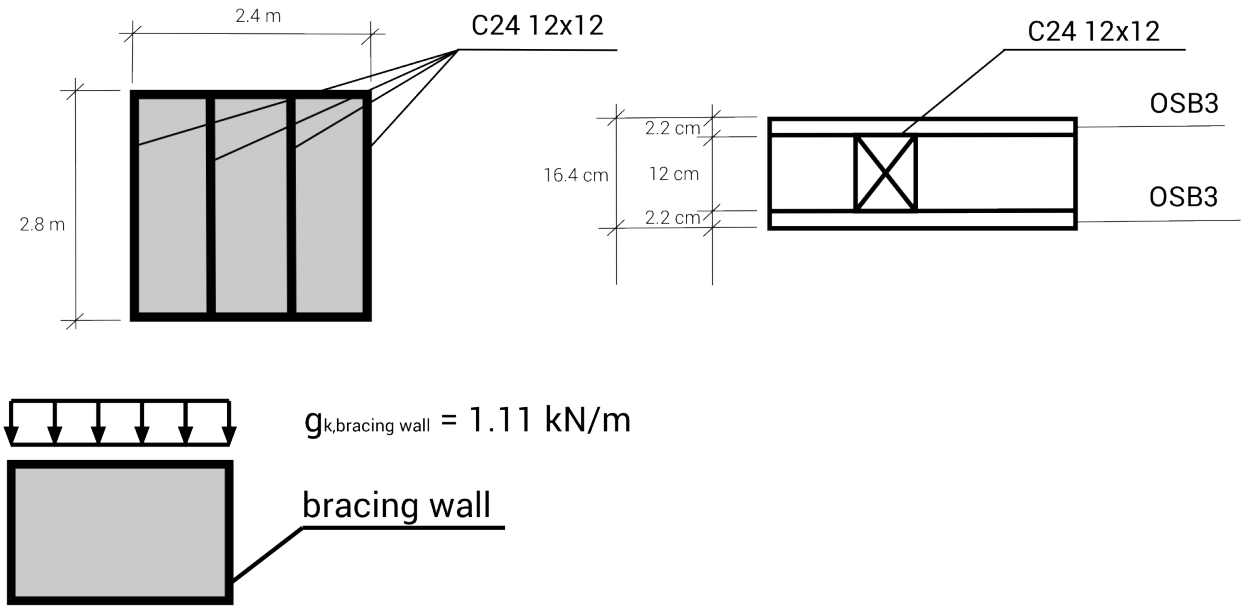


figure 13: dead load W3, calculation sheet and visualizing

Wind pressure and suction (for both cases): see calculation sheet.

Live load: Rule 51.6.6, SDE Rules, version 3.0 (page 100) states that walls must resist exterior and interior impacts as defined in NF P 08-302 — we use the number from the German equivalent.

2.3 Façade and pillars

2.3.1 Façade

After we have been through some design stages of the façade during the development, finally an exterior company “BeLuTec” designed the movable façade elements in cooperation with us and built them.

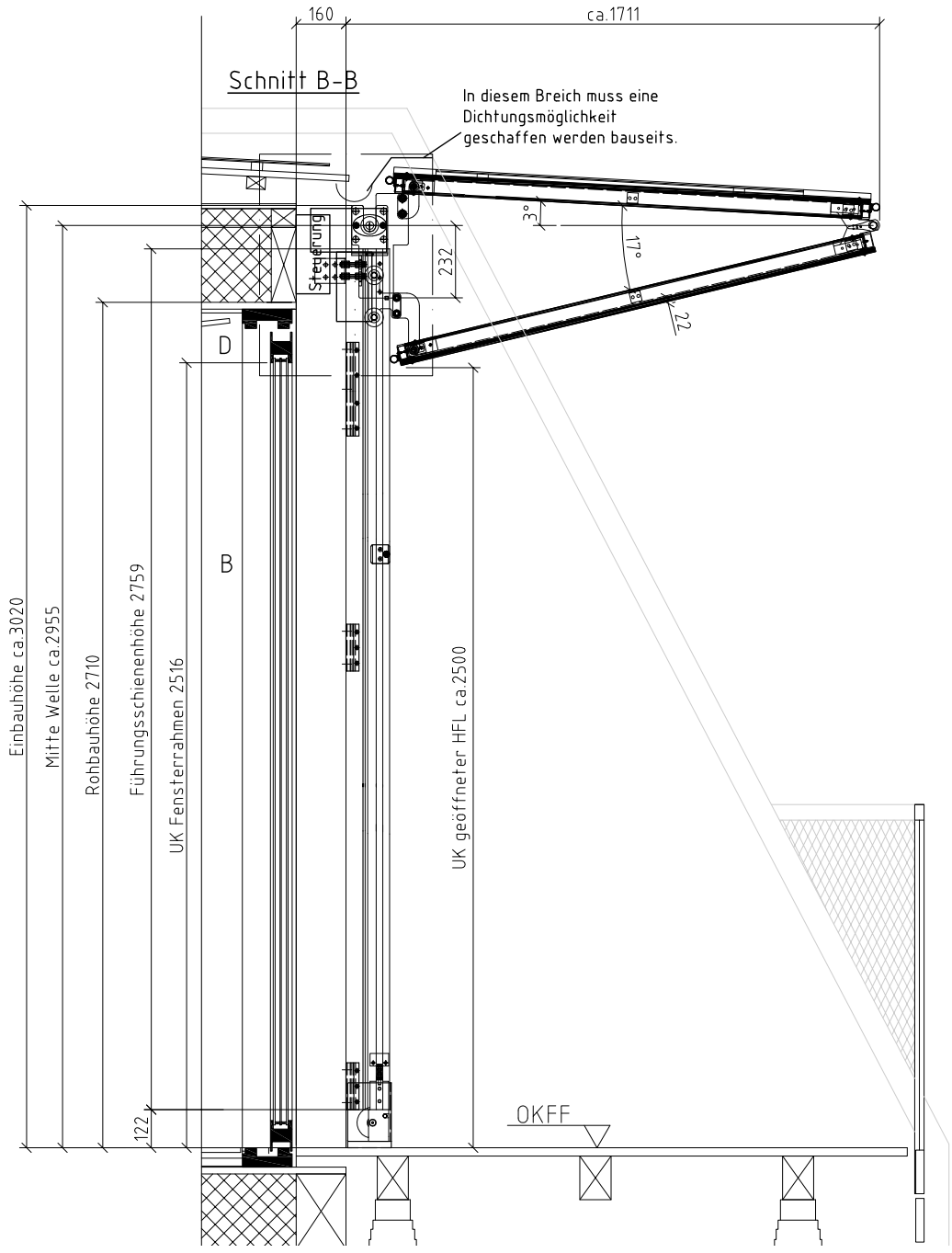


figure 14: opened facade element

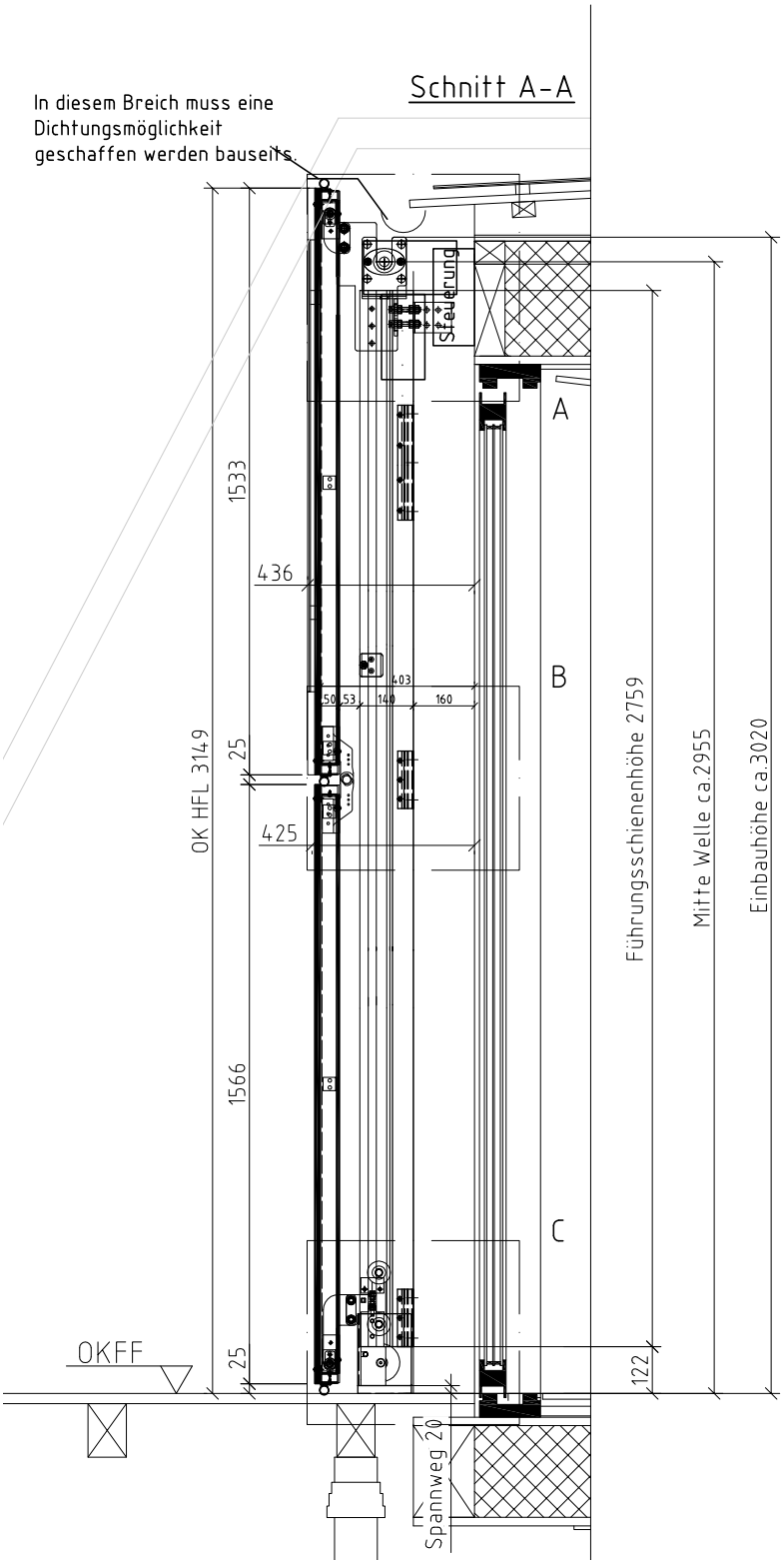


figure 15: closed facade elemet, cross section

The width of one façade module is the distance between to axes so 1.75m.

Each element is made out of a metal frame with wooden covering, whereas PV-modules are put on the upper part. In between the frame and the wooden back and front covering is a layer of insulation.

The mechanism:

The lowest hinge point of the façade is attached to a rail. On the top part of the element is a drifting shaft to which the engine is fixed. By lifting the lowest hinge up and turning the drifting shaft, the façade enfolds smoothly.

The duration of the lifting takes about 15 to 20 seconds. No dynamical influences due to the movement nor due to vibration needs to be taken into consideration.

Dead loads:

So far the RStab model has been designed as a steel frame construction. Therefore the own weight of the system is assumed to be higher than the actual weight. On top of each frame construction is a covering. On the upper frame is an aluminum plate on which the thin film solar cells will be placed and on the lower part a ply wood plate will be installed.

DIMENSIONS OF ONE PANEL			
upper part		lower part	
length [m]	1,65	length [m]	1,6
width [m]	1,75	width [m]	1,75
area [qm]	2,89	area [qm]	2,8
height of building [m]	3,5		

LOADS	force of gravity 10	positive direction of forces is direction of gravity	
own weight of panels			
solar cells[kg/qm] with connection	17,31		
wooden panel, t=15mm [kg/qm]	7,5	wooden panel, t=15mm [kg/qm] + add. coverinng	17,5
connections, 10% of weight	2,481	connections, 10% percent of w	1,75
insulation, t=4,4cm	4,62	insulation, t=4,2	4,62
(Sperrholz) plate inside covering, t=8mm	4	(Sperrholz) plate inside covering, t=8mm	4
assumed weight of upper part: solar cells and construction [kg/qm]	35,911	weight of lower part: wooden panel, construction [kg/qm]	27,87
upper part weight [kg]	103,69	lower part weight [kg]	78,04
load [kN]	1,04	load [kN]	0,78
distributed area load [kN/qm]	0,36	distributed area load [kN/qm]	0,28
load with [m]	0,875	load with [m]	0,875
load on one frame arm due to pannel own weight [kN/m]	0,31	load on one frame arm due to pannel own weight [kN/m]	0,24

wind	
according to EC 3	
Berlin, wind zone 2 inland, on top of the roof (ca. 20 m) – we are aware that structural calculations have to made for the actual construction in	
peak velocity pressure q(p) [kN/qm]	0,9
As the panels are not be open constantly, we assume their's is a "transitional state". Thus, according to DIN EN 1991-1-4/NA, NA-BB, the peak	
factor of reduction	0,5
reduced peak velocity pressure q(p) [kN/qm]	0,45
There is one normative state for the wind calculation: the panel is 90° open and the doors are closed – a projecting roof / canopy / Vordach.	
projecting roof / canopy / Vordach	
according to Schneider Bautabellen (20. Auflage) page 3.33, DIN EN 1991-1-4 does not yet include precise guidelines for projecting roofs, we	

Dead loads:

Tafel 3.34 Aerodynamische Beiwerte $c_{p,net}$ für den resultierenden Druck an Vordächern

Höhenverhältnis h_1/h	Bereich A			Bereich B		
	Abwärtslast	Aufwärtslast $h_1/d_1 \le 1{,}0$	Aufwärtslast $h_1/d_1 \ge 3{,}5$	Abwärtslast	Aufwärtslast $h_1/d_1 \le 1{,}0$	Aufwärtslast $h_1/d_1 \ge 3{,}5$
≤ 0,1	1,1	-0,9	-1,4	0,9	-0,2	-0,5
0,2	0,8	-0,9	-1,4	0,5	-0,2	-0,5
0,3	0,7	-0,9	-1,4	0,4	-0,2	-0,5
0,4	0,7	-1,0	-1,5	0,3	-0,2	-0,5
0,5	0,7	-1,0	-1,5	0,3	-0,2	-0,5
0,6	0,7	-1,1	-1,6	0,3	-0,4	-0,7
0,7	0,7	-1,2	-1,7	0,3	-0,7	-1,0
0,8	0,7	-1,4	-1,9	0,3	-1,0	-1,3
0,9	0,7	-1,7	-2,2	0,3	-1,3	-1,6
1,0	0,7	-2,0	-2,5	0,3	-1,6	-1,9

Für Zwischenwerte $1{,}0 < h_1/d_1 < 3{,}5$ ist linear zu interpolieren; Zwischenwerte h_1/h dürfen linear interpoliert werden.

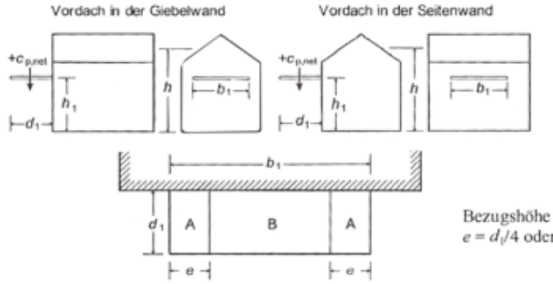


Abb. 3.34a Abmessungen und Einteilung der Flächen für Vordächer

source: Alfons Goris (ed.): Schneider Bautabellen, 20. Auflage, Werner Verlag, Köln, 2012 (page 3.34)

h1/d1[]	1.000	panel as long as h1, in closed state down to floor
h1/h []	1.000	panel in 90° on horizontal line with roof
e	0.413	smaller ratio: length/4 or breadth/2
area A	1.361	
area B	1.526	
total area check	2.888	OK
A: aerodynamic factor c(p,net) downwards	0.700	see table on right side
A: aerodynamic factor c(p,net) upwards	-2.000	
B: aerodynamic factor c(p,net) downwards	0.300	
B: aerodynamic factor c(p,net) upwards	-1.600	
wind loads w(e)=q(p) * c(p,net)		
A: pressure [kN/qm]	0.315	
A: suction [kN/qm]	-0.900	
B: pressure [kN/qm]	0.135	
B: suction [kN/qm]	-0.720	
total area: pressure [kN/qm]	0.220	
total area: suction [kN/qm]	-0.805	

This is the normative case for the dynamic mechanism and the pillar deformations. To simplify matters we averaged the loads of the section areas to calculate the bracing of the house. In the calculation of the company “BeLuTec” only the values of area A are regarded, as shown in ***figure 17: calculation of the facade by "BeLuTec", reaction forces on pillar***, thus their values for are slightly higher.

As the panels will be closed when it snows, we need not consider the snow load. For all loads: see calculation sheet above.

Facade is open 90°:

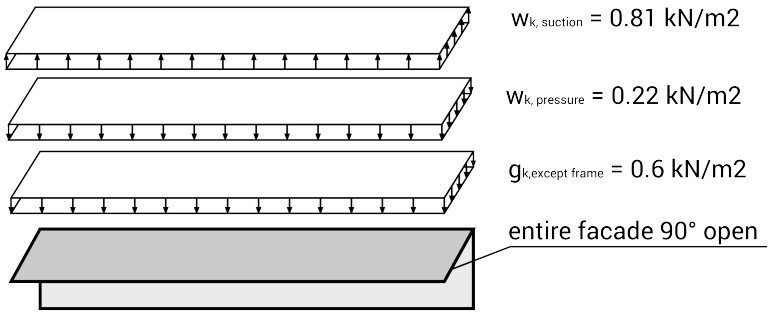


figure 16: loads on open façade

reaction forces the need to be applied on the pillar – calculation by “BeLuTec”:

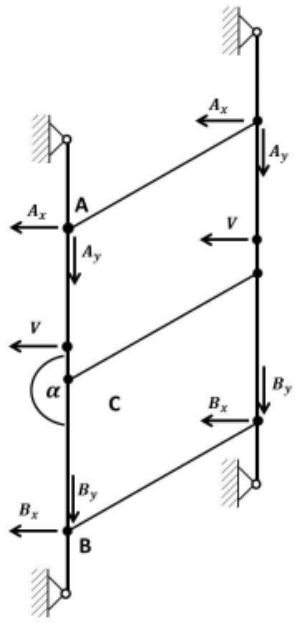
Uni Berlin2

Parameter

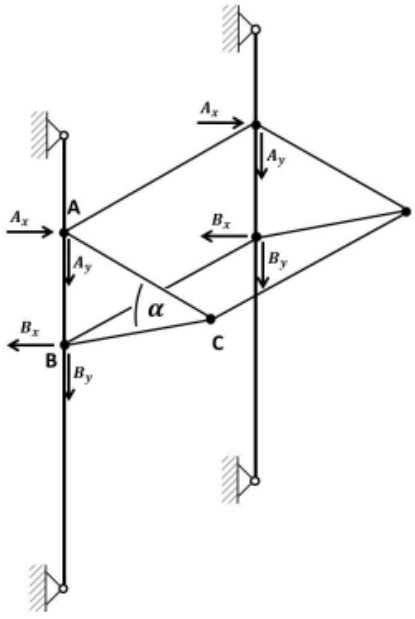
Windlasten [kN/m²]
Aufwind: -0,9237
Abwind: 0,3113
Frontal: -0,835
kritischer Öffnungswinkel: 24 ° (0,411457 Rad)
Höhe: 3150
Breite: 1690
Beplankungsgewicht: 49 kg/m²
Durchgangshöhe: 2460

Auflagerkräfte

	Ax [kN]	Ay [kN]	Bx [kN]	By [kN]	V [kN]
Belastungsfälle bei geöffnetem Faltladen					
ohne Windlast	1,67	0,7	1,67	0,69	0
Aufwind	0,18	0,38	0,42	0,77	0
Abwind	2,09	1	2,17	0,79	0
Belastungsfall bei geschlossenem Faltladen					
Frontalwind	0,43	1,39	-0,56	0	1,23



geschlossener Faltladen

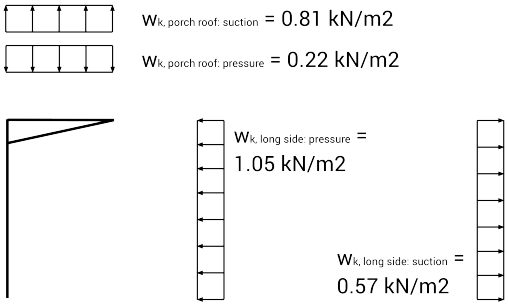


geöffneter Faltladen

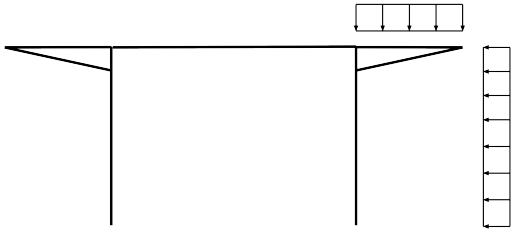
figure 17: calculation of the facade by "BeLuTec", reaction forces on pillar

2.3.2 Possible combination of both wind loadings: wind on long walls and wind on porch roof

wind load case 1a) is decisive.

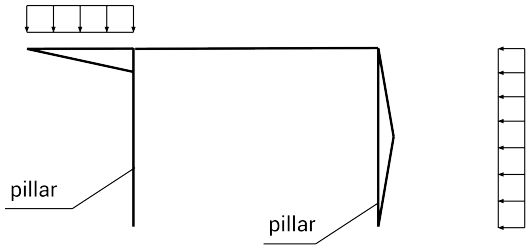


combination 2:

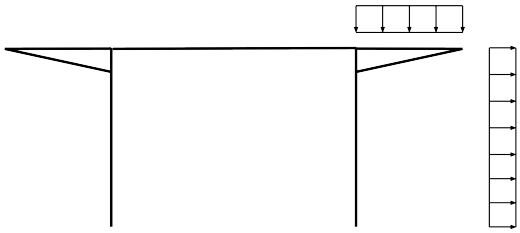


wind pressure on long side + pressure on same porch roof: not possible

combination 1a:

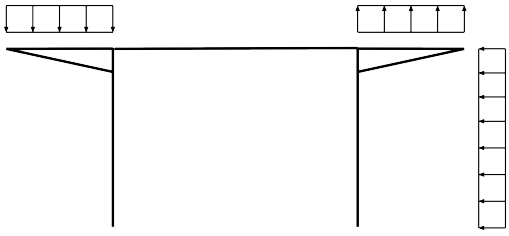


combination 3:



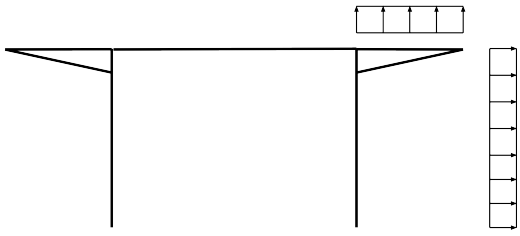
wind suction on long side + pressure on same porch roof

combination 1b:



wind pressure on long side + suction on porch roof on same side + pressure on other porch roof: since the own weight of the facade is higher than wind suction, case 1a is decisive for modeling.

combination 4:



wind suction on long side + suction on same porch roof

figure 18: possible wind load combinations

2.3.3 Pillars

Dead load of a pillar:

material	width [m]	depth [m]	height [m]	area [m²]	specific weight [kN/m³]	load [kN]
construction wood C24 16x20cm	0.20	0.16	3.50	0.03	3.50	0.39
Σ						0.39

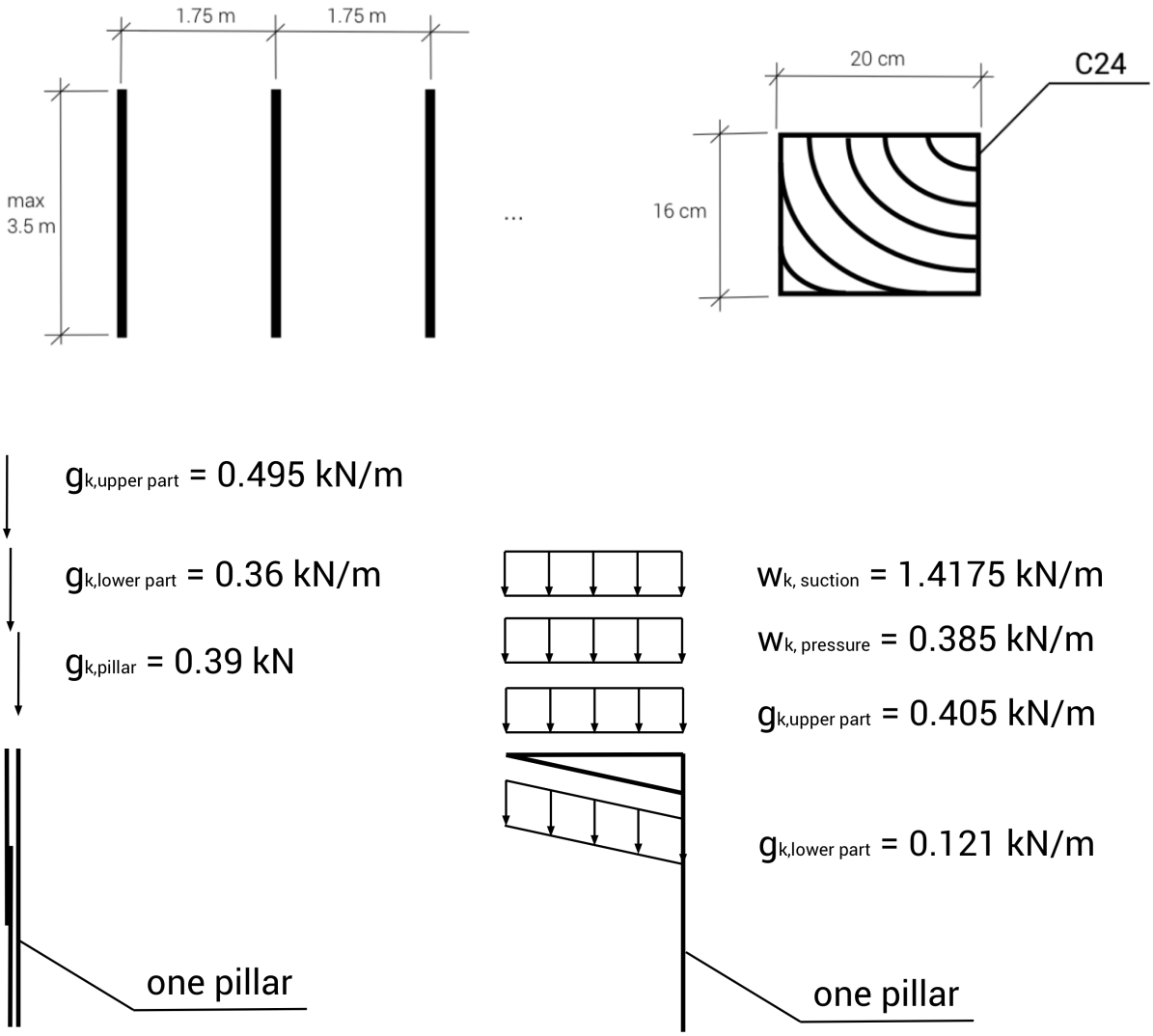


figure 19: loads on pillar

2.4 Floor

Loads visualized:

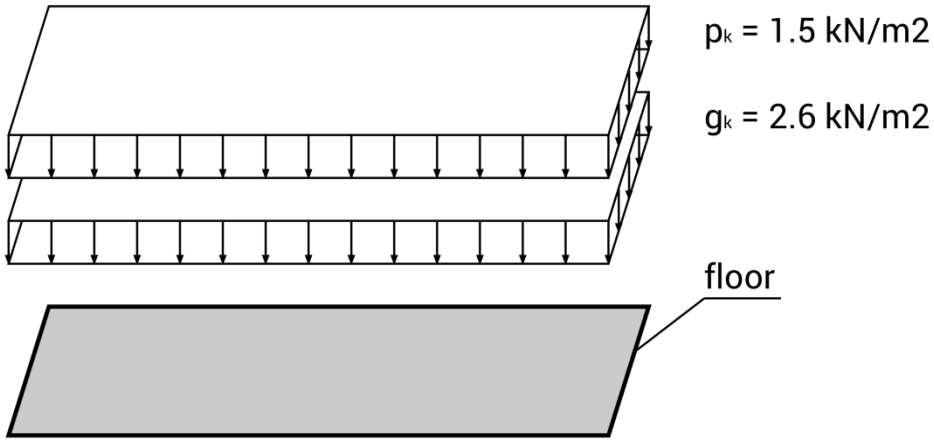


figure 20: loads on floor

source for uniform live load: rule 51.6.2, SDE Rules, version 3.0 (page 98)

→ Yet acc. EC3 (DIN EN 1991-1-1/NA, Tab. 6.1 DE) for the design of a wooden beam construction itself without sufficient transverse distribution, live loads needs to be minimum pk=2,0kN/m². For the design of the supporting building members of this floor construction (here the footings) the value of p_k=2,0kN/m² can be reduced by p_k=2.0kN/m² -0.5kN/m² =1,5kN/m².

For the technical room and the beam underneath wall W1/W2 that need to carry a very high own weight is count to be neglect able.

The glass façade is applied as a line load of 1kN/m on the edges of the longitudinal side of the floor construction.

source for dead load, calculation sheet, figure 1.

#	material	width [m]	length [m]	area [m²]	thickness [m]	specific weight [kN/m³]	total load [kN]	area load [kN/m²]
	construction wood							
7	C24 12x24cm; 18 pieces	81.00				4.60	10.731	0.610
7	C24 8x24cm; 7 pieces		98.00			4.60	12.983	0.738
	other materials							
1	parquet or similar				0.020	5.00		0.100
2	screed				0.020	18.00		0.360
3	soft fiberboard				0.010	1.40		0.014
4	floor heating				0.040	3.30		0.132
4	noise insulation					0.40		0.016
5	OSB				0.022	6.20		0.136
6	wood fiber insulation				0.240	0.50		0.120
8	plasterboard panel				0.040	7.90		0.316
9	wooden substructure				0.012	4.60		0.055
	installations (assumption)							
	Σ	**5.50**	**3.20**	**17.60**	**0.404**			**2.597**

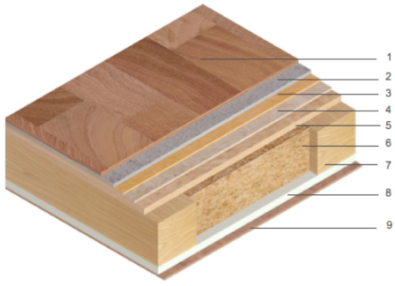


figure 21: source of dead loads of the floor costruction

2.5 Core Module

The own weight of the core module is determined mainly by the technical installations in the technical room. The kitchen and bathroom are dimensioned according to general floor loads (see chapter 2.4). The following table gives an overview of the elements inside the technical room; the drawing shows where their location will be. For noise insulation reasons the technical room itself will be fit into a box made out of Eternit plates and placed on a rubber layer.

component	Dimensions (mm)	Area (m2)	Weight (kg)	Load (kN/m2)	Note
Heat pump / Wärmepumpe	1430 by 1870, 812 high	1.17	424 kg empty shell + 200 liters drinking water = 659 kg	659 kg /1.17 m2 *100 = 5.63 kN/m2	Stiebel Eltron LWZ 304
Water container / Pufferspeicher	Diameter 630, height 1535	0.31	58 kg empty shell + 200 liters water = 258 kg	258 kg / 0.31 m² *100 = 8.33 kN/m²	Stiebel Eltron SBP200 E Cool
Sanitary pipes #8,9,10	Diameter 100		Not decisive		Go through the floor
Electrical #19			Not decisive		Above floor level, attached to walls
Other pipes			Not decisive		

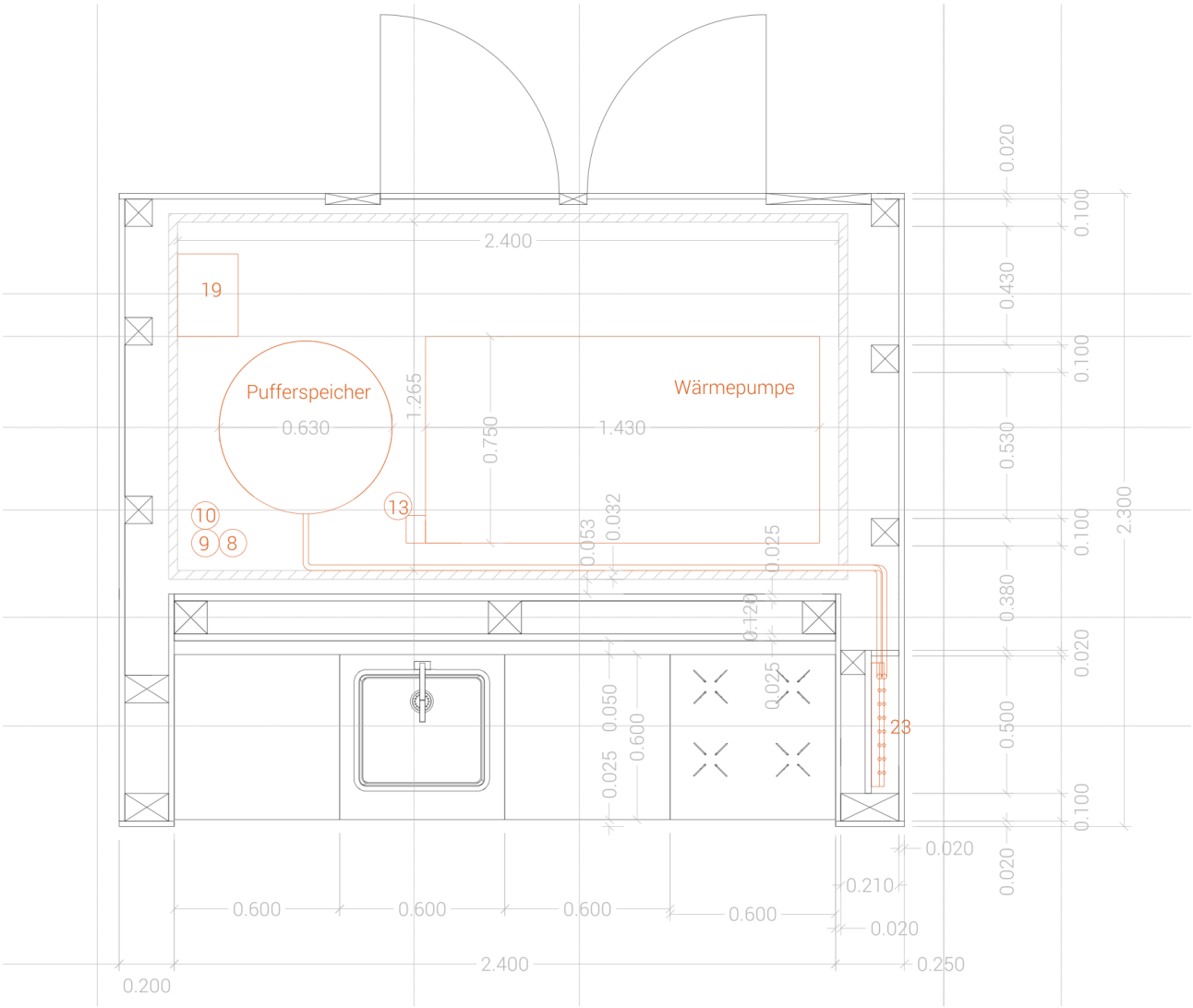


figure 22: Elements of the core module and their positions

The section shows all elements in the floor, under the core module compared to the usual floor set-up:

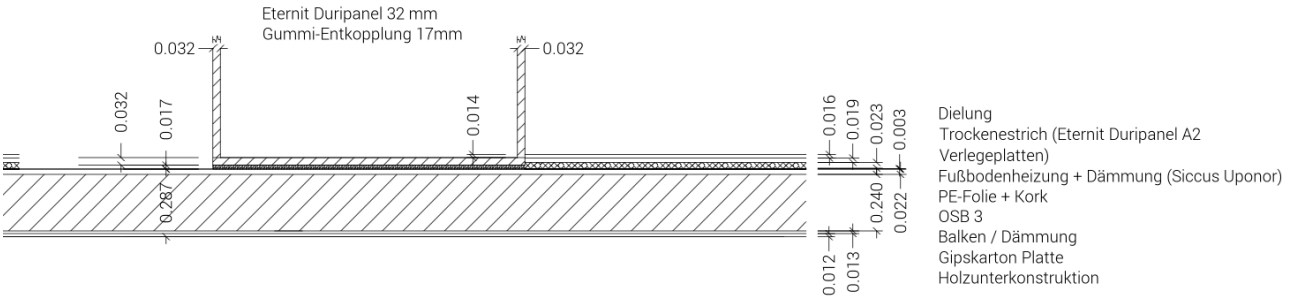


figure 23: set-up of the floor of the core module

Core module			
length [m]	2,45	all calculations in z-direction – vertical,	
width [m]	1,3	direction of gravity is positive direction of forces	
h [m]	2,7		
area [qm]	3,185		
LOADS		force of gravity g	10
own weight per square meter			
total weight of normal floor set up - gk Core module)	kN/m2	2,60	
weight of floor set up not existing in technical room	kN/m^2	0,748	
weight of rubber plate (t=17mm)	kN/m^2	0,26	
weight of Eternit ground plate (t=16mm)	kN/m^2	0,248	Eternit rho =15,5kN/m^3
assumed weight of other installations	kN/m^2	0,40	
sum of Core module floor set up	**kN/m^2**	**2,76**	
line load due to Eternit walls of the box (considering longer walls take the own weight of the box's ceiling)			
line load due to short walls (t=16mm)	kN/m	0,67	
line load due to long walls (t=16mm) + 0.5 of ceiling	kN/m	0,83	
live load (just installation load) - p,k (Core module)	kN/m^2	1	
kitchen:			
total weight of normal floor set up - gk Core module)	kN/m2	2,60	
additional weight due to techn. Devices of kitchen	kN/m2	1,2	

thickness of Ethernit has been changed to t=16mm.

2.6 Footings

See calculations

2.7 Terrace

Uniform live load: rule 51.6.2, SDE Rules, version 3.0; except for stairs – a higher uniform live load will be applied here: rule 51.6.2, SDE Rules, version 3.0

Dead load of water processing system: The system weighs 9 tons in total, for an area of 3.3 by 2.10 meters. The system is structurally independent of the terrace, we will place it on several column bases. Due to his high weight, it will be used as an anchor point to provide horizontal stability to the structural members of the terrace.

Horizontal impact on railings on all sides: rule 51.6.2, SDE Rules, version 3.0.

Dead loads of terrace and beams: please refer to the dimensioning text at 4.6.

Loads visualized in ***figure 24: loads of the terrace construction***:

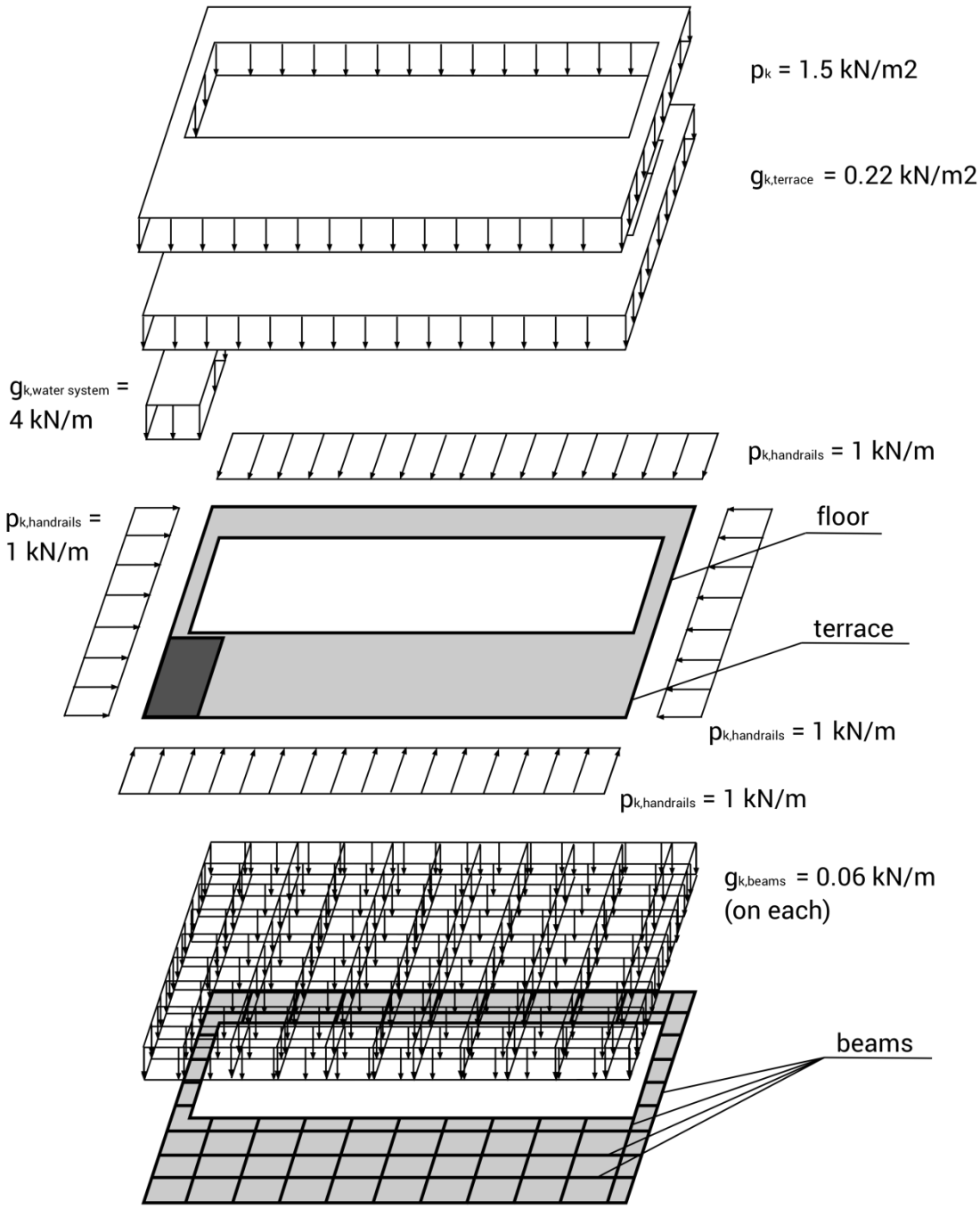


figure 24: loads of the terrace construction

2.8 Surroundings

As one of our main focuses of attention is to illustrate that our house is placed on the roof of a typical Berliner Altbau, we reconstructed the situation in setting up high walls on the east and the west of our building and the terrace and designing the entrance as a fiction staircase.

Horizontal loads – wind loads for temporary constructions: DIN EN 1991-1-4/NA, NA-BB - impact on railings on all sides: rule 51.6.2, SDE Rules, version 3.0.

Vertical loads – own weight and variable weight during installation

3 Bracing

3.1 W1, W2 and W3

In order to withstand horizontal loads the building needs to provide enough horizontal stiffness. The roof construction will be designed as a rigid shear connection. The roof gathers horizontal loads and applies them to the stiffened walls W1, W2 and W3, which eventually introduce the horizontal forces into the floor construction and the footings.

In longitudinal direction wall W3 (which is part of the core module) carries the load in x-direction and in transactional direction the two outer walls W1 and W2 withstand applied loads in y-direction.

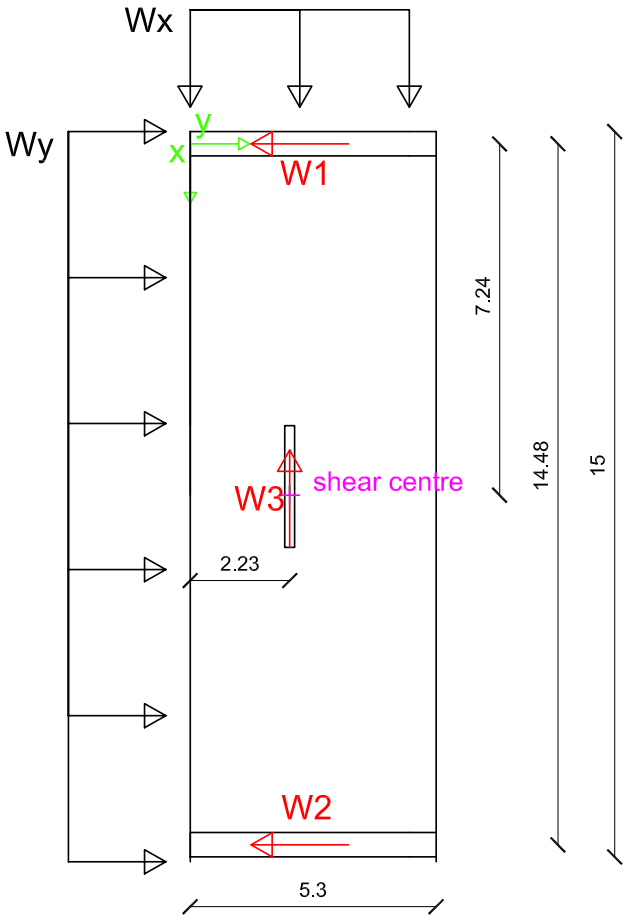


figure 25: bracing of the house

To simplify matters the bracing walls are seen to be of similar construction and their moment of inertia will be calculated by using:

$$I = \frac{b \cdot h^3}{12}$$

$$I_{W3,y} = \frac{0.16m \cdot (2.4m)^3}{12} = 0.184m^4 \qquad I_{W1,x} = \frac{0.3m \cdot (5.235m)^3}{12} = 3.59m^4$$

Table of the moment of inertia:

	$I_x\ [m^4]$	$I_y\ [m^4]$	$x_i\ [m]$	$y_i\ [m]$	$I_x{}^*x_i$	$I_y{}^*y_i$
W3		0.184		2.23		0.41
W1	3.59		0		0	
W2	3.59		14.48		51.98	

Shear centre:

$$x_{shear\ centre} = \frac{\sum I_{x_i} \cdot x_i}{\sum I_{x_i}} = \frac{51.98}{2 \cdot 3.59} = 7.24m$$

$$y_{shear\ centre} = \frac{\sum I_{y_i} \cdot y_i}{\sum I_{y_i}} = \frac{0.41}{0.184} = 2.23m$$

Hence the shear centre is located in wall W3, as shown in figure above, therefore no additional torsional moment has to be carried by walls W2 and W3 due to eccentricity.

Wind loads: See values mentioned in chapter load assumptions. The highest values of both wind load cases will be applied to design each wall.

Wind on short side: $w_{x,k} = w_{e,compr} + w_{e,pull} = 0.63\ \frac{kN}{m^2} + 0.27\frac{kN}{m^2} = 0.9\frac{kN}{m^2}$

Wind on long side: $w_{y,k} = w_{e,compr} + w_{e,pull} = 0.68\ \frac{kN}{m^2} + 0.37\frac{kN}{m^2} = 1.05\frac{kN}{m^2}$

Wall 3:

$$w_{3,k} = 0.9\ \frac{kN}{m^2} \cdot 5.3m \cdot \frac{3.6m}{2} = 8.59kN$$

$$w_{3,d} = \gamma_Q \cdot 8.48kN = 1.5 \cdot 8.59kN = 12.88kN$$

Wall 1 and 2:

$$w_{1/2} = 0.5 \cdot 1.05\frac{kN}{m^2} \cdot 15m \cdot \frac{3.6m}{2} + \ 0{,}56\frac{kN}{m} * \frac{15m}{2} = 18.38kN$$

*) where 0,5 kN/m is the force of the support of the facade on top of one column due to wind load in the most critical position of the façade. $w_{y,k,due\ to\ impact\ of\ moveable\ facade} = \frac{0.98kN}{1.75m} = 0.56\frac{kN}{m}$ see → chapter 4.5.

$$w_{1/2,d} = \gamma_Q \cdot 18.38\ kN = 1.5 \cdot 18.38kN = 27.56kN$$

The roof and the walls will be constructed to withstand those loads. The horizontal loads given above will be applied to design those elements.

4 Dimensioning

4.1 Material properties

Figure below shows an overview of the material properties:

material properties					
NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$	
	k_{mod} =	0,9	(NKL2, kurz)		
	f_{mk} =	2,4	kN/cm^2	f_{md} =	1,66 kN/cm^2
	f_{vk} =	0,4	kN/cm^2	f_{vd} =	0,28 kN/cm^2
	$f_{c,90k}$ =	0,25	kN/cm^2	$f_{c,90,d}$ =	0,17 kN/cm^2
	$f_{c,0,k}$ =	2,1	kN/cm^2	$f_{c,0,d}$ =	1,45 kN/cm^2
	k_{mod} =	0,7	(NKL3, kurz)		
	f_{mk} =	2,4	kN/cm^2	f_{md} =	1,29 kN/cm^2
	f_{vk} =	0,4	kN/cm^2	f_{vd} =	0,22 kN/cm^2
	$f_{c,90k}$ =	0,25	kN/cm^2	$f_{c,90,d}$ =	0,13 kN/cm^2
	$f_{c,0,k}$ =	2,1	kN/cm^2	$f_{c,0,d}$ =	1,13 kN/cm^2
OSB3	γ_M=	1,3		$f_{,d}=f_{,k} \cdot k_{mod}/\gamma_M$	
	k_{mod} =	0,9	(NKL1, kurz)	t≥20mm	
(plain stress)	f_{mk} =	0,9	kN/cm^2	f_{md} =	0,62 kN/cm^2
	f_{vk} =	0,68	kN/cm^2	f_{vd} =	0,47 kN/cm^2
	$f_{c,k}$ =	1,48	kN/cm^2	$f_{c,90,d}$ =	1,02 kN/cm^2
(plate strain)	f_{mk} =	0,74	kN/cm^2	f_{md} =	0,51 kN/cm^2
	f_{vk} =	0,1	kN/cm^2	f_{vd} =	0,07 kN/cm^2

4.2 Roof

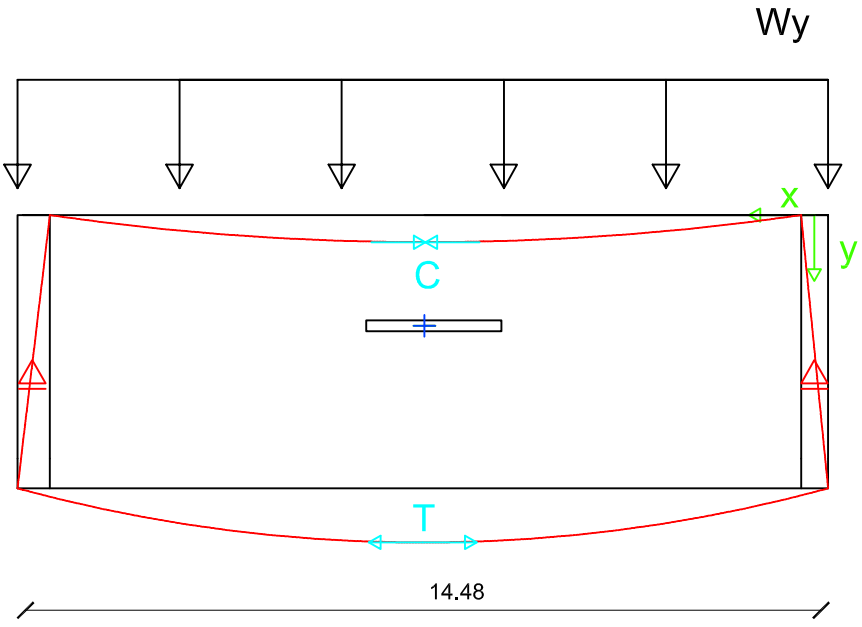
The roof construction is separated into 8 roof modules RM1 – RM8 to enable a pre-construction of each module and to accelerate the construction time. All modules are basically designed in a similar way with almost the same dimension. Only the outer modules RM1 and RM8 do slightly differ in dimensions and an additional beam will be added to RM 4 and RM5 to secure the shear load transmission into wall W3. The length of the modules is the inner distance between the columns of each side (4.555m), the width of modules is the distance of the axis' in longitudinal direction (1.75m), as you can see in the position plan of the roof.

Vertical loads will be transmitted into the columns via a classical purlin-beam system with purlins every 50 cm in longitudinal and beams in transactional direction. The covering of the slab will enable the horizontal load transmission and guarantee the shear stiffness of the slab.

Purlins and beams are designed with spruce – timber NA C24, the covering with OSB 3.

4.2.1 Roof – Horizontal load transmission

In order to provide enough shear stiffness, the one side covered slab construction has to withstand the shear forces due to wind loads. To design the roof construction the structural system shown in figure below will be used. Therefore the moment in the middle of the beam will be split into a couple of forces to design the covering, fasteners and the outer ribs of the roof construction.



Resulting horizontal force in y-direction to be applied on the roof:

$$w_d = 1.5 * w_{on\ long\ side,k} \cdot \frac{h}{2} = 1.5 * 1.05 \frac{kN}{m^2} * \frac{3.2m}{2} = 2.52 \frac{kN}{m}$$

$$w_{y,k,due\ to\ impact\ of\ moveable\ facade} = \frac{0.98kN}{1.75m} = 0.56 \frac{kN}{m} \qquad (*)$$

(*) see → chapter 4.5.

$$H_{y,d} = w_{on\ long\ side,d} + w_{y,d,due\ to\ impact\ of\ moveable\ facade} = 3.08 \frac{kN}{m}$$

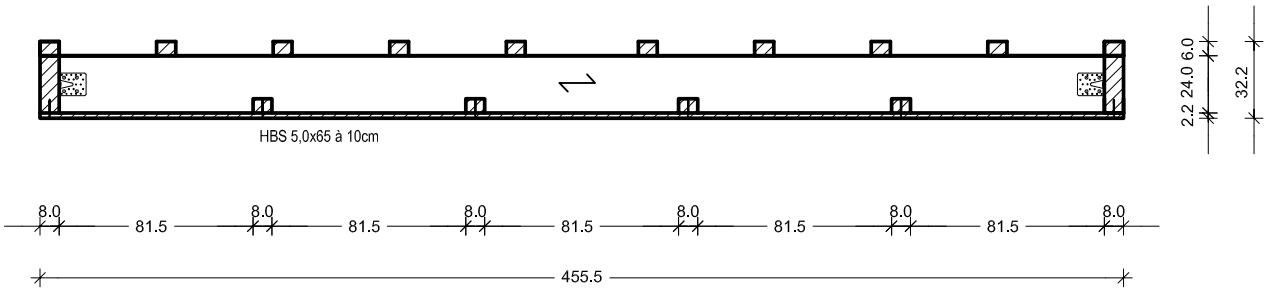
$$M_d = \frac{H_{y,d} \cdot l^2}{8} = \frac{3.08 \frac{kN}{m} \cdot (15m)^2}{8} = 86.6\ kNm$$

$$|C| = T = \frac{M}{b} = \frac{86.6kNm}{4.555m} = 19.01kN$$

$$V_d = H_{y,d} \cdot \frac{l}{2} = \frac{3.08kN}{m} \cdot \frac{15m}{2} = 23.1kN$$

Connections of and between the roof modules must withstand a maximum shear load 23.1 kN.

Cross section of a roof module:



1) geometrics roof modules

roof-module	l =	455,5	cm
	h =	175	cm
	l_{eff} =	175	cm
ribs	b_{inner}=	8	cm
	b_{outer}=	8	cm
	h =	24	cm
covering	a_r =	89,5	cm
	t =	2,2	cm
	b_{net} =	81,5	cm

criteria to build the slab as a shear connection according to simplifying methos of EN 1995-1-1:

a_r/t =	40,68	<!	50
h/b =	3	<!	4

2) Materials

NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,9	(NKL2, kurz)			
	k_{mod} (outside)=					
	f_{mk} =	2,4	kN/cm²	f_{md} =	1,66	kN/cm²
	f_{vk} =	0,4	kN/cm²	f_{vd} =	0,28	kN/cm²
	$f_{c,90k}$ =	0,25	kN/cm²	$f_{c,90,d}$ =	0,17	kN/cm²
	$f_{c,0,k}$ =	2,1	kN/cm²	$f_{c,0,d}$ =	1,45	kN/cm²
OSB3	γ_M=	1,3		$f_{m,d}=f_{m,k} \cdot k_{mod}/\gamma_M$		
(Scheibe)	k_{mod} =	0,9	(NKL1, kurz)			
	f_{mk} =	0,9	kN/cm²	f_{md} =	0,62	kN/cm²
	f_{vk} =	0,68	kN/cm²	f_{vd} =	0,47	kN/cm²
	$f_{c,k}$ =	1,48	kN/cm²	$f_{c,90,d}$ =	1,02	kN/cm²

2) Designing

a) Design of outer ribs (vertical load transmission)

buckling

$i_x = h/\sqrt{12} =$	6,93		radius of inertia
$\lambda = l_{eff}/i =$	25,26		slimness factor
$k_c =$	0,97		buckling value

tension and compression forces to be applied on outer ribs:

$F_{hd} = 1.5*F_{hk} =$	19,01	kN	
$F_{1hc/t}$ = 1,5* Fhd	28,52	kN	outer ribs are slotted, acc. EC5 force has to be
$F_{1hc/t}/(A_{c3}*k_c*f_{c0d}) =$	0,11	<! 1	multiplied by 1,5

shear force: $F_{vd} =$ 23,10 kN

b) design for swell stress of the beam:

$b_{additonal} =$	3	cm
$A_{eff,outer\ rib} =$	264	cm^2
$k_{c,90} =$	1,25	

swell stress due to force of outer rib:

$N_{ca}/(A_{eff}*k_{c,90}*f_{c,90,d}) =$ 0,499 <! 1

c) design of covering

c.1) fastener:

$s_{v,0} = Fv_d/(l*n) =$	0,05	kN/cm	shear force on fasteners
a =	7,50	cm	chosen distance fasteners
$F_{vd,Na} = s_{v,0}*a =$	0,38	kN	shear force on each fastener
$F_{v,Rk} =$	0,774	kN	cab. cleaving force of clamps clamps d=1,8mm (SBT ch. 9.54)
$F_{v,Rd} = k_{mod}*F_{v,Rk}/\gamma_m =$	0,54	kN	>! $F_{vd,Na}$

c. 2) covering:

$K = 35*t/b_{net} =$	0,94		reduction factor
$\tau_d = F_{vd}/(a*t) =$	0,02	kN/cm^2	shear force
$k_{1v} =$	0,83		slotted cover
$k_{2v} =$	0,33		covering just one side
$\tau_d/(k_{1v}*k_{2v}*K*f_{vd}) =$	0,19	<! 1	

d) connection between the roof modules

$F_{max\ t,d}$ =	28,52	kN	maximum tension force
$F_{v,d}$ =	23,10	kN	maximum shear force

chosen connection (see plans)
5x bolts Bo ⦰16 S235, C24, α=0°, $t_{h,req}$=60mm

each: d=	16	mm	
A=	201,06	mm^2	

design for maximum tension forces between roof modules:
sigmay,d =Ft,d/(n*A)
> 2 bolts chosen at the end of each purlin.

sigmay,d=	7,09	kN/cm^2	>! f_{vd}

swell stress under bolt plat bolt plate= 65 cm^2

$R_{c,90,d}$ /(2* $A_{bolt\ plate}$*$k_{c,90}$*$f_{c,}$	1,01	<! 1

design for shear force:

$F_{vrk,90}$ =	10,6	KN	
Fv,Rd =n*kmod*Fv,Rk/γm =	36,69	KN	>! F_{vd}

; where n=5

proof for whole reveal stress is not necessary t=100mm > t req

4.2.2 Roof – Vertical load transmission

In order to design the wooden members following equations have been used.

Design for bending and compression (only M_y moments):

$$\frac{\sigma_{c,o,d}}{k_{c,y} \cdot f_{c,o,d}} + \frac{\sigma_{m,y,d}}{k_{crit} \cdot k_h \cdot f_{m,y,d}} \leq 1$$

Design for shear force:

$$\frac{\tau_d}{f_{v,d}} = \frac{1.5 \cdot V_d}{A_n \cdot k_{cr} \cdot f_{v,d}} \leq 1$$

4.2.2.1 Roof – Vertical load transmission – roof area 1

The critical area load combination for the roof (sum load above beams/purlins): q_d= 2,2 kN/m^2.

To simplify matters this area load will be used to design each significant member above the beams.

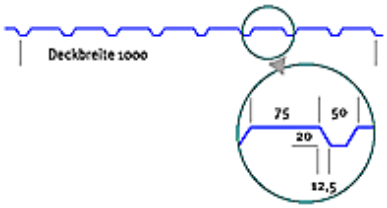
(Consider the variable load is higher than a working load of 1 kN/m^2)

i. Design of profiled sheeting

Flexton profiled sheeting with a thickness of t=0,5mm will be used. The table below shows the capable bearing area load according to the manufactory:

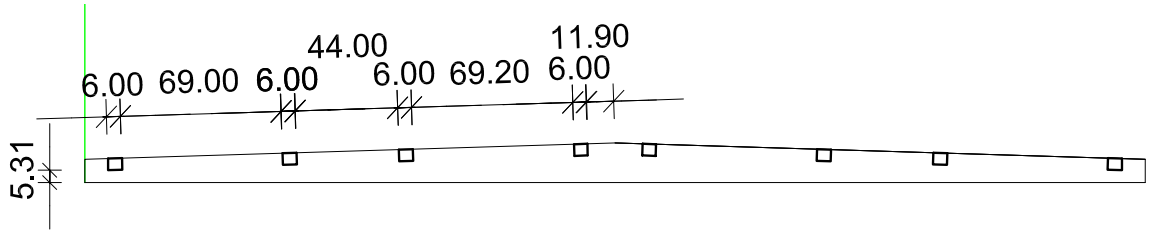
t=0.5 mm:
0.80 | 1.00 | 1.20 | 1.40 | 1.60 | 1.80 | 2.00 m
(length between supports L)

4.94 | 3.32 | 2.38 | 1.78 | 1.30 | 0.92 | 0.67 kN/m²
(capable bearing load q)



Thus the length of the supports should not exceed l=1.2m. The distance between the supporting rafters will be chosen as l=1.0m.

ii. Design of the counter-battens/rafters (Konterlattung)



static system, beam on two supports: q_d= 2,2 kN/m² (1.85kN/m²):

Max. gathering load width of one raster = 1,5m. They are not seen to be continuous girder, yet considered to be beams on two supports due to modular construction design; length l=1.0m.

$$q = 2.2\frac{kN}{m^2} \cdot 1.5m = 3.3\frac{kN}{m}$$

$$M = 0.413\ kNm;\ V = 1.39\ kN$$

$$b = 6cm; h = 5cm;\ A = 30\ cm^2;\ A_{Netto} = 27{,}5\ cm^2;\ W = \frac{5{,}5cm \cdot (5cm)^2}{6} = 22{,}91\ cm^3$$

Bearing capacity:

$$\sigma_{m,y,d} = \frac{0{,}413kNm}{27{,}5cm^3} = 1.5\frac{kN}{cm^2} < 1.66\frac{kN}{cm^2}$$

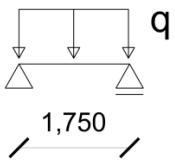
Shear stress:

$$\tau_d = 1.5 \cdot \frac{V_d}{h \cdot b \cdot k_{cr}} = 1.5 \cdot \frac{1.39kN}{5.5cm \cdot 5cm \cdot 0.5} = 0.151\frac{kN}{cm^2} < 0.28\frac{kN}{cm^2}$$

The trapezoid wooden rafter nor the DWD plate needs to be designed in particular.

iii. Design of the rafters:

static system, beam on two supports: q_d= 2,2 kN/m²:



Since the rafters are only designed to transport vertical loads, they don't need to be built as continuous girders.

Gathering load width of one raster = 50cm

$$q = 2.2\frac{kN}{m^2} \cdot 0.5m = 1.1\frac{kN}{m}$$

$$M_d = 0.42\ kNm; V_d = 0.96\ kN$$

$$b = 8cm; h = 6cm;\ A = 48\ cm^2;\ A_{Netto} = 45\ cm^2;\ W = \frac{7{,}5cm \cdot (6cm)^2}{6} = 45\ cm^3$$

Bearing capacity:

$$\sigma_{m,y,d} = \frac{0{,}42kNm}{45cm^3} = 0.93\frac{kN}{cm^2} < 1.66\frac{kN}{cm^2}$$

Shear stress:

$$\tau_d = 1.5 \cdot \frac{V_d}{h \cdot b \cdot k_{cr}} = 1.5 \cdot \frac{0.96kN}{45\ cm^2 \cdot 0.5} = 0.064\frac{kN}{cm^2} < 0.28\frac{kN}{cm^2}$$

iv. Design of the beams:

Two types of beams B1 (7 elements) and B2 (2 elements) are to be designed:

The beams B1 have a load width of 1.75m/2. Hence the load on the beam B1 is:

$$q = \left(2.2\frac{kN}{m^2} + g_{k,below\ beams} + g_k, beam\right) \cdot loadwidth = \left(\underbrace{\left(2.2\frac{kN}{m^2} + 0.52\frac{kN}{m^2}\right)}_{q = 2{,}72\frac{kN}{m2}} + 0.133\frac{kN}{m}\right) \cdot \frac{1.75m}{2} = 2.49\frac{kN}{m}$$

and secondly the beams B2 of the outer roof modules have a load width of l=1.75 m/2+0.44 m=1.315 m.

Hence the load on beams B2 is:

$$q = \left(2.2\frac{kN}{m^2} + g_k, beam + g_{k,below\ beams}\right) \cdot loadwidth = \left(2.2\frac{kN}{m^2} + 0.133\frac{kN}{m} + 0.52\frac{kN}{m^2}\right) \cdot 1.315m = 3.75\frac{kN}{m}$$

Static system is a beam on two supports. Forces:

Beams B1:

$$M = 2.49\frac{kN}{m} \cdot \frac{(4.555m)^2}{8} = 6.46\ kNm$$

$$V = 2.49\frac{kN}{m} \cdot \frac{4.555m}{2} = 5.67kN\ \ , where\ V_{g,k} = 2.56kN\ and\ V_{q,k} = 3.11kN$$

$$N = \gamma_Q \cdot w_{on\ long\ side,d} \cdot \frac{h}{2} \cdot b + 0.5 \cdot facadeload\ = 1.5 \cdot \frac{1.05kN}{m^2} \cdot \frac{3.5m}{2} \cdot \frac{1.75m}{2} + 0.5 \cdot 0.64kN$$
$$= 3.05kN$$

$$A = 10cm \cdot 24cm = 240cm^2;\ W = 960cm^3$$

$$\sigma_{c,0,d} = \frac{3.05kN}{240cm^2} = 0.013\frac{kN}{cm^2}$$

$$\sigma_{m,y,d} = \frac{6.46kNm}{960cm^3} = 0.67\frac{kN}{cm^2}$$

$$\tau_d = 1.5 \cdot \frac{V_d}{h \cdot b \cdot k_{cr}} = 1.5 \cdot \frac{5.67kN}{10cm \cdot 24cm \cdot 0.5} = 0.071 \frac{kN}{cm^2}$$

Design for bending and compression:

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,d}} = \left(\frac{0.013}{1.45}\right)^2 + \frac{0.67}{1.66} = 0.41 < 1.0$$

Design for shear force:

$$\frac{\tau_d}{f_{v,d}} = \frac{0.071}{0.28} = 0{,}25 < 1.0$$

Beams B2:

$$M = 3.75\frac{kN}{m} \cdot \frac{(4.555m)^2}{8} = 9.73\ kNm$$

$$V = 3.75\frac{kN}{m} \cdot \frac{4.555m}{2} = 8.54\ kN \quad ,where\ V_{g,k} = 3.84kN\ and\ V_{q,k} = 4.85kN$$

$$N = \gamma_Q \cdot w_{on\ long\ side,d} \cdot \frac{h}{2} \cdot b + 0.5 \cdot facadeload = 1.5 \cdot \frac{1.05kN}{m^2} \cdot \frac{3.5m}{2} \cdot \frac{1.75m}{2} + 0.5 \cdot 0.98kN$$
$$= 3.05kN$$

$$A = 12cm \cdot 24cm = 288cm^2;\ W = 1152cm^3$$

$$\sigma_{c,0,d} = \frac{3.05\ kN}{288\ cm^2} = 0.011\frac{kN}{cm^2}$$

$$\sigma_{m,y,d} = \frac{9.73\ kNm}{1152\ cm^3} = 0.845\frac{kN}{cm^2}$$

$$\tau_d = 1.5 \cdot \frac{V_d}{h \cdot b \cdot k_{cr}} = 1.5 \cdot \frac{8.54\ kN}{12cm \cdot 24cm \cdot 0.5} = 0.089\frac{kN}{cm^2}$$

Design for bending and compression:

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,d}} = \left(\frac{0.011}{1.45}\right)^2 + \frac{0.85}{1.66} = 0.52 < 1.0$$

Design for shear force:

$$\frac{\tau_d}{f_{v,d}} = \frac{0.089}{0.28} = 0{,}32 < 1.0$$

For the connections of the roof beams to the pillar the minimum edge distance of the screws will be decisive therefore cross sections are chosen conservatively.

4.2.2.2 Roof – Vertical load transmission – roof area 2

As to be seen in the load assumptions the additional loading on roof area 2 compared to area 1due to solar thermal and wooden construction is $\boldsymbol{q_d = 0.13\,\frac{kN}{m^2}}$

Since the actual area load for profiled sheeting and the counter battens is still less than q_d= 2,2 kN/m² no additional calculation are required here.

i. Design of the rafters:

The static system and the gathering width remain the same:

$$q_d = 2.2\frac{kN}{m^2} + 0.13\frac{kN}{m^2} = 2.33\frac{kN}{m^2}$$

$$q = 2.33\frac{kN}{m^2} \cdot 0.5m = 1.2\frac{kN}{m}$$

$$M_d = 0.46\ kNm; V_d = 1.05\ kN$$

Bearing capacity:

$$\sigma_{m,y,d} = \frac{0{,}46kNm}{45cm^3} = 1.02\frac{kN}{cm^2} < 1.66\frac{kN}{cm^2}$$

Shear stress:

$$\tau_d = 1.5 \cdot \frac{V_d}{h \cdot b \cdot k_{cr}} = 1.5 \cdot \frac{1.05kN}{45\ cm^2 \cdot 0.5} = 0.07\frac{kN}{cm^2} < 0.28\frac{kN}{cm^2}$$

ii. Design of the beams B1:

The static system remains the same; only Position beam1 needs to be recalculated:

$$M = 2.6\frac{kN}{m} \cdot \frac{(4.555m)^2}{8} = 6.74\ kNm$$

$$V = 2.6\frac{kN}{m} \cdot \frac{4.555m}{2} = 5.92kN\ \ , where\ V_{g,k} = 2.66kN\ and\ V_{q,k} = 3.26kN$$

$$\sigma_{c,0,d} = \frac{3.05kN}{240cm^2} = 0.013\frac{kN}{cm^2}$$

$$\sigma_{m,y,d} = \frac{6.65kNm}{960cm^3} = 0.69\frac{kN}{cm^2}$$

$$\tau_d = 1.5 \cdot \frac{V_d}{h \cdot b \cdot k_{cr}} = 1.5 \cdot \frac{5.92kN}{10cm \cdot 24cm \cdot 0.5} = 0.074\frac{kN}{cm^2}$$

Design for bending and compression:

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,d}} = \left(\frac{0.013}{1.45}\right)^2 + \frac{0.69}{1.66} = 0.42 < 1.0$$

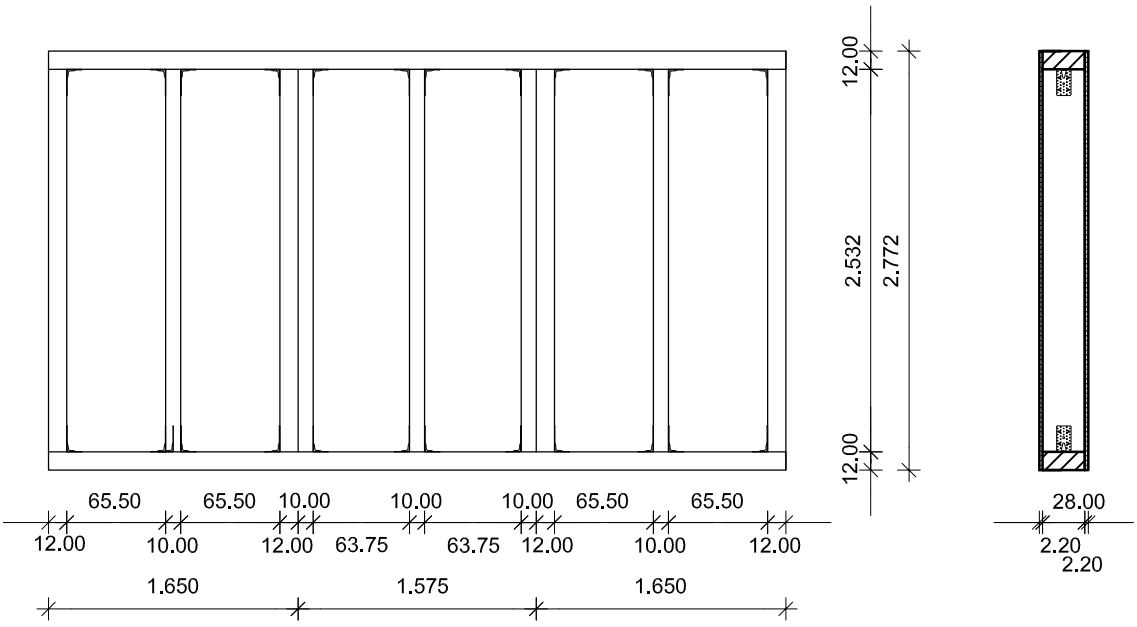
Design for shear force:

$$\frac{\tau_d}{f_{v,d}} = \frac{0.074}{0.28} = 0{,}26 < 1.0$$

4.3 Bracing walls W1/W2

Structural system of one wall, figure 2.

W 1/2



Dimensioning wall, which is a wooden frame made of three modules, and OSB3 planks on one side, calculation sheet. Above the wall in the roof level as well as underneath in the floor construction layer are beams placed and connected to the head respectively bottom rib of the wall. Therefore the horizontal ribs are seen to be continuous

1) geometrics wall W1/W2			
total wall W1/W2	l =	487	cm
	h =	280	cm
	l_{eff} =	280	cm
ribs	$b_{interior}$=	10	cm
	$b_{exterior}$=	12	cm
	h =	28	cm
covering	a_r =	76,6	cm
	t =	2,2	cm
	b_{net} =	65,6	cm

criteria to build the slab as a shear connection according to simplifying methos of EN 1995-1-1:

a_r/t =	34,82	<!	50
h/b =	2,8	<!	4

2) Materials						
NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,9	(NKL2, kurz)			
	k_{mod} (outside)=					
	f_{mk} =	2,4	kN/cm²	f_{md} =	1,66153846	kN/cm²
	f_{vk} =	0,4	kN/cm²	f_{vd} =	0,27692308	kN/cm²
	$f_{c,90k}$ =	0,25	kN/cm²	$f_{c,90,d}$ =	0,17307692	kN/cm²
	$f_{c,0,k}$ =	2,1	kN/cm²	$f_{c,0,d}$ =	1,45384615	kN/cm²
OSB3	γ_M=	1,3		$f_{m,d}=f_{m,k} \cdot k_{mod}/\gamma_M$		
(Scheibe)	k_{mod} =	0,9	(NKL1, kurz)			
	f_{mk} =	0,9	kN/cm²	f_{md} =	0,62307692	kN/cm²
	f_{vk} =	0,68	kN/cm²	f_{vd} =	0,47076923	kN/cm²
	$f_{c,k}$ =	1,48	kN/cm²	$f_{c,90,d}$ =	1,02461538	kN/cm²

2) Designing
a) Design of outer ribs (vertical load transmission)

buckling

$i_x = h/\sqrt{12} =$	8,08		radius of inertia
$\lambda = l_{eff}/i =$	34,64		slimness factor
$k_c =$	0,92		buckling value

vertical force in outer ribs due to horizontal load

$F_{hk} =$	15,40	kN	
$F_{hd} = 1.5*F_{hk} =$	23,10	kN	
$F_{1hc}/t = F_{hd}*h/l =$	13,28	kN	
$g_{k,Wall} =$	3,50	kN/m	selfweight
$LW_{outer\ rib} =$	0,45	m	loadwith exterior rib
$F_{vg,outer\ rib} =$	2,13	KN	force due to selfweight
$LW_{interior\ rib} =$	0,76	m	loadwith exterior rib
$F_{vg,interior\ rib} =$	3,59	KN	force due to selfweight
$N_t = F_{1ht} - F_{vga} =$	11,16	KN	tension force outer rib
$N_{ci} = F_{vg,i} =$	3,59	KN	compression force inner rib
$F_{3hc} = F_{1hc} + F_{vg} =$	15,41	KN	* compression force outer rib
$F_{hc3}/(A_{c3}*k_c*f_{c0d}) =$	0,03	<! 1	

b) design for swell stress of the beam:

$b_{additonal} =$	3	cm
$A_{eff,outer\ rib} =$	420	cm^2
$A_{eff,inner\ rib} =$	448	cm^2
$k_{c,90} =$	1,25	

swell stress due to force of outer rib:

$N_{ca}/(A_{eff}*k_{c,90}*f_{c,90,d}) =$	0,170	<! 1

swell stress due to force of inner rib:

$N_{ci}/(A_{eff}*k_{c,90}*f_{c,90,d}) =$	0,037	<! 1

c) design of covering

c.1) fastener:

$s_{v,0} = F_{hd}/(l*n) =$	0,05	kN/cm	shear force on fasteners
a =	7,50	cm	chosen distance fasteners
$F_{vd,Na} = s_{v,0}*a =$	0,36	kN	shear force on each fastener
$F_{v,Rk} =$	0,774	kN	cab. cleaving force of clamps clamps d=1,5mm (SBT ch. 9.54)
$F_{v,Rd} = k_{mod}*F_{v,Rk}/\gamma_m =$	0,54	kN	>! $F_{vd,Na}$

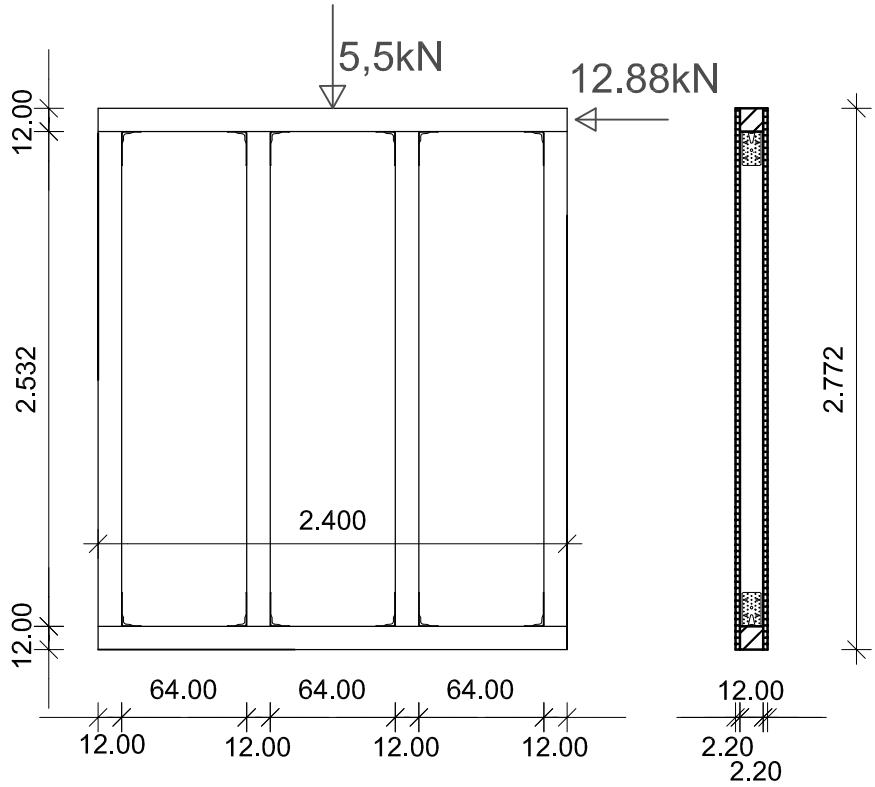
c. 2) covering:

$K = 35*t/b_{net} =$	1,17		reduction factor
$\tau_d = F_{vd}/(a*t) =$	0,02	kN/cm^2	shear force
$k_{1v} =$	1,00		unslotted cover
$k_{2v} =$	0,33		covering just one side
$\tau_d/(k_{1v}*k_{2v}*K*f_{vd}) =$	0,12	<! 1	

d) connection between the wall modules

Since the horizontal ribs at the top and at the bottom of the wall are continous and all shear loads will be taken by the enitre covering, the connection between the inner ribs of the wall are just positive/constructional (rein konstruktiv).

4.4 Bracing wall W3



Although the beam B4 over wall W3 in axis E is not supposed to put loads on the wall in vertical direction, a smeared load due to loads on beam in axis E will be applied on wall W3 in vertical direction.

Load width of the smeared load is assumed to be half of the length of the beam 4.555m/2:

$F_{vertical,d} = \frac{4.555m}{2} \cdot 2.437 \frac{kN}{m} = 5.5kN$

This load will be applied on the length of wall W3 as a constant line load.

$F_{vertical,smeared\ load,d} = \frac{5.5kN}{2.4m} = 2.3 \frac{kN}{m}$

$F_{horizontal,d} = 12.88kN$

1) geometrics wall W3

total wall W3	l =	260	cm
	h =	280	cm
	l_{eff} =	280	cm
ribs	$b_{interior}$=	12	cm
	$b_{exterior}$=	12	cm
	h =	12	cm
covering	a_r =	62,5	cm
	t =	2,2	cm
	b_{net} =	102	cm

criteria to build the slab as a shear connection according to simplifying methos of EN 1995-1-1:

a_r/t =	28,41	<!	50
h/b =	1,00	<!	4

2) Materials

NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,9	(NKL2, kurz)			
	k_{mod} (outside)=					
	f_{mk} =	2,4	kN/cm^2	f_{md} =	1,66	kN/cm^2
	f_{vk} =	0,4	kN/cm^2	f_{vd} =	0,28	kN/cm^2
	$f_{c,90k}$ =	0,25	kN/cm^2	$f_{c,90,d}$ =	0,17	kN/cm^2
	$f_{c,0,k}$ =	2,1	kN/cm^2	$f_{c,0,d}$ =	1,45	kN/cm^2
OSB3	γ_M=	1,3		$f_{m,d}=f_{m,k} \cdot k_{mod}/\gamma_M$		
(Scheibe)	k_{mod} =	0,9	(NKL1, kurz)			
	f_{mk} =	0,9	kN/cm^2	f_{md} =	0,62	kN/cm^2
	f_{vk} =	0,68	kN/cm^2	f_{vd} =	0,47	kN/cm^2
	$f_{c,k}$ =	1,48	kN/cm^2	$f_{c,90,d}$ =	1,02	kN/cm^2

2) Designing
a) Design of outer ribs (vertical load transmission)

buckling

$i_x = h/\sqrt{12} =$	3,46		radius of inertia
$\lambda = l_{eff}/i =$	80,83		slimness factor
$k_c =$	0,67		buckling value

vertical force in outer ribs due to horizontal load

$F_{hk} =$	8,59	kN	
$F_{hd} = 1.5*F_{hk} =$	12,88	kN	
$F_{1hc/t} = F_{hd}*h/l =$	13,87	kN	
$g_{k,Wall} =$	1,10	kN/m	selfweight
$g_{k,smeared\ load} =$	2,30	kN/m	smeared load
$LW_{outer\ rib} =$	0,63	m	loadwith exterior rib
$F_{vg,outer\ rib} =$	2,89	KN	force due to selfweight
$LW_{inner\ rib} =$	1,14	m	loadwith exterior rib
$F_{vg,inner\ rib} =$	1,69	KN	force due to selfweight
$N_t = F_{1ht} - F_{vga} =$	10,98	KN	tension force outer rib
$N_{ci} = F_{vg,i} =$	1,69	KN	compression force inner rib
$F_{3hc} = F_{1hc} + F_{vg} =$	16,76	KN	* compression force outer rib
$F_{hc3}/(A_{c3}*k_c*f_{c0d}) =$	0,12	<! 1	

b) design for swell stress of the beam:

$b_{additonal} =$	3	cm	
$A_{eff,outer\ rib} =$	180	cm^2	
$A_{eff,inner\ rib} =$	216	cm^2	
$k_{c,90} =$	1,25		

swell stress due to force of outer rib:

$N_{ca}/(A_{eff}*k_{c,90}*f_{c,90,d}) =$	0,430	<! 1

swell stress due to force of inner rib:

$N_{ci}/(A_{eff}*k_{c,90}*f_{c,90,d}) =$	0,036	<! 1

c) design of covering

c.1) fastener:

$s_{v,0} = F_{hd}/(l*n) =$	0,02	kN/cm	shear force on fasteners
$a =$	10,00	cm	chosen distance fasteners
$F_{vd,Na} = s_{v,0}*a =$	0,25	kN	shear force on each fastener
$F_{v,Rk} =$	0,774	kN	cab. cleaving force of clamps clamps d=1,8mm (SBT ch. 9.5
$F_{v,Rd} = k_{mod}*F_{v,Rk}/\gamma_m =$	0,54	kN	>! $F_{vd,Na}$

c. 2) covering:

$K = 35*t/b_{net} =$	0,75		reduction factor
$\tau_d = F_{vd}/(a*t) =$	0,01	kN/cm^2	shear force
$k_{1v} =$	1,00		unslotted cover
$k_{2v} =$	0,33		covering on both sides
$\tau_d/(k_{1v}*k_{2v}*K*f_{vd}) =$	0,10	<! 1	

4.5 Façade and pillars

1) Facade

As mentioned in the load assumptions we have been to some design stages of the façade during the last year. Finally an exterior company called “BeLuTec” in cooperation with us has done the structural design.

It’s their responsibility to ensure the structural feasibility of the facades framework and the connection to the pillar. To see the effort we put in finding a suitable solution in the moveable façade’s design can be seen in former deliverables. Attached you can find the most lately assumptions and calculations we did completely ourselves in April 2014 (deliverable #5). The current design state is the outcome of our own work mixed with the experience of a unique company that is specialized for these very solutions.

The most significant values of the façade from “BeLuTec” can be seen in the figure below:

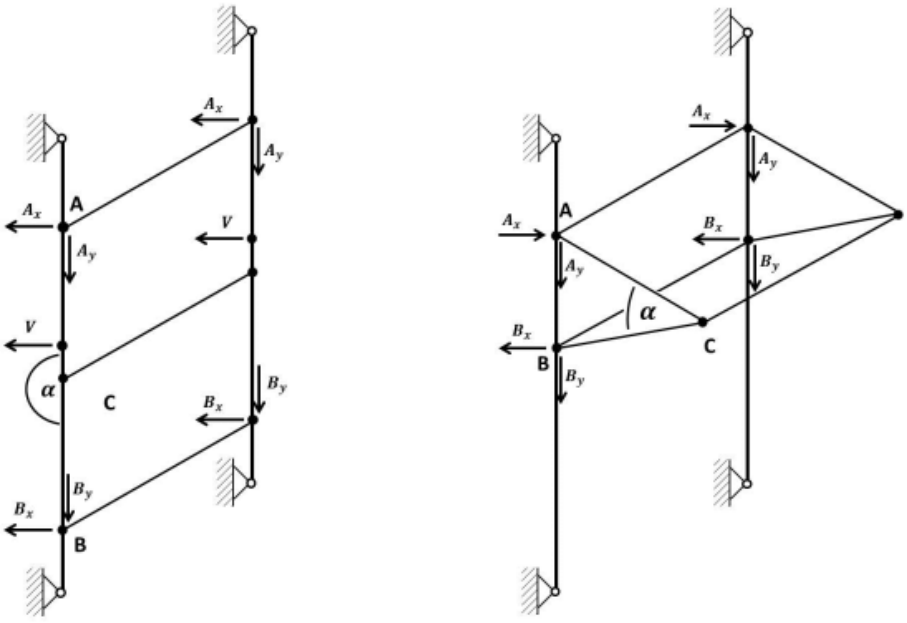
Uni Berlin2

Parameter

Windlasten [kN/m²]
Aufwind: -0,9237
Abwind: 0,3113
Frontal: -0,835
kritischer Öffnungswinkel: 24 ° (0,411457 Rad)
Höhe: 3150
Breite: 1690
Beplankungsgewicht: 49 kg/m²
Durchgangshöhe: 2460

Auflagerkräfte

	Ax [kN]	Ay [kN]	Bx [kN]	By [kN]	V [kN]
Belastungsfälle bei geöffnetem Faltladen					
ohne Windlast	1,67	0,7	1,67	0,69	0
Aufwind	0,18	0,38	0,42	0,77	0
Abwind	2,09	1	2,17	0,79	0
Belastungsfall bei geschlossenem Faltladen					
Frontalwind	0,43	1,39	-0,56	0	1,23



geschlossener Faltladen geöffneter Faltladen

figure 26: facade's calcualtion sheet by "BeLuTec", significantreaction forces

The most critical opening position of the façade is if the façade is fully opened (critical opening window 24°). The lower hinge of the element is at a height of 246 cm from the top edge of the

finished floor construction (reaction force Bx), the highest point of the façade is at 315 cm from the same point (reaction force Ax). As you can see in our drawings the connection of the façade to the pillar, that indicates the upper support of the pillar itself, is placed in between those two points.
So now a flank moment is introduced at the head of the pillar. The pillar needs to withstand this moment force.
Similar to a bowstring bridge horizontal compression (Bx) and tension forces (Ax) will be shorted in the frame construction and connections of the façade itself.

$$h = 3.15m; h_1 = 2.46m; e = h - h_1 = 0.69m$$

$$M_{flank\ moment\ of\ facade} = A_x * \frac{e}{2} + B_x * \frac{e}{2} = \underbrace{2.09kN * \frac{0.69m}{2}}_{tension\ force\ on\ upper\ hinge} + \underbrace{2.17kN * \frac{0.69m}{2}}_{compression\ force\ on\ actuator}$$

$$= 1.47kNm$$

$$M_{on\ \text{each}\ pillar} = 2 * 1.47kNm = 2.94kNm$$

To hold the pillar in position the roof/bracing needs to support the column. This additional supporting force will be introduced in the pillar as a shear force, so that the moment force in the pillar is 0 at its bottom. In the meantime that additional force needs to be considered for bracing.

$$V_{in\ \ Pillar,resp.supportingforce\ roof} = \frac{M_{on\ \text{each}\ pillar}}{length\ of\ pillar} = \frac{2.94kNm}{3m} = 0.98kN$$

2) Dimensioning of one pillar, position P1

a) System

The pillar is designed as a swing arm that is fixed with a joint connection to the foundation and horizontally held by the roof. In order to dimension the element, the dead loads of the panel and the pillar, the roof loads and the wind pressure as well as wind suction (as surveyed in chapter above) have to be considered.

For the calculation with R-Stab the system is modeled in the following way. At the base of the vertical pillar (beam 1-2) is a fixed hinge and in a height of 3.05 m horizontally held by a slide bearing that is vertically free in its movement and resembling the connection to the roof structure. The rest of the beams resemble the panel structure in its opened position, which is linked flexible to the pillar.

Pillars of position P2 won't be considered since the design of P1 is more critical.

2) Material information and cross section

The pillar is designed of pinewood C24, the class of use is NKL 3 since the structure is open and not protected of the weather and the KLED is short due to wind forces. Therefore the following intensity factors have to be considered:

$$\boldsymbol{k_{mod} = 0.7;\ y_m = 1.3}$$

The rest of the modeled structure in R-Stab is not taken into consideration since the panel is designed separately. For the calculation its dead weight is only considered in the external panel load, not in the model itself.

The cross section of the pillar resembles a rectangle with a dimension of 16x20 cm.

3) Loads

a)loads of the roof:

Vertical support of one beam (Pos. B2-B8) $V_{g,k}$= 2.56kN; $V_{q,k}$= 3.11kN

b) Vertical reaction forces of the façade according to ***figure 26: facade's calcualtion sheet by "BeLuTec", significantreaction forces***:

$$N_{pillar,own\ weight\ facade,char.} = \frac{\underbrace{2 * (0.7 + 0.69)kN}_{vertical\ load\ due\ to\ facade}}{\underbrace{1.35}_{\gamma_m}} = 2.06kN$$

$$N_{pillar,\text{pushing wind on } facade,char.} = \frac{\underbrace{2 * \big((1.0 - 0.7) + (0.79 - 0.69)\big)kN}_{vertical\ load\ due\ to\ facade}}{\underbrace{1.5}_{\gamma_m}} = 0.53kN$$

$$N_{pillar,\text{lifting wind on } facade,char.} = \frac{\underbrace{2 * \big((0{,}38 - 0.7) + (-0{,}77 - 0.69)\big)kN}_{vertical\ load\ due\ to\ facade}}{\underbrace{1.5}_{\gamma_m}} = -2.37kN$$

Most critical load case for the pillar is the open façade, while the sliding door façade is closed.

Overview of characteristic loadings:

$$N_{pillar,g,k} = \underbrace{2 * 2.56kN}_{roof} + \underbrace{2.06kN}_{vertical\ load\ due\ to\ facade} + \underbrace{0.39kN}_{EG\ pillar} = 7.57kN$$

$$N_{pillar,q,k,snow} = \underbrace{2 * 3.11kN}_{roof} = 6.22kN$$

$$N_{pillar,q,k,wind} = \underbrace{0.16N}_{roof} + \underbrace{2 * 0.53kN}_{vertical\ load\ due\ to\ facade} = 1.22kN$$

$$M_{on\ pillar,g,k,facade} = 2 * 0.85Nm = 1.7kNm$$
$$V_{on\ pillar,g,k,facade} = 0.57kN$$

$$M_{on\ pillar,g,k,facade} = 2 * 0.215\text{k}Nm = 0.43kNm$$
$$V_{on\ pillar,g,k,facade} = 0.14kN$$

5) Design

load combinations:

Load combination 1 (wind pressure, significant):

$$E_{d,wp} = 1.35 \cdot g_k + 1.5 \cdot q_{w,k} + +1.5 \cdot 0.5 \cdot s_k$$

Load combination 4 (deformation combination):

$$E_{d,d} = 1.0 \cdot \sum g_k + 1.0 \cdot \sum w_{p,k} + 0.5 \cdot \sum s_k$$

The following chart is giving an overview of the used parameters for the analysis. The used calculations are based on the normative of the DIN EN 1995-1-1 and the national appendix DIN EN 1995-1-1/NA.

Design for bending and compression (only M_y moments):

$$\frac{\sigma_{c,o,d}}{k_{c,y} \cdot f_{c,o,d}} + \frac{\sigma_{m,y,d}}{k_{crit} \cdot k_h \cdot f_{m,y,d}} \leq 1$$

Design for shear force:

results of the dimensioning:

cross section		resistance		stress resultants, bearing in connection	
b_o [cm]	20.00	y_m	1.30	N_{max} [kN]	16.72
b_u [cm]	20.00	NKL	3	$\sigma_{c,0,d}$ [kN/cm2]	0.062
b_m [cm]	20.00	KLED	kurz	$M_{y,max}$ [kNcm]	294
h/ $h_{h\text{-}cut\ out}$[cm]	16 / 15	k_{mod}	0.70	$\sigma_{m,0,d}$ [kN/cm2]	0.4
A/$A_{netto\ assumed}$ [cm2]	320/270	$f_{m,k}$ [kN/cm2]	2.40	V_{max} [kN]	0.98
W_y [cm3]	853.33 / 750	$f_{m,d}$ [kN/cm2]	1.29	τ_d	0.049
beta	1.00	fc,0,k [kN/cm2]	2.10	Design for Bending and Compression	
L [cm]	305.00	fc,0,d [kN/cm2]	1.13	Compression	0.06
lef [cm]	305.00	fv,k	0.40	Bending	0.31
iy [cm]	4.62	fv,d	0.22	Result !< 1.0	0.37
lambda	66.03			Design for shear force	
kcy	0.60			result	0.27
lef*h/(b^2)	12.20				
kcrit	1.00			Deformation	
kh (<1.3)	0.99			winst,max < l/300 [mm]	10.17
Kcr	0.92			W in ULS [mm]	4.3

4.6 Floor

Description:

The floor construction will be designed as a supporting grid. All pillars and every wall module will be attached to it. The floor construction itself is divided into modules of a width of 1.75m and a length equal to the width of the building itself (see position plan floor: modules FM1-FM8).

Each module is punctually supported by four point fundaments, whereas the supports are offset by 45cm from the outer edge of the modules to reduce the deflection in the middle of the modules. Thus the pushing forces of the pillars acting on the edge of the modules balance the stresses of the modules due to self-weight and live loads.

4.6.1 Floor Beam FB 1

Global dimensioning of floor plates, position floor beam 1 (FB1)

1) System

beam on two supports with cantilever arms on both sides

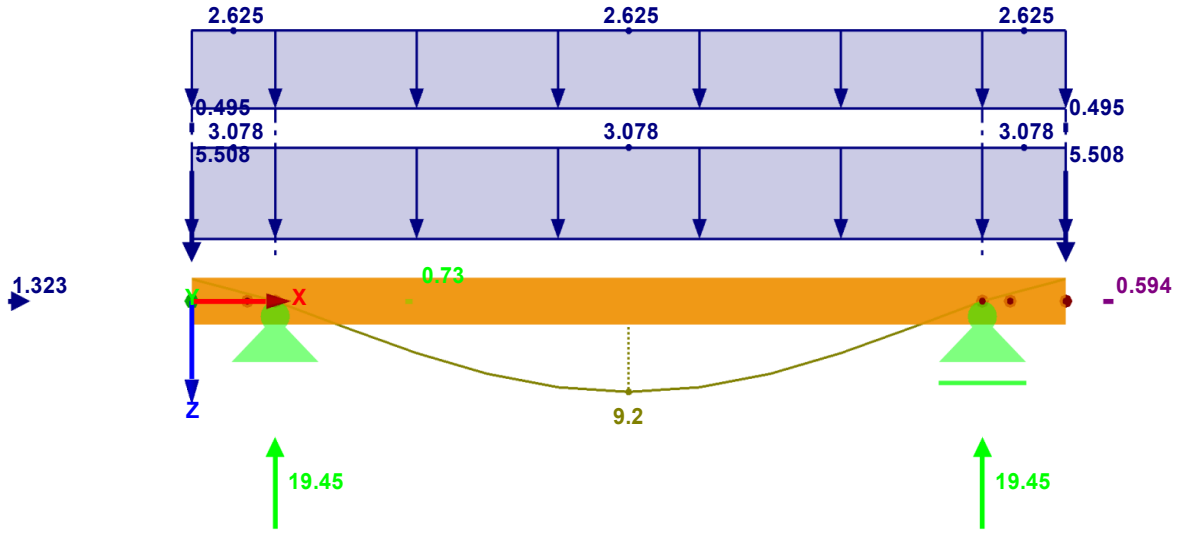
2) loading

own weight and live loads, special situation in core module and loads of the pilars

load widht= 0,875 m

selfweight:		g_k = 2,6 KN/m^2 * 0,875m =	2,28 KN/m
liveload:		q_k = 1,5 KN/m^2 * 0,875m =	1,31 KN/m
(explanation se chapt. 2.4)		q_k = 2,0 KN/m^2 * 0,875m =	1,75 KN/m
due to walls			
due to pillar (half of the load):		N,g,k=	4,08 kN
	(snow)	N,q,k=	3,11 kN
	(wind)	N,q,k=	0,55 kN
		H,g,d=0,98kN/2	0,54 kN
	(wind)	H,q,k= 1,05kN/m^2*1,6m* 0,875m	1,47 kN

significant load case: live load as variable load 1



3) cross section

NH C24

γ_M =	1,3		$f_{m,d}=f_{m,k}\cdot k_{mod}/\gamma_M$		
k_{mod} =	0,9	(NKL1, kurz)			
f_{mk} =	2,4	KN/cm^2	f_{md} =	1,66	
f_{vk} =	0,4	KN/cm^2	f_{vd} =	0,28	
$f_{c,90k}$ =	0,25	KN/cm^2	$f_{c,90,d}$ =	0,17	

b =	12	cm
h =	24	cm
A =	288	cm^2
$W_y=b\cdot h^2/6$ =	1152	cm^3
k_h =	1,000	

4) design for bending

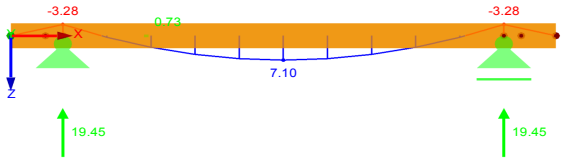
one-axial bending:

bending stress design: $M_{max,1}/W_y \leq kh*f_{m,d}$

$M_{max,Stütz}$	-380	KNcm
$M_{max,Feld}$	710	KNcm

Nachweis:

$M_{max,1}/(k_h*W_y*f_{m,d})$=	0,371	≤	1,0



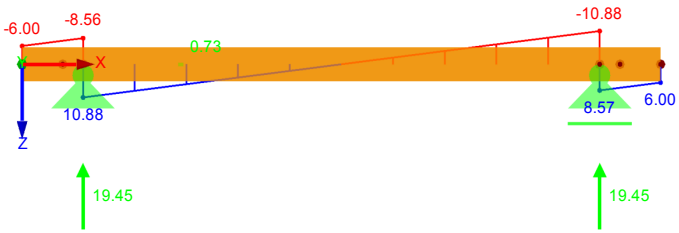
5) design for shear force:

shear force stresses: $1,5*V_d/(k_{cr}*A_n)$

V_{max} =	10,88	KN
k_{cr} =	0,5	

design

$1,5*V_d/(k_{cr}*A_n*f_{vd})$ =	0,409	≤	1



6) swell stress of the beam above supports

N_{90} =	20,63	KN
ü =	3	cm
$l_{Auflager}$ =	20	cm
A_{ef} =	276	cm^2
l_1 >	2h	
$k_{c,90}$ =	1	

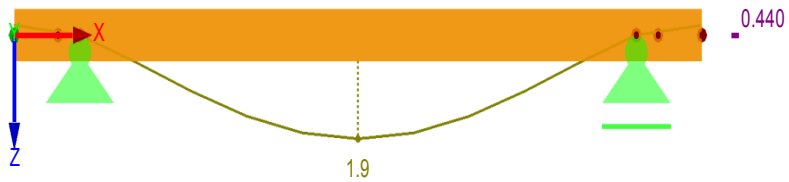
design:

$N_{90,d}/(A_{ef}*k_{c,90}*f_{c,90,d})$ = 0,432 ≤ 1,0

7) deflection

$E_{0,mean}$ =	1100	KN/cm^2		
I=	13824	cm^4		
L=	365,5	cm		
k_{def}=	0,8	(NKL2, VH)		
y_2=	0,3	(use load cat. B)		
$w_{inst,G}$	1,900	mm	w_0=	0 mm
$w_{inst,Q}$	3,200	mm		

$w_{creep\ G}=k_{def}\cdot w_{inst,G}$=	1,520	mm
$w_{creep,Q}=y_2\cdot k_{def}\cdot w_{inst,Q}$=	0,768	mm
$w_{fin,G}=w_{inst,G}+w_{creep,G}$=	3,420	mm
$w_{fin,Q}=w_{inst,Q}+w_{creep,Q}$=	3,968	mm
$w_{fin}=w_{fin,G}+w_{fin,Q}$=	7,388	mm



8) Design for deflection:

design sitautions of deflection

1a:

$w_{inst,Q} \leq L_1/300$

$w_{inst,Q}$=	3,200	≤	12,183	= $L_1/300$

26,265 % degree of capacity

1b:

$w_{creep,G} + w_{fin,Q} \leq L_1/200$

$w_{creep,G} + w_{fin,Q}$=	5,488	≤	18,275	= $L_1/200$

30,030 % degree of capacity

2) final deflection

$w_{fin} - w_0 \leq L_1/200$

$w_{fin} - w_0$=	7,388	≤	18,275	= $L_1/200$

40,427 % degree of capacity

9) vibration

deflection w of permanent and quasi-permanet deflection in cm

w= 1,2876 cm

f_1= 5/(0,8*w)^0,5

f_1= 4,93 < 8Hz

4.6.2 Floor Beam FB 2

Global dimensioning of floor plates, position floor beam 2 (FB2):

½ of loads of pillar P2:

$$\mathbf{0,5 * N_{P2;g,k} = 0.5 * loads\ of\ facade_{P1} + loads\ of\ roof_{B1} - g_{k,difference\ of\ pillar}}$$

$$\mathbf{0,5 * N_{P2;g,k} = 0.5 * 2.26kN + 3.84kN - 0.02m * 0.16m * 3.07m * \frac{4.6kN}{m^3} = 4.92kN}$$

$$\mathbf{0,5 * N_{P2;q,k(wind,on\ facade)} = 0.5 * 0.83kN = 0.415kN}$$

$$\mathbf{0,5 * N_{P2;q,k(snow)} = 3.26\frac{kN}{2} = 1,63kN}$$

loads of outer rib of wall W1.

$$\mathbf{F_{1,h,c} = 15.15kN\ ;\ F_{1,h,t} = 10.9kN}$$

1) System *Position: FB2*

beam on two supports with cantilever arms on both sides

2) loading

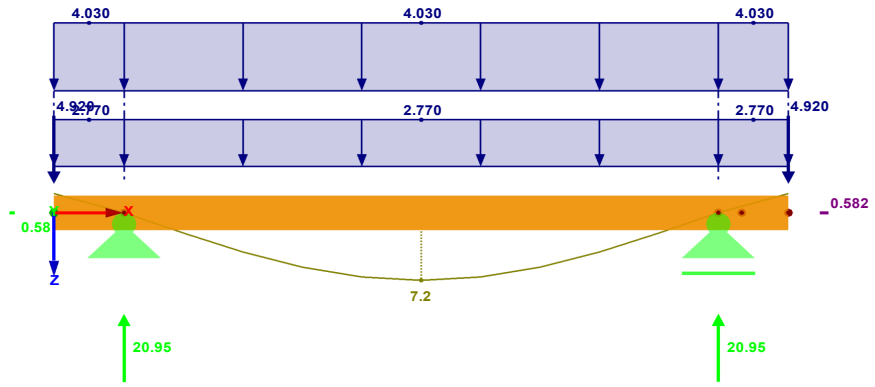
own weight and live loads and influence of bracing wall1

load width= 1,065 m

selfweight:		g_k = 2,6 KN/m^2 * 1,065m =	2,77 KN/m
liveload:		q_k = 1,5 KN/m^2 * (1,065-0.43)m =	0,95 KN/m
(explanation se chapt. 2.4)		q_k = 2,0 KN/m^2 * (1,065-0,43)m =	1,27 KN/m
due to walls		$g_{k,w1}$ =	4,03 kN/m
compression force of outer rib W1		Fc=15,15/1,5	10,10 kN
tension force of outer rib W1		Ft=10,9/1,5	7,27 kN
due to pillar P2		N,g=	4,92 kN
	(snow)	N,q= 3,26kN/2	2,78 kN
		H,g,d=0,88kN/2 * 1,2	0,528 kN
	(wind)	H,q,k= 1,05kN/m^2*1,6m* 0,875m	2,80 kN

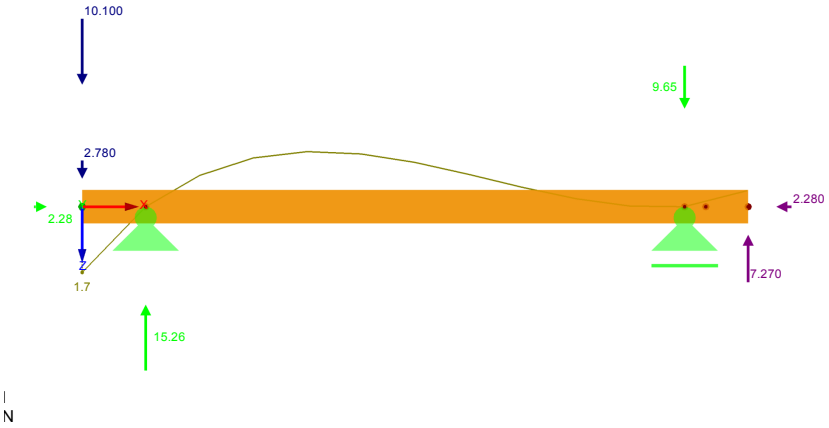
significant load case: wind load as variable 1

characteristic self weight

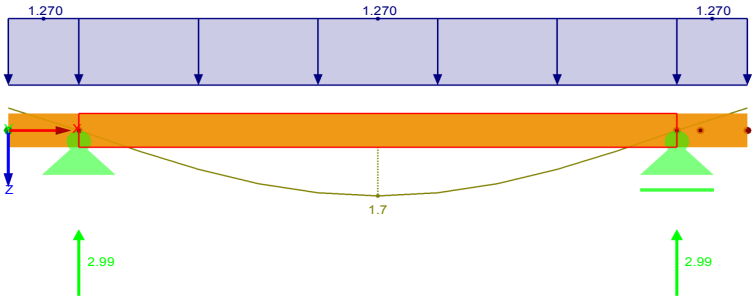


ım]
ı: 65.00
: -0.58 kN
Z': 20.95 kN

characteristic wind loads



characteristic live loads



3) cross section

NH C24	γ_M=	1,3		$f_{m,d}=f_{m,k}\cdot k_{mod}/\gamma_M$	
	k_{mod} =	0,9	(NKL1, kurz)		
	f_{mk} =	2,4	KN/cm^2	f_{md} =	1,66
	f_{vk} =	0,4	KN/cm^2	f_{vd} =	0,28
	$f_{c,90k}$ =	0,25	KN/cm^2	$f_{c,90,d}$ =	0,17
	b =	18	cm		
	h =	24	cm		
	A =	432	cm^2		
	$W_y=b\cdot h^2/6$ =	1728	cm^3		
	k_h =	1,000			

4) design for bending

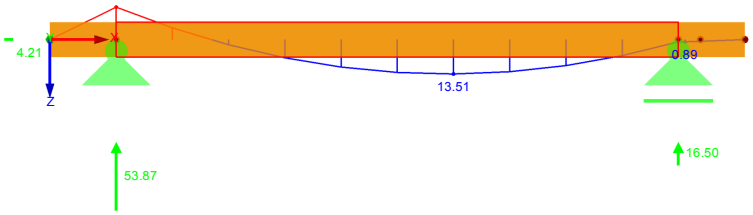
one-axial bending:

bending stress design: $M_{max,1}/W_y \leq kh*f_{m,d}$

$M_{max,Stütz}$	-1273	KNcm
$M_{max,Feld}$	1351	KNcm
N_{max}	3,42	kN - very small no influence!

Nachweis:

$M_{max,1}/(k_h*W_y*f_{m,d})=$ 0,471 ≤ 1,0



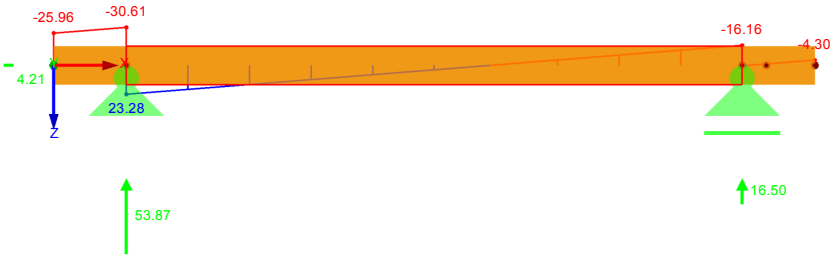
5) design for shear force:

shear force stresses: $1,5*V_d/(k_{cr}*A_n)$

V_{max} =	30,61	KN
k_{cr} =	0,5	
An=	388,8	

design

$1,5*V_d/(k_{cr}*A_n*f_{vd})$ = 0,853 ≤ 1



6) swell stress of the beam above supports

N_{90} =	65,2	KN
ü =	3	cm
$l_{Auflager}$ =	22	cm
A_{ef} =	400	cm^2
l_1 >	2h	
$k_{c,90}$ =	1	

design:

$N_{90,d}/(A_{ef}*k_{c,90}*f_{c,90,d})$ = 0,942 ≤ 1,0

7) deflection

$E_{0,mean}$=	1100	KN/cm^2		
I=	20736	cm^4		
L=	365,5	cm		
k_{def}=	0,8	(NKL2, VH)		
y_2=	0,3	(use load cat. B)		
$w_{inst,G}$	7,200	mm	w_0=	0 mm
$w_{inst,Q}$	1,700	mm		

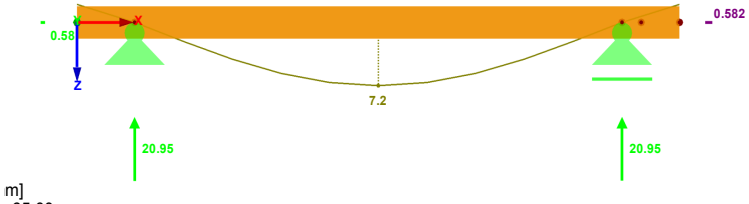
$w_{creep\ G}=k_{def}\cdot w_{inst,G}$= 5,760 mm

$w_{creep,Q}=y_2\cdot k_{def}\cdot w_{inst,Q}$= 0,408 mm

$w_{fin,G}=w_{inst,G}+w_{creep,G}$= 12,960 mm

$w_{fin,Q}=w_{inst,Q}+w_{creep,Q}$= 2,108 mm

$w_{fin}=w_{fin,G}+w_{fin,Q}$= 15,068 mm



m]
: 65.00
: -0.58 kN

8) Design for deflection:

design sitautions of deflection

1a:

$w_{inst,Q}\leq L_1/300$

$w_{inst,Q}$= 1,700 ≤ 12,183 = $L_1/300$

13,953 % degree of capacity

1b:

$w_{creep,G}+w_{fin,Q}\leq L_1/200$

$w_{creep,G}+w_{fin,Q}$= 7,868 ≤ 18,275 = $L_1/200$

43,053 % degree of capacity

2) final deflection

$w_{fin}-w_0\leq L_1/200$

$w_{fin}-w_0$= 15,068 ≤ 18,275 = $L_1/200$

82,451 % degree of capacity

9) vibration

deflection w of permanent and quasi-permanet deflection in cm

w= 2,2936 cm

f_1 = 5/(0,8*w)^0,5

f_1 = 3,69 < 8Hz

4.6.3 Design of OSB covering

1) System

continous girder (6 fields) in longitutional direction of each module

2) loading

	load width=	1	m
selfweight=	g_k =	1	KN/m
	q_k =	1,50	KN/m

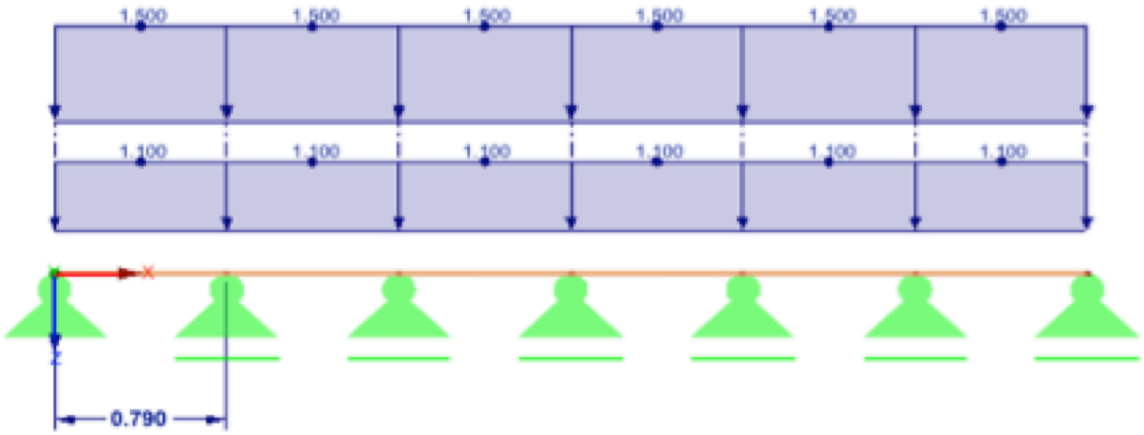
2) cross section

the upper covering is designed as a 22mm thick OSB-plate. The equivalent static system of the design is a continous girder with a load width of 1m

OSB3-plate

γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$	
kmod =	0,9	(NKL1, kurz)		
fmk =	1,48	KN/cm²	fmd =	1,02
fvk =	0,1	KN/cm²	fvd =	0,07
fc,90k =	0,25	KN/cm²	fc,90,d =	0,17

b =	100	cm
h =	2,2	cm
A =	220	cm²
$W_v=b \cdot h^2/6$ =	80,67	cm³



4) design for bending

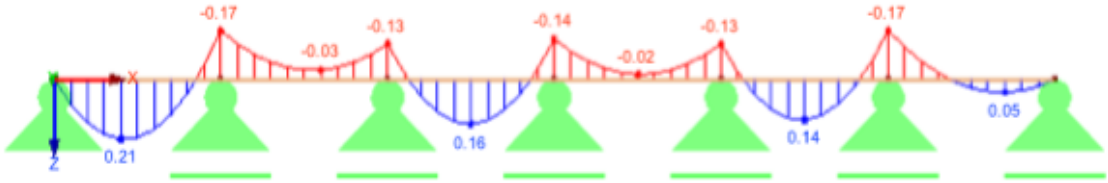
one-axial bending:
bending stress design: $M_{max,1}/W_v \leq kh*f_{m,d}$

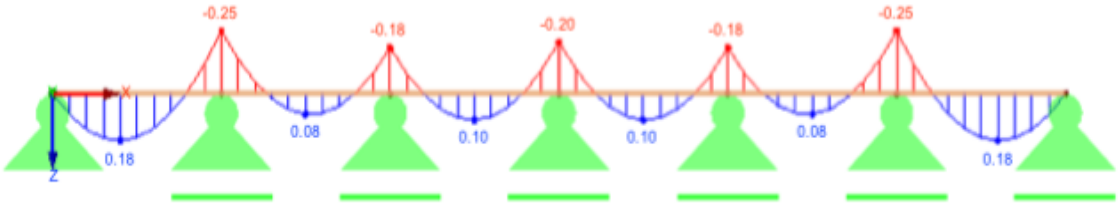
$M_{max,stütz}$	-25	KNcm
$M_{max,Feld}$	21	KNcm

Nachweis:

$M_{max,1}/(W_y*f_{m,d})$ =	0,318	≤	1,000

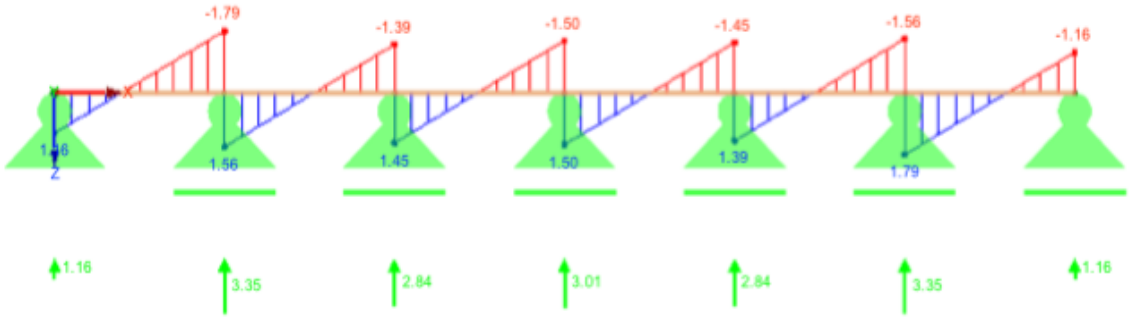
Figure 3.





5) design for shear force

shear force stresses		$\tau_d = 1{,}5*V_d/A_n$	
shear force:	V_{max} =	1,79	KN
design $1{,}5*V_d/(A_n*f_{vd})$ =		0,18	



6) deflection

$E_{0,mean}$ =	493	KN/cm^2		
I =	88,733333	cm^4		
L =	79	cm		
k_{def} =	1,5	(NKL2, VH)		
y_2 =	0,3	(Nutzlast Kat. B)		
$w_{inst,G}$ =	0,800	mm	w_0=	0 mm
$w_{inst,Q}$ =	1,000	mm		

Figure 4.

$w_{creep,G}=k_{def}\cdot w_{inst,G}=$	1,200 mm
$w_{creep,Q}=y_2\cdot k_{def}\cdot w_{inst,Q}=$	0,450 mm
$w_{fin,G}=w_{inst,G}+w_{creep,G}=$	2,000 mm
$w_{fin,Q}=w_{inst,Q}+w_{creep,Q}=$	1,450 mm
$w_{fin}=w_{fin,G}+w_{fin,Q}=$	3,450 mm



7) design for deflection

design sitautions of deflection

1a:

$w_{inst,Q} \leq L_1/300$

$w_{inst,Q}=$	1,000 ≤	2,633 =	$L_1/300$
	37,975 % degree of capacity		

1b:

$w_{creep,G}+w_{fin,Q} \leq L_1/200$

$w_{creep,G}+w_{fin,Q}=$	2,650 ≤	3,95 =	$L_1/200$
	67,089 % degree of capacity		

2: final deflection

$w_{fin}-w_0 \leq L_1/200$

$w_{fin}-w_0=$	3,450 ≤	3,95 =	$L_1/200$
	87,342 % degree of capacity		

4.7 Core Module

Since the technical room and the kitchen will be transported as one part including most of the technical devices, the floor modules in the middle need to be separated differently, as to be seen in the position plan floor.

Floor module FM 4 will be the base of the technical core module. Two states will be considered: situation in usage and transportation. For transportation the loads will be less, since all water storages won't be filled before they are in use on side, yet other support conditions will be decisive.

Situation in usage:

The Eternit plate doesn't need to be designed in particular it's basically placed on the covering of the floor. However it is considered to withstand the high point compression forces and helps to distribute the point loads.

4.7.1 Floor Rafter FR2

The Rafters of floor module 4 are placed according to the heavy technical devices shown in the load assumptions. Floor Rafter FR1, FR2, FR3 will take the loads of the heat pump and buffer storage.

The most critical rafter will be designed here:

Position FR2: load width =1.2m; l=1.4m

1) System				*Position: FR2*
beam on two supports				
2) loading				
own weight and live loads, special situation in core module				
own weight	area load - gk	3	kN/m^2	
half the weight of heat pump	point load - Gk	3,3	kN/m	acting in the middle of the beam
liveload	area load - pk	1	kN/m^2	
	load width=	0,76	m	
	line load qd=	4,18	kN/m	

3) cross section

b =	8	cm
h =	24	cm
A =	192	cm^2
$W_y=b \cdot h^2/6$ =	768	cm^3
k_h =	1,000	

4) design for bending

one-axial bending:

bending stress design: $M_{max,1}/W_y \leq kh*f_{m,d}$

M_{max} 258 KNcm

$M_{max,1}/(k_h*W_y*f_{m,d})$= 0,202 ≤ 1,0

5) design for shear force:

shear force stresses: $1,5*V_d/(k_{cr}*A_n)$

V_{max} =	6,27	KN	here point load considered to act
k_{cr} =	0,5		at 3/4 of the length
An=	180	cm^2	

design

$1,5*V_d/(k_{cr}*A_n*f_{vd})$ = 0,377 ≤ 1

4.7.2 Floor Beam 3

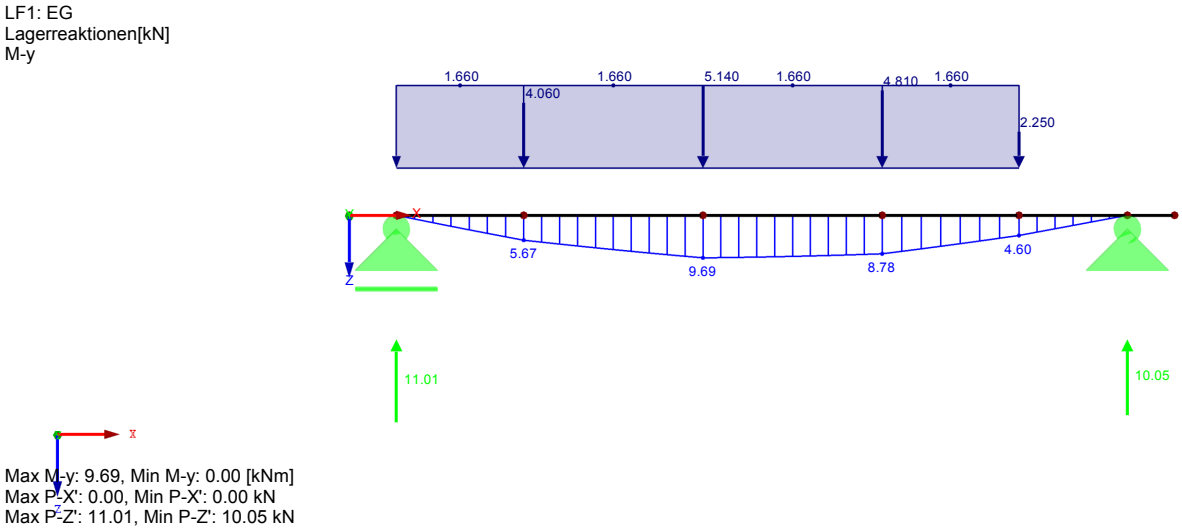
1) System *Position: FB3*

beam on two supports

2) loading

V,FR1= 4,06kN	b= 0,72m qd=3,96kN/m; Fk=2,58kN
V,FR2= 5,14kN	b= 0,76m qd=4,18kN/m; Fk=3,3kN
V,FR3= 4,81kN	b= 0,67m qd=3,69kN; Fk=3,3kN
V,FR4= 2,25kN	b= 0,63m qd=2,55+1,34+0,6kN/m

g,k (Eternit)=1,66kN/m^2



3) cross section

b =	12	cm
h =	24	cm
A =	288	cm^2
$W_y=b \cdot h^2/6$ =	1152	cm^3
k_h =	1,000	

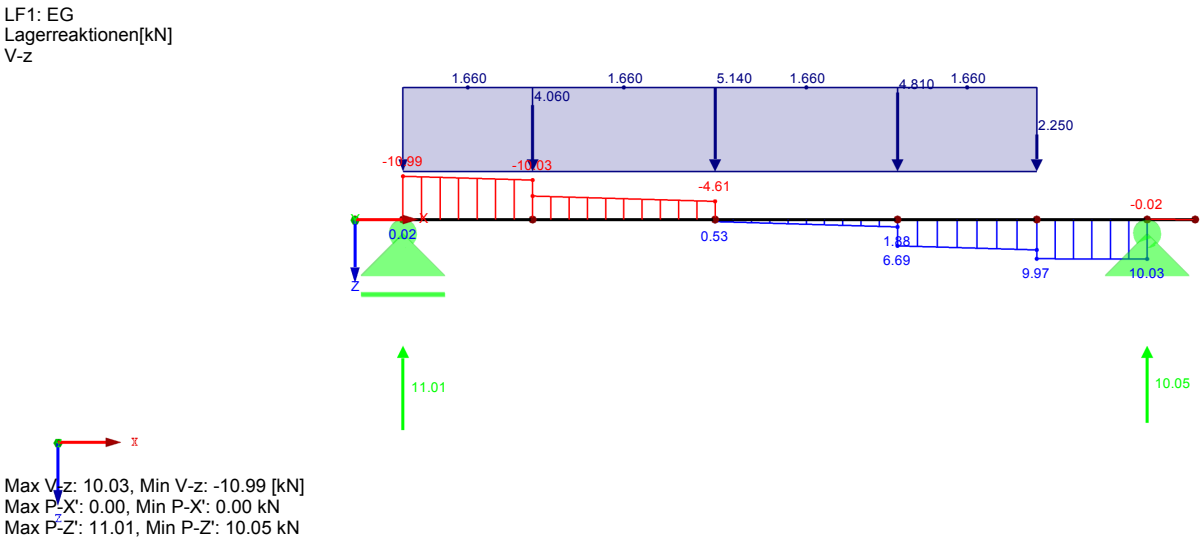
4) design for bending

one-axial bending:

bending stress design: $M_{max,1}/W_y \leq kh*f_{m,d}$

M_{max} 969 KNcm

$M_{max,1}/(k_h*W_y*f_{m,d})$= 0,506 ≤ 1,0



5) design for shear force:

shear force stresses: $1{,}5*V_d/(k_{cr}*A_n)$

V_{max} =	10,99	KN
k_{cr} =	0,5	
An=	268,8	cm^2

design

$1{,}5*V_d/(k_{cr}*A_n*f_{vd})$ = 0,443 ≤ 1

4.7.3 Floor Beam 4

1) System *Position: FB4*

beam on two supports

2) loading

V,FR1= 4,725kN	b= 0,72m qd=3,96kN/m; Fk=2,58kN	point loads acting at 3/4 of rafter
V,FR2= 6,26kN	b= 0,76m qd=4,18kN/m; Fk=3,3kN	
V,FR3= 5,96kN	b= 0,67m qd=3,69kN; Fk=3,3kN	
V,FR4= 2,25kN	b= 0,63m qd=2,55+1,34+0,6kN/m	

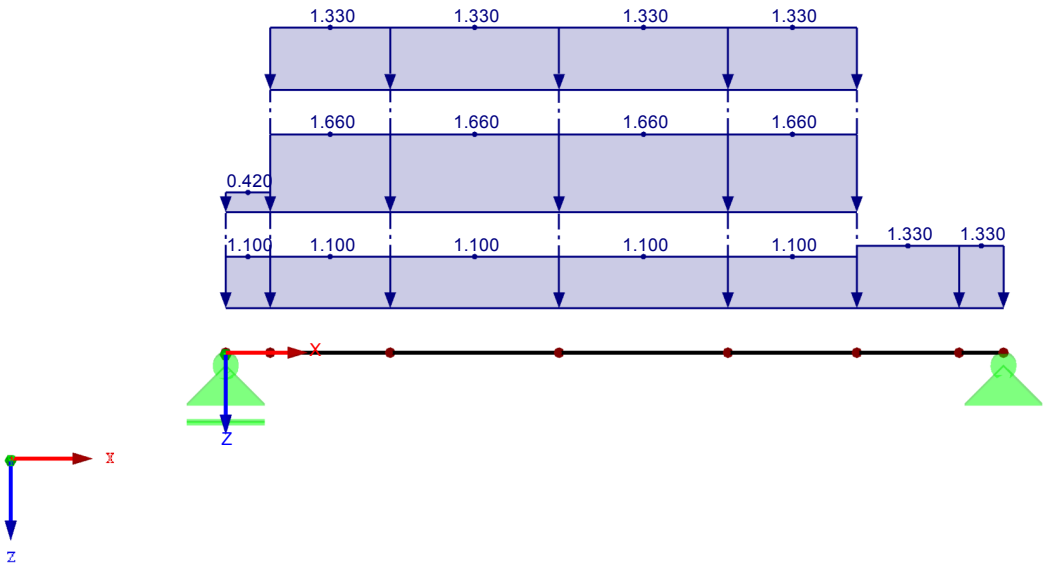
g,k (Eternit)=1,66kN/m^2
g,k (wall 3)=1,1kN/m^2
T=C= 15.03kN point loads due to wind

0.5 of kitchen area, load width 0,35m
g,k (kitchen)=0,42kN/m^2
g,k (floor)= 0.91kN/m^2

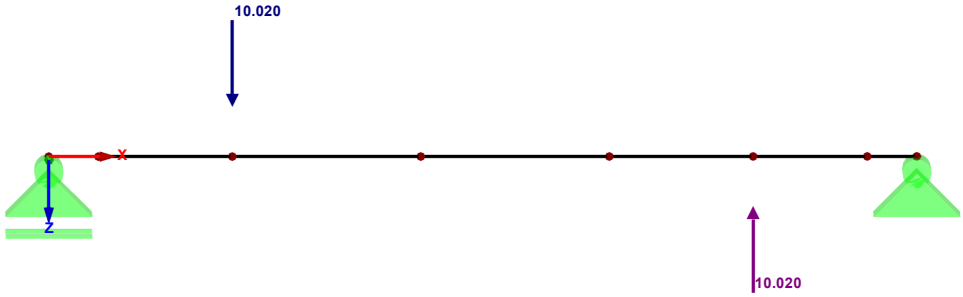
Overview of loads:

Loads due to walls and kitchen area:

LF6: Ausbaulast

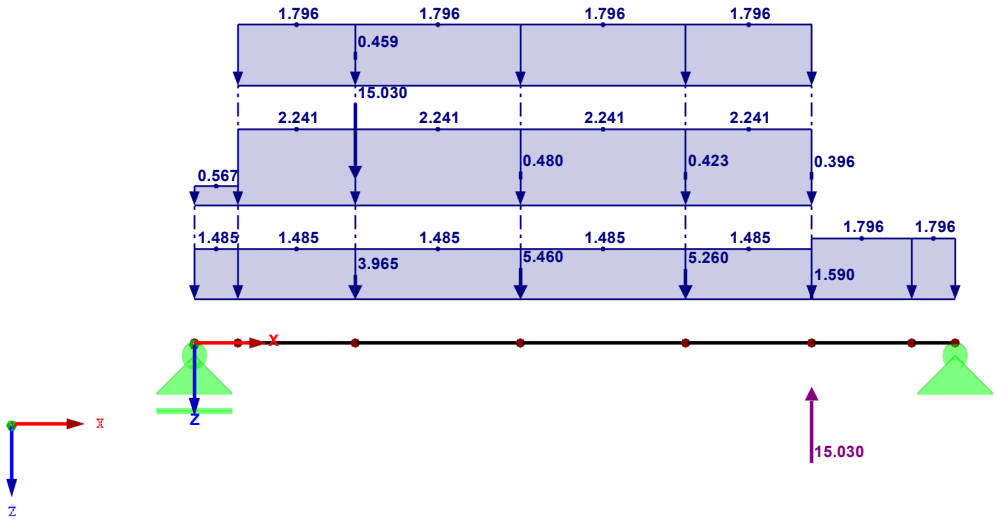


Characteristic wind loads of wall 3:



All loads of critical load combination:

LK4: LF1 + 1.5*LF4 + 1.35*LF6 + 0.9*LF7



3) cross section

b =	16	cm
h =	24	cm
A =	384	cm^2
$W_y=b \cdot h^2/6$ =	1536	cm^3
k_h =	1,000	

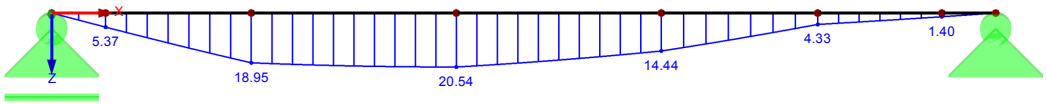
4) design for bending

one-axial bending:

bending stress design: $M_{max,1}/W_y \leq kh*f_{m,d}$

M_{max}	2054	KNcm	
$M_{max,1}/(k_h*W_y*f_{m,d})$=	0,805	≤	1,0

LK4: LF1 + 1.5*LF4 + 1.35*LF6 + 0.9*LF7
M-y





Max M-y: 20.54, Min M-y: 0.00 [kNm]

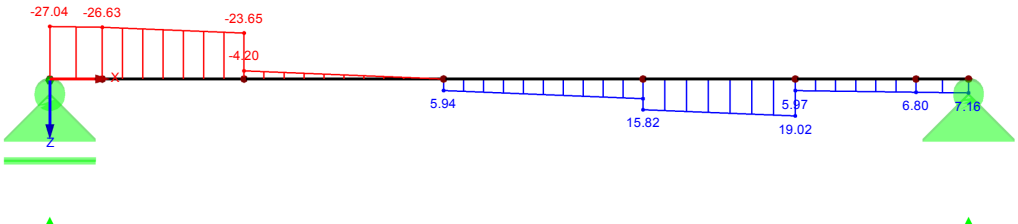
5) design for shear force:

shear force stresses: $1{,}5*V_d/(k_{cr}*A_n)$

V_{max} = 27,04 KN
k_{cr} = 0,5
An= 344 cm^2

design
$1{,}5*V_d/(k_{cr}*A_n*f_{vd})$ = 0,852 ≤ 1

LK4: LF1 + 1.5*LF4 + 1.35*LF6 + 0.9*LF7
Lagerreaktionen[kN]
V-z

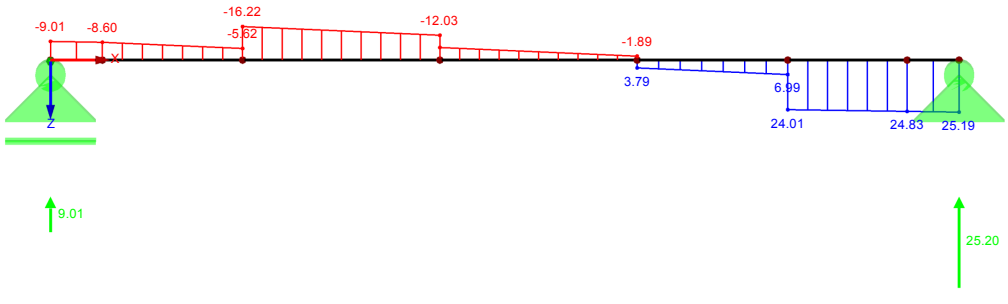




Max V-z: 19.02, Min V-z: -27.04 [kN]
Max P-X': 0.00, Min P-X': 0.00 kN
Max P-Z': 27.05, Min P-Z': 7.16 kN

Highest load on the support in axis F, for wind case wind on west side:

LK3: Wind load from other side
Lagerreaktionen[kN]
V-z



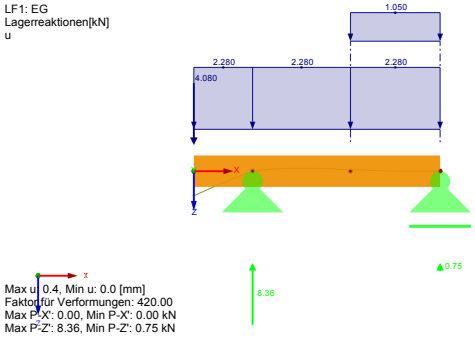
Max V-z: 25.19, Min V-z: -16.22 [kN]
Max P-X': 0.00, Min P-X': 0.00 kN
Max P-Z': 25.20, Min P-Z': 9.01 kN

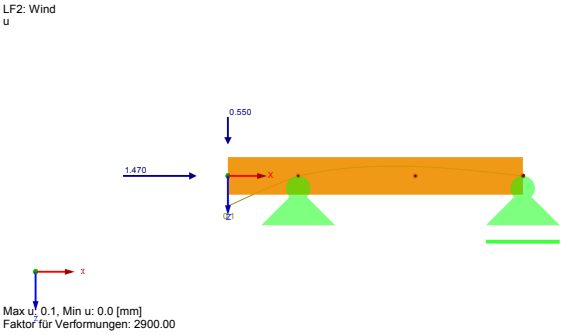
4.7.4 Floor Beam FB 5

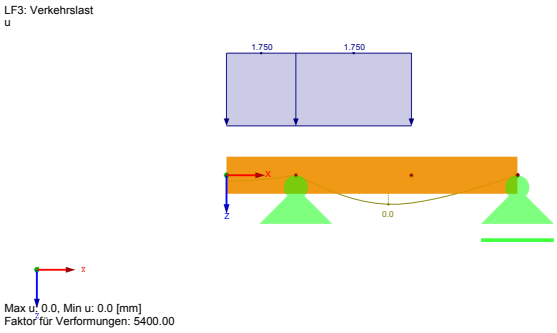
Floor beam 5 connects the floor module of type FM 5 to the core module FM 4. As connection between the modules bolts will be used. They will need to withstand the cut sizes resulting at the interface between the two modules.

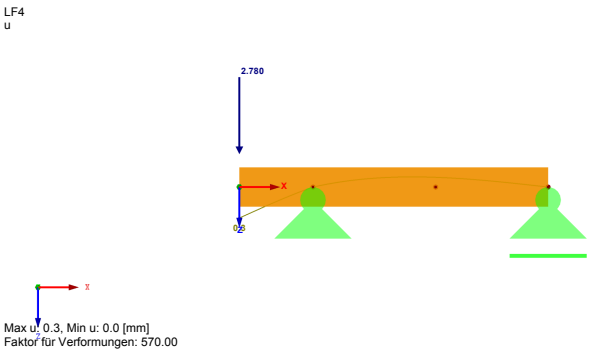
To consider deformation in particular here all load cases are summed up in detail in the following:

Clock wise starting from the top one left: LC 1) own weight, LC2) wind; LC 4) extraordinary snow load, LC 3) live load (traffic)



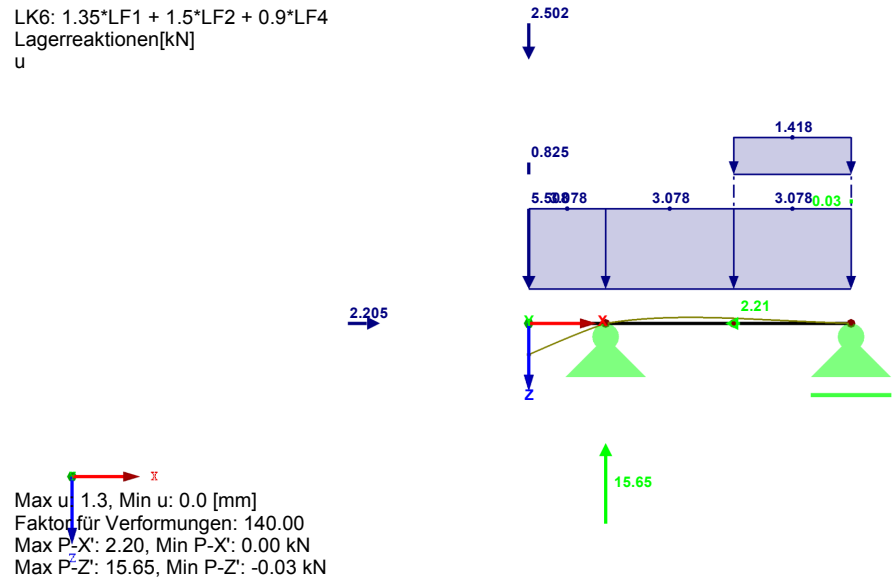


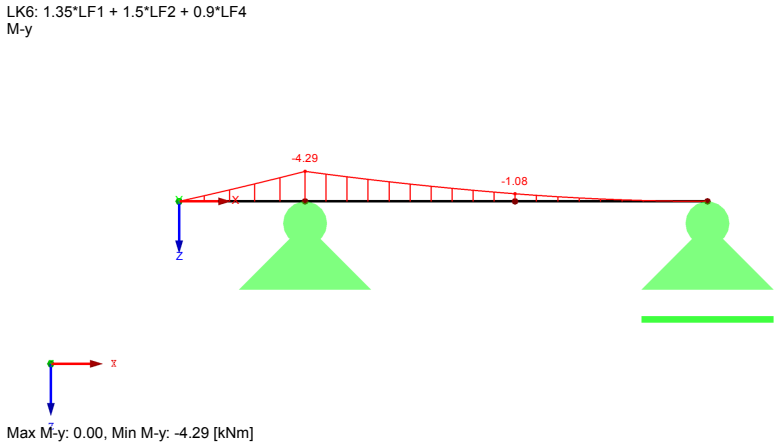




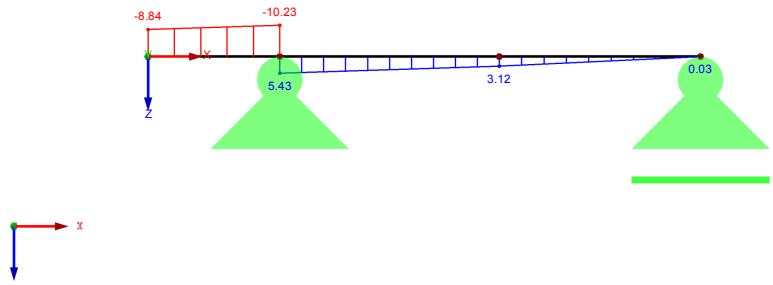
The most significant load case is the one with the snow load as the leading variable and wind as variable 2.

Bearing, reaction forces and deformations:





LK6: 1.35*LF1 + 1.5*LF2 + 0.9*LF4
V-z



Max V-z: 5.43, Min V-z: -10.23 [kN]

The beam doesn't need to be designed in particular. All cut sizes are lower than for FB 3, which is constructed with the same cross section.

The bolt connections need to withstand:

V=3.12kN, M=1.08kNm – detailed calculation please refer to

At each connection location two vertically differently leveled bolts will be used: The distance between the bolts is 12cm. Therefore the tension force in one bolt will be: T=M/e=1.08kNm/0.12m=9kN

d) connection between FM 4 and FM 5

$F_{max\,t,d}$ =	9,00	kN	maximum tension force
$F_{v,d}$ =	3,12	kN	maximum shear force

chosen connection (see plans)
2x bolts Bo ⌀**12** S235, C24, α=90°, $t_{h,req}$=77mm

each: d=	12	mm	
A=	113,10	mm^2	
sigmay,d=	7,96	kN/cm^2	

design for maximum tension forces between roof modules:
sigmay,d =Ft,d/(n*A)
> 2 bolts chosen at the end of each purlin.

sigmay,d=	3,98	kN/cm^2	>! f_{vd}

swell stress under bolt plate: bolt plate=		50	cm^2
$R_{c,90,d}/(2* A_{bolt\ plate}*k_{c,90}*f_{c,9(}$	0,42	<! 1	

design for shear force:

$F_{vrk,90}$ =	5,75	KN	
Fv,Rd =n*kmod*Fv,Rk/γm =	15,92	KN	>! F_{vd}

; where n=2*4

proof for whole reveal stress is not necessary t=100mm > t req

4.8 Footings

Please find detailed drawings of the footings on plan ST–302.

Footing F2 is under the greatest bearings (as to be seen in ST-001)

1) resistance: admissible soil pressure

σ_{zul} = 50 kN/m²

2) vertical loads

FB 2 $(G+Q)_d$ 53,87
$(G+Q)_k$ 20,95+2,99+15,26/2= 31.57kN

essential footing area $a_{footing} = ((G+Q)_k / \sigma_{zul})$ 0,63 m²
footing area: $a_{footing}$ = 0,9m*0,9m 0,81 m²
assumned load transmission angular: 45° - 60°
$h_{essential}$=0,2m

3) bearing pressure of floor panel on footing

horizontal load transfer via perforated metal plate

$H_{id,eff}$ = 5 kN

design for hole reveal stress (not needed: t> t,h,req)

k_{mod} = 0,9 NKL 2, short
$f_{c,90,k}$ = 0,25 kN/cm²
$f_{c,90,d}$ = 0,173 kN/cm²
2 bolts A_{bolts} = 38,4 cm²

$H_{id,eff} / (A_{bolts}*f_{c,90,d})$ 0,429 <! 1

shearing of steel dowels
with t_s = 5 mm < d = 8 mm and α = 2°

Minimum wood thickness
$t_{h,req}$ = 50 mm

bearing capacity per fitting bolt and shear plane
$F_{v,Rk0}$ = 4.5 kN

for 2 fitting bolts and 2 shear planes
$F_{v,Rd0}$ = 12.489 kN ≥ $H_{x,d}$

4) shearing of perforated vertical metal plate

connection
steel plate S235

t =	0,5	cm	γ_M =	1,1	
b =	5	cm	f_{yk} =	23,5	kN/cm²
h =	37	cm	f_{yd} =	22,4	kN/cm²
			τ_{rd}	12,33	kN/cm²
t_{plate} =	0,5	cm			
A_{plate}	2,5	cm²			
$\tau_{ed} = H_{id} / A$ =	2	kN/cm²	eigtl. noch H,d/2		

proof: τ_{ed} / τ_{ed} = 0,162 ≤ 1

5) design of screw: d=32mm

d=	32	mm	A=	804,25	mm^2
e=	0,12	m	I_y=	5,15	cm^4
h_{max}=	0,2	m			

F_1 =	53,87	kN	
$H_{1,d,max}$ =	5	kN	(eigtl. 3.82kN)
$H_{1,d,max,red}$ =	2,5	kN	temporary construction (less than 3 months wind loads reduced by 50%; referring to DIN EN 1991-1-2/NA

$H_{1,d,max} > H_{2,d,max}$ = 12,88kN/4 ; no need to consider interaction!

M=$H_{1,d,max,red}$*(e+h)= 80 kNcm

$N_{pl,Rd}$=	172,11	kN		
$V_{pl,Rd}$=	99,37	kN	>>	$H_{1,d,max,red}$

buckling and bending:

N_{cr}=	2668,49	kN		
λ=	0,27		χ=	0,98
$N_{b,Rd}$=	168,67			

$F_1/N_{b,Rd}$= 0,32

$M_{pl,y,Rd}$=	110,21	kNcm			
$M_{N,y,Rd}$=	94,38	kNcm	>	80 kNcm	; 85% of capacity

threaded sleeve: (äußeres Gewinde)

d= 40mm, t=4mm A= 452,00 mm^2

same cut sizes as for threated bar

$N_{pl,Rd}$=	96,73	kN			
$V_{pl,Rd}$=	55,85	kN	>>	$H_{1,d,max,red}$	
buckling and bending:					
N_{cr}=	3844,70	kN			
ʎ=	0,17		χ=	1	
$N_{b,Rd}$=	96,73				
$F_1/N_{b,Rd}$=	0,56				
$M_{pl,y,Rd}$=	158,788	kNcm			
$M_{N,y,Rd}$=	100,08	kNcm	>	80 kNcm	; 80% of capacity

5) load transfer of the horizontal force via friction in the solid

coefficient of friction μ = 0,5

vertical load without live load because favoring

F_{vd} = 1.35*F_{vk} = 36.666 kN

F_{rd} = 1.35*F_{vk} = 18.333 kN/m ≥! $H_{id}/a_{footing}$ = 3.167 kN/m

4.9 Terrace and Surroundings

4.9.1 Terrace modules

Please refer to the structural terrace plan.

Since the terrace as well as the surroundings is a temporary construction that illustrates the Berlin Altbau load assumptions due to conditions in Versailles will be taken. Those are less critical as the one for Berlin that we normally ought to use. Yet for a future use of this construction in Berlin retrofitting can easily be done.

a) Construction:

The Terrace floor as well as the ramp construction is divided into modules of similar geometrics. Only the most critical module will be calculated. Each module consists out of a upper layer of lark terrace floor boards that is supported on wooden beams each 50cm. The modules will be connected in two directions, in one direction the modules will be connected by the floor boards that overlay the next module and in longitudinal direction of the beams special wooden dove-tail connection will be used. Due to their special geometrics, no additional metal is needed for the connection and to enhance and easy and fast construction. Those modules are supported by recyclable Polypropylen-Copolymer post of the company Buzon. We will use in height-adjustable supports, which also enhance slope correction between 0 - 5%. To transfer the loads into the ground, wooden load distribution plates made out of ply-wood are used.

Horizontal stiffness will be given to the system in attaching it to members of high masses as the house, the basin and the high walls.

All additional technical data used is given in the Appendix.

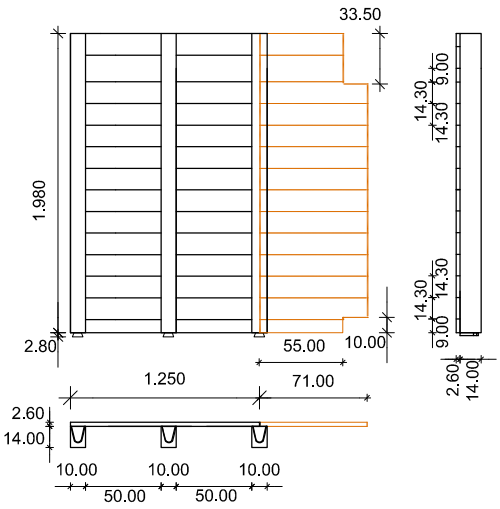


figure 27: terrace module

b) Loads:

Most critical module				
length [m]	2,05	all calculations in z-direction – vertical,		
width [m]	1,75	direction of gravity is positive direction of forces		
h [m]	0.247			
area [qm]	3,5875			
LOADS				
own weight			load width = 0.6m	
weight of floorboards (h=2,7cm)	kN/m2	0,11	kN/m	0,012474
weight of beams 14*14cm	kN/m	0,098	kN/m	0.098
live loads				
live load (normal modules)	kN/m2	1,50	kN/m	0,9
live loads (stairs)	kN/m2	2,5	kN/m	1,5

c) Designing of most critical members:

1) System — Position: terrace beams

beam on two supports (l_b=2,0m)

2) loading

load width l= 0,6 m

selfweight:	floorboards	g_k = 0.11 KN/m2 * 0,6m	0,66 KN/m
	beam	g_k =	0,10 KN/m
liveload:		q_k = 1,5 KN/m^2 * 0,6m =	0,90 KN/m

3) cross section

NH C 24

γ_M=	1,3		$f_{m,d}=f_{m,k}\cdot k_{mod}/\gamma_M$	
k_{mod} =	0,9	(NKL1, kurz)		
f_{mk} =	2,4	KN/cm^2	f_{md} =	1,66
f_{vk} =	0,4	KN/cm^2	f_{vd} =	0,28
$f_{c,90k}$ =	0,25	KN/cm^2	$f_{c,90,d}$ =	0,17

b =	10	cm
h =	14	cm
A =	140	cm^2
$W_y=b\cdot h^2/6$ =	326,666667	cm^3
k_h =	1,000	

4) design for bending

one-axial bending:

bending stress design: $M_{max,1}/W_y \leq kh*f_{m,d}$

$M_{max,Feld}$ 78 KNcm

Nachweis:

$M_{max,1}/(k_h*W_y*f_{m,d})$= 0,144 ≤ 1,0

5) design for shear force:

shear force stresses: $1,5*V_d/(k_{cr}*A_n)$

V_{max} =	1,55	KN
k_{cr} =	0,5	
$A_{netto=}$	128,8	

design

$1,5*V_d/(k_{cr}*A_n*f_{vd})$ = 0,120 ≤ 1

6) swell stress of the beam above supports

N_{90} =	4,55	KN
ü =	3	cm
$l_{Auflager}$ =	10	cm
A_{ef} =	130	cm^2
l_1 >	2h	
$k_{c,90}$ =	1	

design:

$N_{90,d}/(A_{ef}*k_{c,90}*f_{c,90,d})$ = 0,202 ≤ 1,0

6) dove tail connection

see detailed calculation in chapter 5.10

the dove-tail connections allows a transmitting of shear forces, so using this coonection only the half of the pillars will be needed

7) supports of the terrace (Buzon; DPH - 9; 395-630cm)

according to data of the company, please refer to Appendix for further information

capable baering compression force= 14,2kN*0,85/2 = 6,04 kN

critical load: 2*1,55kN = 3,1 kN ≤ 6,55 kN

8) deflection

$E_{0,mean}$=	1100	KN/cm^2		
I=	2286,666667	cm^4		
L=	100	cm		
k_{def}=	0,8	(NKL2, VH)		
y_2=	0,3	(use load cat. B)		
$w_{inst,G}$	0,100	mm	w_0=	0 mm
$w_{inst,Q}$	0,600	mm		

$w_{creep\ G}=k_{def}\cdot w_{inst,G}$=	0,080	mm
$w_{creep,Q}=y_2\cdot k_{def}\cdot w_{inst,Q}$=	0,144	mm
$w_{fin,G}=w_{inst,G}+w_{creep,G}$=	0,180	mm
$w_{fin,Q}=w_{inst,Q}+w_{creep,Q}$=	0,744	mm
$w_{fin}=w_{fin,G}+w_{fin,Q}$=	0,924	mm

9) Design for deflection:

design sitautions of deflection

1a:

$w_{inst,Q} \leq L_1/300$

$w_{inst,Q}$= 0,600 ≤ 3,333 = $L_1/300$

18,000 % degree of capacity

1b:

$w_{creep,G} + w_{fin,Q} \leq L_1/200$

$w_{creep,G} + w_{fin,Q}$= 0,824 ≤ 5 = $L_1/200$

16,480 % degree of capacity

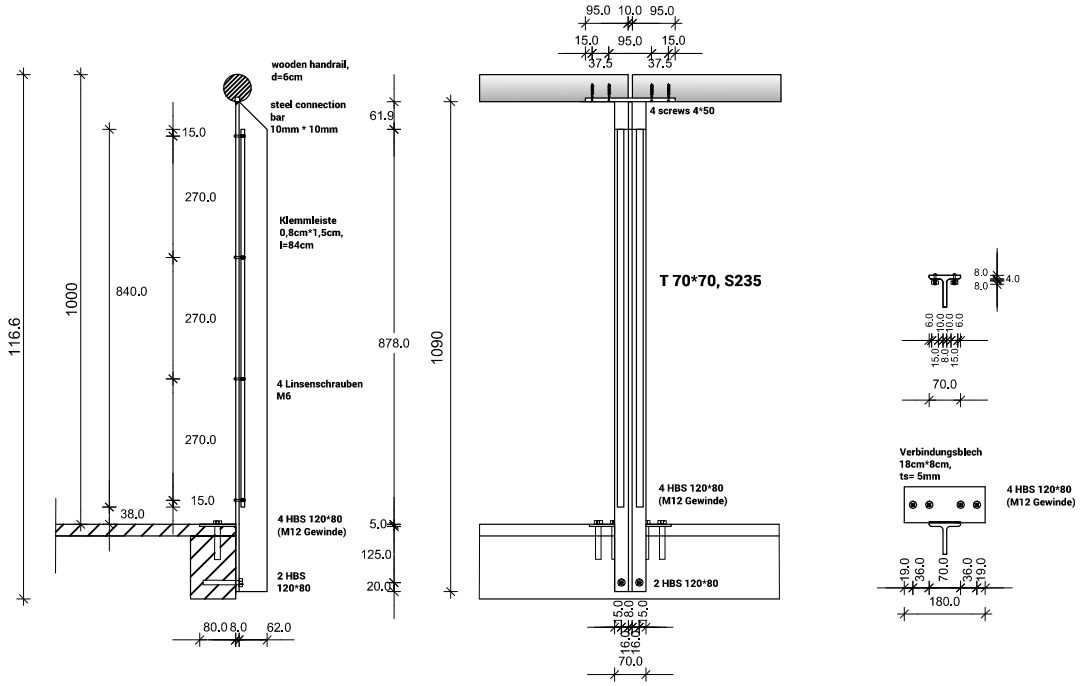
2) final deflection

$w_{fin} - w_0 \leq L_1/200$

$w_{fin} - w_0$= 0,924 ≤ 5 = $L_1/200$

18,480 % degree of capacity

4.9.2 Design of Handrails



a) Construction:

The handrail is adapted to the grid of the house, so the distance between the railing posts are 1,75m. The height of the handrail is 1,00m from the top edge of the terrace floor modules and every post foot is fastened on the floorboards and beams with 4 bolts and 2 hexagonbolt.

b) Loads:

Horizontal live load: $q_{k,line}$= 1,0kN/m

influence width: LEB = 1,75m

height (to middle point of support) : h= 1,10m

distance between screws: e= 11,1cm

$$Live\ load: q_k = q_{k,line} \cdot LEB = 1.0\frac{kN}{m} \cdot 1.75 = 1.75kN$$

c) Ultimate limit state:

Static system: cantilever

Vertical decisive supporting force in screws as result of torque caused by horizontal live load $\boldsymbol{F_{2,k}}$:

Total torque in foot of the posts:

$$M_{Ed} = q_k * h = 1.75kN * 1.10m = 1.925kNm$$

$$M_{Rd} = \sigma_{Rd} * W_{el,y} = 24\frac{kN}{cm^2} * 8.79\ cm^3 = 210.96\ kNcm$$

$$M_{Rd} > M_{Ed}$$

d) Connection to terrace modules:

vertical distance between screws: e=11,1cm significant for load transmission:

$$V_{on\ upper\ bolts} = \frac{M_{Ed}}{e} + \frac{V_{Ed}}{4} = \frac{1{,}925/4}{0{,}111} + \frac{1}{4} = 4{,}58kN$$

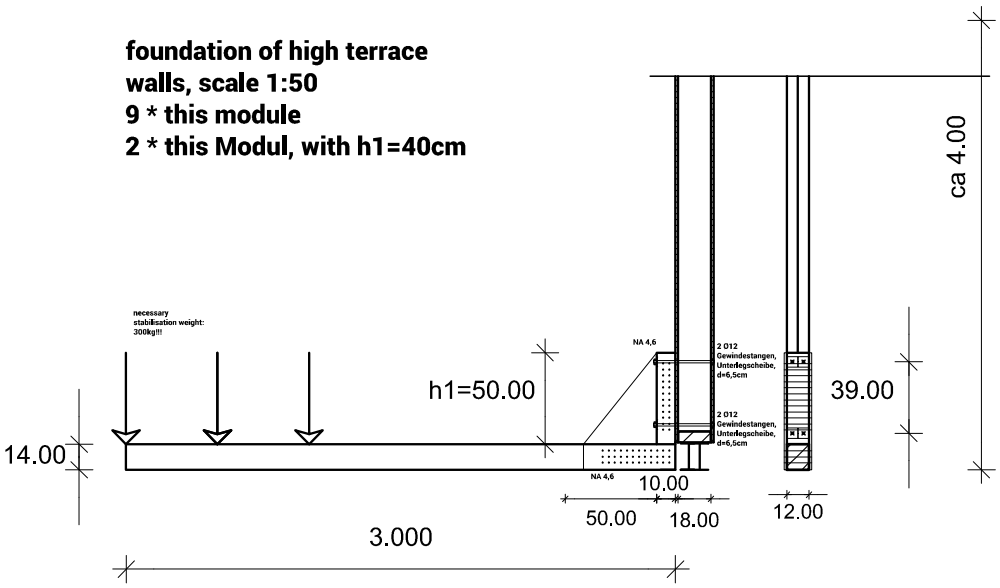
capable bearing force M12:

$$F_{v,Rd} = 6.47kN * \frac{0.9}{1.1} = 5.29kN$$

welt connection on fixing at the bottom: t= 5mm:

$$\tau_{v,Rd} = 0.5cm * 7cm * \frac{\frac{24kN}{cm^2}}{1.1} = 76kN \gg 4 * 4{,}58kN$$

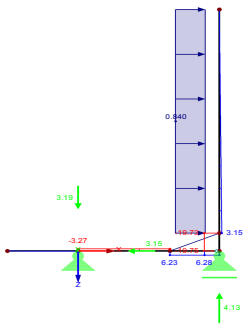
4.9.3 Supporting structure to stabilize high walls

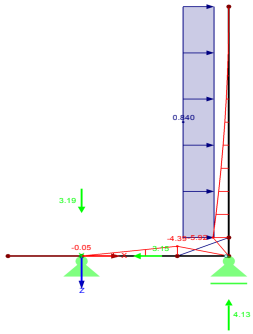


Every 1.25m a triangular construction stabilizes the compartment walls that we set up to illustrate the Berliner Altbau.

loads compartement walls:		
wind pressure	0,63	kN/m^2
eind suction	0,27	kN/m^2
load width	1,25	m
w,k = 1,25m * (0,63+0,27)kN/m^2	1,125	kN/m
temporary construction, reduction of wind loading by 50%	0,5625	kN/m
impact load (on height of 1,2m)	1,25	kN
h [m] untill fixed connection	3,75	m

system: critical load case	
shear force	moment forces





M;at fixing=	5,92	kNm
V,Ed=	3,15	kN
normal force on bolt connection = M/e= 5,92kNm/0,39m	15,18	kNm

$F_{max\ t,d}$ =			15,81 kN	maximum tension force

chosen connection
a) bolts Bo ⦰12 S235, C24, α=90°, $t_{h,req}$=77mm

each:	d=		12 mm	
	A=		113,10 mm^2	

design for maximum tension forces at the rigid connection on the bottom of the wall
sigmay,d =Ft,d/(n*A)
2 bolts chosen at the end of each purlin.

	sigmay,d=		6,99 kN/cm^2	>! f_{yd}

b) swell stress under bolt plate d=5,5cm:

bolt plate=		30,25 cm^2	A,eff=	63,25
$R_{c,90,d}/(2*\ A_{bolt\ plate}*k_{c,90}*f_{c,90,d})$=			0,93 <! 1	

c) nail connection (nails 4,60)	I,p=r^2=x^2+y^2=36cm^2+11664cm^2=11700cm^2	
	F,x=M/I,p * y+V,z/24=525kNcm/11700cm*18cm=	0,94kN< F,rd

d) foundation:
1) desing for sliding:
coefficient of friction μ = 0,6

vertical load without live load because favoring

F_{vd} = H,d		3,15 kN	
F_{ed} = 3,15kN/0,6		5,25 kN	
own weight	2,2	kN	
needed additional weight to ensure stability	3,05	kN	

2) design to save for tipp over
needed additional weight to ensure stability is equal reaction force of 3.19kN due to wind pressure:

4.9.4 Grey water treatment basin

The horizontal pressure due to water and pumice stone is assumed to be 1.5* the one of water:

q,k= rho, water* 1,5.

To be able to cope with the high deformations that results of the horizontal bearing we use wind tension belts to apply pre-stress on the structure. Finally the forces in the frame beams on top and bottom of the walls can equalize themselves via the principal of a boiler.

upper frame beam: k,mod= 0,6

UDS 1,35*1,5* 10kN/m²

b= 6 cm
h= 14 cm
I= 1372 cm4
Med= 460,35 kNcm
Ned= 4,16 kN

sigma(t,0,d)= 0,0495 f(t,0,d) = 0,6462
sigma(m,y,d)= 1,00659621 f(m,y,d) = 0,9231

design: 1,17

upper frame beam: k,mod= 0,6

pre-stress.: 1,0* 10kN/m²

b= 6 cm
h= 14 cm
I= 1372 cm4
Med= -227,333 kNcm
Ned= -2,05 kN

sigma(t,0,d)= -0,02444 f(t,0,d) = 0,646
sigma(m,y,d)= -0,49708 f(m,y,d) = 0,923

Nachweis: 0,58

upper frame beam: k,mod= 0,6

combi 1,0* 10kN/m²

b= 6 cm
h= 14 cm
I= 1372 cm4
Med= 233,02 kNcm
Ned= 2,10 kN

sigma(t,0,d)= 0,0251 f(t,0,d) = 0,6462
sigma(m,y,d)= 0,5095 f(m,y,d) = 0,9231

Nachweis: 0,59

upper frame beam: k,mod= 0,6

ULS 1,0*1,5* 10kN/m²

b= 6 cm
h= 14 cm
I= 1372 cm4
Med= 341 kNcm
Ned= 4 kN

sigma(t,0,d)= 0,0495 f(t,0,d) = 0,6462
sigma(m,y,d)= 0,74562682 f(m,y,d) = 0,9231

upper frame beam: k,mod= 0,6

pre-stress.: 1,0* 10kN/m²

b= 6 cm
h= 14 cm
I= 1372 cm4
Med= -227,333 kNcm
Ned= -3 kN

sigma(t,0,d)= -0,033 f(t,0,d) = 0,646
sigma(m,y,d)= -0,49708 f(m,y,d) = 0,923

upper frame beam: k,mod= 0,6

combi 1,0* 10kN/m²

b= 6 cm
h= 14 cm
I= 1372 cm4
Med= 113,67 kNcm
Ned= 1 kN

sigma(t,0,d)= 0,0165 f(t,0,d) = 0,6462
sigma(m,y,d)= 0,2485 f(m,y,d) = 0,9231

design:

$w_{inst,G}$= 0,854364067 cm < l/300= 1,1 cm

$w_{inst,G,creep}$= 0,683491254 cm

w_{final}= 1,537855321 cm < l/200= 1,65 cm

$w_{net,final}$= 0,683491254 cm < l/300= 1,1 cm

upper frame beam k,mod= 0,6

UDS **1,35*1,5* 10kN/m²**

b= 12 cm
h= 16 cm
I= 4096 cm4
Med= 307 kNcm
Ned= 12,56 kN

sigma(t,0,d)= 0,06539063 f(t,0,d) = 0,64615385
sigma(m,y,d)= 0,44970703 f(m,y,d) = 0,92307692

design: 0,59

upper frame beam k,mod= 0,6

prestress **1,0* 10kN/m²**

b= 12 cm
h= 16 cm
I= 4096 cm4
Med= -151,60494 kNcm
Ned= -6,20 kN

sigma(t,0,d)= -0,0322917 f(t,0,d) = 0,64615385
sigma(m,y,d)= -0,2220775 f(m,y,d) = 0,92307692

design: 0,29

upper frame beam k,mod= 0,6

combination **1,0* 10kN/m²**

b= 12 cm
h= 16 cm
I= 4096 cm4
Med= 155,395062 kNcm
Ned= 6,36 kN

sigma(t,0,d)= 0,03309896 f(t,0,d) = 0,64615385
sigma(m,y,d)= 0,22762948 f(m,y,d) = 0,92307692

design: 0,30

upper frame beam k,mod= 0,6

ULS **1,0*1,5* 10kN/m²**

b= 12 cm
h= 16 cm
I= 4096 cm4
Med= 341 kNcm
Ned= 4 kN

sigma(t,0,d)= 0,02165625 f(t,0,d) = 0,64615385
sigma(m,y,d)= 0,49951172 f(m,y,d) = 0,92307692

upper frame beam k,mod= 0,6

Vorsp.: **1,0* 10kN/m²**

b= 12 cm
h= 16 cm
I= 4096 cm4
Med= -227,33333 kNcm
Ned= -3 kN

sigma(t,0,d)= -0,0144375 f(t,0,d) = 0,64615385
sigma(m,y,d)= -0,3330078 f(m,y,d) = 0,92307692

upper frame beam k,mod= 0,6

kombi **1,0* 10kN/m²**

b= 12 cm
h= 16 cm
I= 4096 cm4
Med= 113,666667 kNcm
Ned= 1 kN

sigma(t,0,d)= 0,00721875 f(t,0,d) = 0,64615385
sigma(m,y,d)= 0,16650391 f(m,y,d) = 0,92307692

design:

$w_{inst,G}$= 0,286178589 cm < l/300= 0,66666667 cm

$w_{inst,G,creep}$= 0,228942871 cm

w_{final}= 0,51512146 cm < l/200= 1 cm

$w_{net,final}$= 0,228942871 cm < l/300= 1 cm

5 Details

5.1 Roof to pillars

Dimensioning of the connection of a roof beam to a pillar

1) description: connection roof to pillars

special connections GH TOP UV Verbinder (connections): to simplfy modular construction
clip-connection (Aushängesicherung mit Schwalbenschwanzführung

2) loads

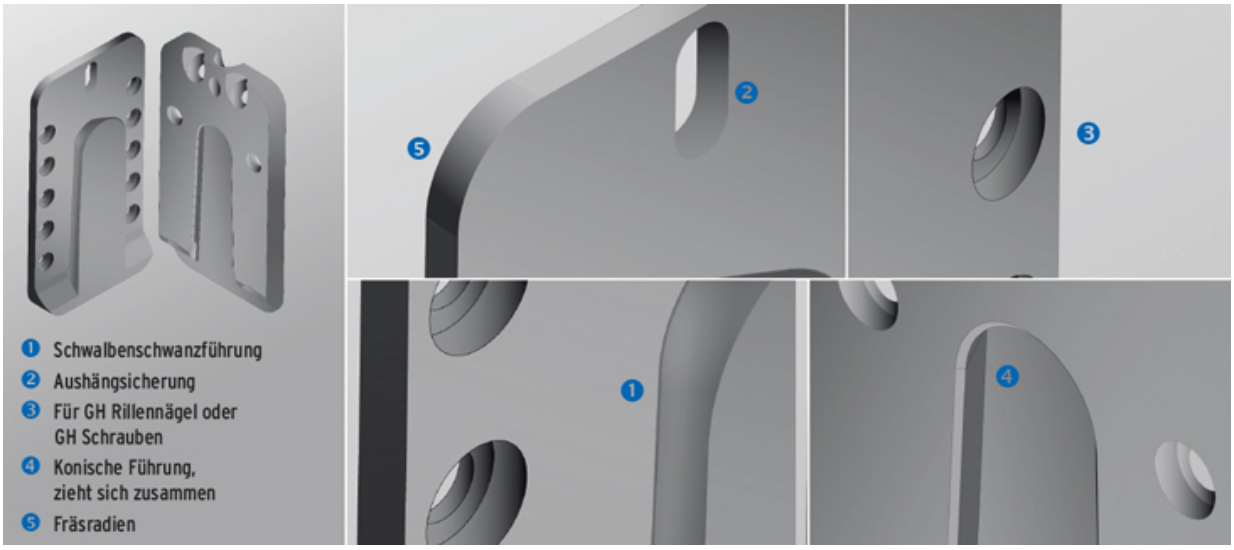
reaction forces of beam supports (here Beam B1) in critical load combination:

A,z,down=	8,54	kN
A,x=	0,98	kN

3) resistance

GH TOP UV connections
technical data according to: http://www.holzverbinder.de/top-uv-verbinder/
with screws (Vollschraube) 10* x 5,0*60mm for connection to roof beam and 4* x 6,0*165mm for connection to pillar

$R_{zDown,k}$ =	15,34	kN	(k_{mod} =0,9, NKL 2, short)
$R_{zDown,d}$ =	10,62	kN	
$R_{xDown,k}$ =	4	kN	
$R_{xDown,k}$ =	2,77	kN	



5.2 Roof to walls W1/W2

Bolt connections will be used connecting the upper rib of the wall with beam above the wall in the roof construction.

The shear force that need to be transmitted is: V_d=23.1 kN

6 bolts M12 S235

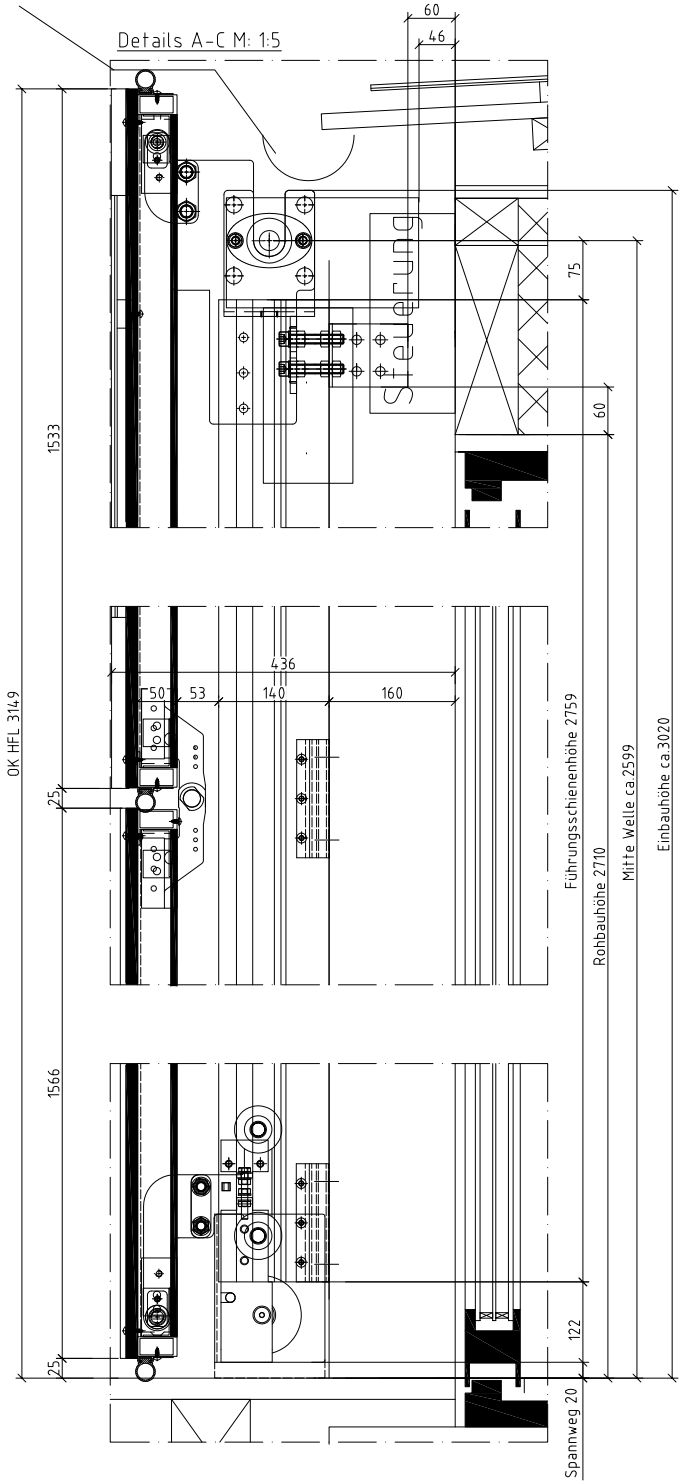
Design for shear force:

V_d =23.1kN

$$F_{v,0,R,d} = F_{v,0,R,k} \cdot n \cdot \frac{k_{mod}}{\gamma_m} = 6.47kN \cdot 6 \cdot \frac{0.9}{1.3} = 26.88kN > 23.1kN$$

Proof for whole reveal stress is not necessary, since $t = 120mm > t_{req} = 60mm$

5.3 Façade to pillars



The connection façade to pillar is done by two elements. Forces of the façade will be applied via an angular sheet at the top of the column and the aluminum rail that is continously attached to the column over its very height via screws.

Due to cooperate secret of the façade building company “BeLuTec” only the highest values that need to be applied on the columns are handed out to us as considered in the design of the columns and the bracing of the whole structure. Yet it is their responsibility to ensure that the detail façade to pillar won’t fail. We did calculations of this detail by hand ourselves and are not doubting the connection to fail.

5.4 Core module (inner bracing wall) to roof and to floor

Bolt connections will be used connecting the upper rib of the wall with beam B16 and B17 of the roof construction.

The shear force that need to be transmitted is: V_d=12.88kN

4 bolts M12 S235

Design for shear force:

V_d =12.88kN

$$F_{v,0,R,d} = F_{v,0,R,k} \cdot n \cdot \frac{k_{mod}}{\gamma_m} = 6.47kN \cdot 4 \cdot \frac{0.9}{1.3} = 17.92kN > 12.88kN$$

Proof for whole reveal stress is not necessary, since $t = 120mm > t_{req} = 60mm$

5.5 Pillar to floor

Dimensioning of the connection between a pillar and the floor plate:

1) reaction forces lower support of pillar

H_d=	2,45	kN	if wind load is gathered by closed glas facade and the opened moveable facade the load = 1.47kN+0.98kN
N_d=	16,72	kN	(where the glas facade is continously attached to the roof, the floor and the pillar so half of the horizontal wind load needs to be taken into consider for this detail)

2) cross section

NH C 24

γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$
k_{mod} =	0,7		(NKL3, kurz)
b =	20	cm	
h =	16	cm	
A =	320	cm^2	
$W_y=b \cdot h^2/6$ =	853,33	cm^3	
k_h =	1,00		

3) connection

metal sheet S 235 — lying inside

t=	0,5	cm	γ_M=	1,1	
b=	10	cm	f_{yd} =	23,5	kN/cm^2
h=	30	cm	tau_{rd} =	13.56	kN/cm^2

bolts (Stabdübel) S 235

d=	1	cm
A_{Bo} =	0,5	cm
γ_M=	1,1	

4) swell stress of the beam above supports

A_n =	310	cm^2
$k_{c,90}$ =	1	

design:

$N_{90,d}/(A_{ef}*k_{c,90}*f_{c,90,d})$ =		≤	1,0
	0,38	≤	1,0

5) design of upper bolt connection (force vertical to wood fiber α = 90°)

$F_{v,90,R,d} = F_{v,90,R,k} \cdot n \cdot k_{mod} / \gamma_m$ $t_{h,req}$ = 73 mm

$F_{v,90,R,k}$=	5,44	kN
$F_{v,90,R,d}$ =	2,93	kN

1 bolt/
2 shear bands (n): 5,8585 >= H_d = 3.82 kN

proof for whole reveal stressis not necessary, since t >=th,req

minimal distances:

a_1=3*d=	3	cm
a_{3c}=4*d=	4	cm

6) design of metal sheet

shear stress in metal sheet in between pillar and floor construction

t_{Blech}=	5	mm				
A_{Blech}=	5	cm^2				
tau_{ed}=V/A=	3,21	kN/cm^2	≤	tau_{rd} =	13.56	kN/cm^2

7) design of screws: 6 screws d=10

M= Hd*e	67,424	kNcm	moment: excenticity * horizontal force, e=17,2cm
Ip=	137,5	cm^2	polar moement of inertia of screws
Fx = M/Ip*y+Hd/6=	3,105	kN	force in x-direction of screw under greatest bearing
Fy = M/Ip*x=	1,226	kN	force in y-direction of screw under greatest bearing
R=(Fx^2#Fy^2)^0,5	3,338	kN	resulant
alpha=	21°		

$F_{v,alpha,R,d} = F_{v,alpha,R,k} \cdot n \cdot k_{mod} / \gamma_m$

$F_{v,alpha,R,k}$=	4,44	kN	
$F_{v,0,R,d}$ =	3,07	kN	≥ R

5) design of upper bolt connection (force vertical to wood fiber α = 90°)

$F_{v,90,R,d} = F_{v,90,R,k} \cdot n \cdot k_{mod} / \gamma_m$ $t_{h,req}$ = 73 mm

$F_{v,90,R,k}$= 5,44 kN

$F_{v,90,R,d}$ = 2,93 kN

1 bolt/
2 shear 5,8585 >= H_d = 2.45 kN
bands (n):

proof for whole reveal stressis not necessary, since t >=th,req

minimal distances:

a_1=3*d= 3 cm

a_{3c}=4*d= 4 cm

6) design of metal sheet

shear stress in metal sheet in between pillar and floor construction

t_{Blech}= 5 mm

A_{Blech}= 5 cm^2

tau_{ed}=V/A= 3,21 kN/cm^2 ≤ tau_{rd} = 13.56 kN/cm^2

7) design of screws: 6 screws d=10

M= Hd*e 42,14 kNcm moment: excenticity * horizontal force, e=17,2cm
Ip= 137,5 cm^2 polar moement of inertia of screws

Fx = M/Ip*y+Hd/6= 1,941 kN force in x-direction of screw under greatest bearing
Fy = M/Ip*x= 0,766 kN force in y-direction of screw under greatest bearing
R=(Fx^2#Fy^2)^0,5 2,086 kN resulant
alpha= 21°

$F_{v,alpha,R,d} = F_{v,alpha,R,k} \cdot n \cdot k_{mod} / \gamma_m$

$F_{v,alpha,R,k}$= 4,44 kN

$F_{v,0,R,d}$ = 3,07 kN ≥ R

5.6 Wall W1/W2 to floor

Dimensioning of the connection of the short walls to the floor plate:

connection wall1/2 to floor

$F_{max\ t,d}$ =	11,16	kN	maximum tension force

chosen connection (see plans)
bolts Bo ⦰16 S235, C24, α=90°, $t_{h,req}$=77mm

each:	d=	16	mm
	A=	201,06	mm^2
	sigmay,d=	5,55	kN/cm^2

design for maximum tension forces between roof modules:
sigmay,d =Ft,d/(n*A)
> 2 bolts chosen at the end of each purlin.

	sigmay,d=	2,78	kN/cm^2 >! f_{vd}

swell stress under bolt pl	bolt plate=	100	cm^2
$R_{c,90,d}$/(2* $A_{bolt\ plate}$*$k_{c,90}$*f	0,26	<! 1	

5.7 Wall W3 to floor

1) traction force acting on outer ribs of wall due to wind loading

* for technical drawings please refer to ST-301-details and module plan, wall modules

V_d= 10,09 kN

2) cross section

NH C 24

γ_M= 1,3 $f_d=f_k \cdot k_{mod} / \gamma_M$

k_{mod} = 0,9 (NKL 2, kurz)

pillar

b = 12 cm

h = 12 cm

A = 144 cm^2

$W_y=b \cdot h^2/6$ = 288 cm^3

k_h = 1,00

3) connection via tension anchor Top Vario 240 permission ETA-10/0010

Tragfähigkeiten gem. ETA-10/0010

Art. Nr.	Typ	n_{Na}	KLED	4x40 /5x40 $F_{Rd\ up}$	4x40 /5x40 $F_{B,t,Ed}$	4x50 / 5x40 $F_{Rd\ up}$	4x50 / 5x40 $F_{B,t,Ed}$	4x60 / 5x50 $F_{Rd\ up}$	4x60 / 5x50 $F_{B,t,Ed}$
110850	Top Vario 240	12	kurz	13,0	19,4	14,5	21,5	14,5	21,5
			mittel	11,6	17,3	13,8	20,6	14,3	21,2
			ständig	8,7	13,0	10,4	15,4	10,7	15,9
110867	Top Vario 280	17	kurz	14,5	21,5	14,5	21,5	14,5	21,5
			mittel	14,5	21,5	14,5	21,5	14,5	21,5
			ständig	12,3	18,4	14,5	21,5	14,5	21,5

chosen connection 12 nails in vertical rib of wall, and 5*50 screws do attach the anchor to the floorbeam, thus:

F, rd,up= 14,5kN > 10.09kN



5.8 Floor module FM 4 to FM 5: RAMPA bolt connection

conection RAMPA-bolt: connection with outside wooden screw threating and metrical winding for bolt onnection according to permission ETA120481-HB-RAMPA-DE-FINAL

1) acting forces

$F_{t,d}$ =	9	kN	tension force on connection
$F_{v,d}$ =	3,12	kN	shear force on connection
R =	9,53	kN	force resultant
α=	90	°	angle connection to wooden fibre
	1,571	rad	
γ=	10	°	angle of force acting on Muffe resp. axial direction
	0,175	rad	

data coonection Rama-Muffe

d_{RM} =	22	mm	diameter of RM
$d_{threaded\ bar}$ =	12	mm	
$M_{y,RkRRM}$ =	65000	Nm	characteristical yield moment of RM
$l_{et,RM}$ =	80	mm	

Materials

NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,9	(NKL2, kurz)			
	k_{mod} (outside)=					
	f_{mk} =	2,4	kN/cm^2	f_{md} =	1,66	kN/cm^2
	f_{vk} =	0,4	kN/cm^2	f_{vd} =	0,28	kN/cm^2
	$f_{c,90k}$ =	0,25	kN/cm^2	$f_{c,90,d}$ =	0,17	kN/cm^2
	$f_{c,0,k}$ =	2,1	kN/cm^2	$f_{c,0,d}$ =	1,45	kN/cm^2

2) design

a) bearing of hole stress:

$f_{h,1,c}$= 0,082*ρ_k*(1-0,01*dRM)/(2.5*(cosα)^2+(sinα)^2) 22,39 N/mm2

b) char. Tensile force

$F_{ax,Rk}$ = $\min\left\{\frac{9 \cdot d_{RM} \cdot l_{et,RM}}{1,2 \cdot (\cos\alpha)^2 + (\sin\alpha)^2} \cdot \left(\frac{\rho_k}{350}\right)^{0,8}\right\}$ 15,84 kN

c) shear strength

$F_{ax,Rk}$ = $\min\left\{\frac{0,4 f_{h,1,k} t_1 d_{RM}}{1,15\sqrt{2 M_{y,Rk,RM} f_{h,1,k} d_{RM}}} + \frac{F_{ax,Rk}}{4}\right\}$ min 15,76 kN

13,16 kN (*)

d) maximum capable load due to load acting on ceonnection under certain angle

max. F_{Ek} (γ=10°)= $\frac{1}{\sqrt{\left(\frac{\sin\gamma}{F_{v,Rk}}\right)^2 + \left(\frac{\cos\gamma}{F_{ax,Rk}}\right)^2}}$ 15,73 kN

max. F_{Ed} (γ=10°)= 10,89 kN ≥ 9,53 kN

5.9 Floor Rafter to Floor Beam – joist hanger (Balkenschuh)

1) force

V_d= 6,27 kN

2) cross section

NH C 24

γ_M=	1,3	$f_d=f_k \cdot k_{mod}/\gamma_M$
k_{mod} =	0,9	(NKL 2, kurz)

beam 1			beam 2	
b =	8	cm	12	cm
h =	24	cm	24	cm
A =	192	cm^2		
$W_y=b \cdot h^2/6$ =	768	cm^3		
k_h =	1,00			

3) connection

Balkenschuh Typ 04 aussenliegend Kombi

ArtNR	B	x	H	x	T	nH1 Ø 5	nN2 Ø 5	nH1 Ø 11
30631KOM	80	x	210	x	2	30	16	6

ETA 769	Z-9.1-	EAN 4019346. .	Gewicht KG	Palette	VPE	Preis 1
ETA-08/264	244	100363	0,553	600	25	5,9

$F_{z,Rd}$=15.82kN; half of the number of possibly screws used; screws 5,0*50 (n=8)

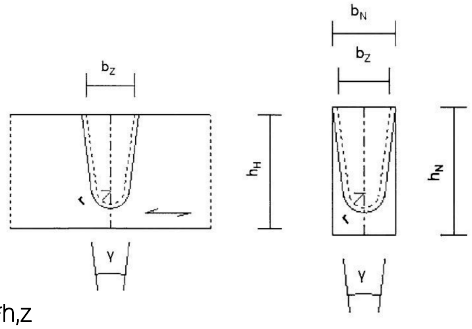
5.10 Terrace – wooden dove tail connection

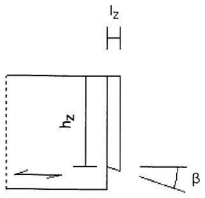
conection dove-tail connection: Z-9.1-649 Zimmerhandwerk e.V.

1) geometry

main member:

b_h =		mm	
h_h =	140	mm	
secundary member:			
b_n =	100	mm	
h_n =	140	mm	
connection:			
h_z =	100	mm	
r=	30	mm	
b_z =	80	mm	≥0,8*h,z
l_z =	28	mm	
t_{eff} =	100	mm	min (bh, 100mm)
δ=	0	°	vertical angular of connection (even)
	0,000	rad	
Ausklinkung (jog)			
α=	0,50	> 0,4	
konstruktiv			
β=	15	°	angle of dove-tail
	0,262	rad	
γ=	7	°	angle of konus
	0,122	rad	





Materials

NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,7	(NKL3, kurz)			
	k_{mod} (outside)=					
	f_{mk} =	2,4	kN/cm²	f_{md} =	1,29	kN/cm²
	f_{vk} =	0,4	kN/cm²	f_{vd} =	0,22	kN/cm²
	$f_{t,90k}$ =	0,04	kN/cm²	$f_{t,90,d}$ =	0,02	kN/cm²
	$f_{c,0,k}$ =	2,1	kN/cm²	$f_{c,0,d}$ =	1,13	kN/cm²

2) design

$$R_{90,d} = \min \left\{ \begin{array}{l} k_{ab} \cdot \frac{h_z}{h_z - r} \left(6{,}5 + \frac{18 \cdot (h_H - h_z + r)^2}{h_H^2} \right) \cdot (t_{ef} \cdot h_H)^{0,8} \cdot f_{t,90,d} \\ \frac{k_v \cdot b_N \cdot (h_z - r)}{1{,}5} \cdot f_{v,d} \end{array} \right.$$

k_{ab} = 1 one side connection

$$k_v = \min \left\{ \begin{array}{ll} 1 & = 1 \\ \frac{k_n}{\sqrt{h_N} \cdot \left(\sqrt{\alpha \cdot (1-\alpha)} + 0{,}4 \cdot \frac{\ell_Z}{h_N} \cdot \sqrt{\frac{1}{\alpha} - \alpha^2} \right)} & = 0{,}70 \end{array} \right.$$

$R_{90,d}$ = min { 7,02 kN
7,01 kN } >= Vd= 1,70kN

6 Fire protection

The calculations for the fire protection are based on DIN EN 1995-1-2; using the simplified procedure as assessed by the ideal residual cross-sections. The most critical members of the construction will be proved for a fire resistance time of 30 minutes as asked in the building codes.

6.1 Roof - Vertical load transmission in case of fire

Most critical member: Roof beam B2, NH C24

Burning rate (graph EC 5, graph 3.2)

$d_{ef} = d_{charakt.} + k_0 * d_0$

k_0 = 1,0 (t=30min > 20min); d_0 = 7mm

$ß_n$ = 0,8 mm/min

$d_{charakt} = ß_n * t = 0,8 * 30 = 24$ mm

d_{ef} = 31 mm

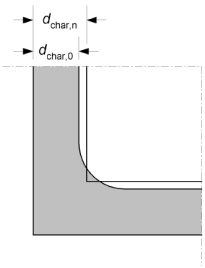


Bild 3.2 — Bemessungswert der Abbrandtiefe $d_{char,0}$ für eindimensionalen Abbrand und die ideelle Abbrandtiefe $d_{char,n}$

Dimension and loads:

C 24, NKL 2

b = 120 mm; h = 240 mm

l = 4,55 m

LEF = 1,315 m

$q_{k,\ man\ load}$	1,00	kN/m²
$q_{k,\ wind}$	0,04	kN/m²
$g_{k,beam}$	0,092	kN/m²
$g_{k,roof}$	1,3	kN/m²

$E_{d,\ fi} = 1,0 * g_k + 0,5 * q_{k,w} + 0,3\ q_k = 1.712$kN/m²

$M_{Ed,fi}$ = 5,83 kNm

Ideal residual cross section (considering member due to fire from 3 sides): b_i = 58 mm; h_i = 209 mm

W_{fi} = 422249,67 mm³; k_{fi} = 1,25 (solid wood)

$M_{Rd,fi} = (1,0 * k_{fi} *(f_k / \gamma_{M,fi}))* W_{fi} =(1,0 * 1,25 * (24\ N/mm^2)/1,0)) * 422249,67\ mm^2$ = 12,67 kNm

$M_{Ed,fi}$ = 5,83 kNm < $M_{Rd,fi}$ = 12,67 kNm

According to EN 1995-1-2 chapter 4.3.1 (2) shear bearing of rectangular and round cross sections

may be neglected.

6.2 Roof - Horizontal load transmission in case of fire

The bracing of the house still needs to be in function during the beginning of a fire. Wind loads may be reduced respectively EN 1995-1-2 as done in chapter 6.1: $W_k=0,5 * q_{k,w}$

The OSB-plate will be burned during the first 30 minutes. Yet the reduced wind loads can be carried by the wood-fibre plate on top of the roof modules. The procedure of the calculation remains the same as in chapter 4.2.1.

1) geometrics roof modules						
roof-module		l =	455,5	cm		
		h =	175	cm		
		l_{eff} =	175	cm		
ribs		b_{inner}=	8	cm		
		b_{outer}=	8	cm		
		h =	24	cm		
		d_{eff} =	3,1	cm		
		A_{Netto}=	37,62	cm^2		
covering		a_r =	49	cm		
		t =	1,6	cm		
		b_{net} =	43	cm		
criteria to build the slab as a shear connection according to simplifying methos of EN 1995-1-1:						
		a_r/t =	30,63	<!	50	
		h/b =	3	<!	4	
2) Materials						
NH C24	γ_M=	1,3		$f_d=f_k \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,9	(NKL2, kurz)			
	k_{mod} (outside)=					
	f_{mk} =	2,4	kN/cm^2	f_{md} =	1,66	kN/cm^2
	f_{vk} =	0,4	kN/cm^2	f_{vd} =	0,28	kN/cm^2
	$f_{c,90k}$ =	0,25	kN/cm^2	$f_{c,90,d}$ =	0,17	kN/cm^2
	$f_{c,0,k}$ =	2,1	kN/cm^2	$f_{c,0,d}$ =	1,45	kN/cm^2
DWD-plate	acc. DIN EN 622					
	γ_M=	1,3		$f_{m,d}=f_{m,k} \cdot k_{mod}/\gamma_M$		
	k_{mod} =	0,6	(NKL 2, kurz)			
	f_{mk} =	0,18	kN/cm^2	f_{md} =	0,08	kN/cm^2
	f_{vk} =	0,25	kN/cm^2	f_{vd} =	0,12	kN/cm^2

3) Designing a) Design of outer ribs (vertical load transmission)						
buckling						
	$i_x = h/\sqrt{12}$ =	6,93			radius of inertia	
	$\lambda = l_{eff}/i$ =	25,26			slimness factor	
	k_c =	0,97			buckling value	
tension and compression forces to be applied on outer ribs:						
	$F_{hd} = 0.5*F_{hk}$ =		6,22	kN		
	$F_{1hc/t}$ = 1,5* Fhd		9,33	kN	outer ribs are slotted,	
					acc. EC5 force has to be	
	$F_{1hc/t}/(A_{netto}*k_c*f_{c0d})$ =		0,18	<! 1	multiplied by 1,5	
shear force:	F_{vd} =		7,55	kN		
b) design for swell stress of the beam:						
	$b_{additonal}$ =	3	cm			
	$A_{eff,outer\ rib}$ =	264	cm^2			
	$k_{c,90}$ =	1,25				
swell stress due to force of outer rib:						
	$N_{ca}/(A_{eff}*k_{c,90}*f_{c,90,d})$=		0,163	<! 1		
c) design of covering						
c.1) fastener:						
	$s_{v,0} = Fv_d/(l*n)$ =		0,02	kN/cm	shear force on fasteners	
	a =		10,00	cm	chosen distance fasteners	
	$F_{vd,Ch} = s_{v,0}*a$ =		0,17	kN	shear force on each fastener	
	$F_{v,Rk}$ =		0,774	kN	cab. cleaving force of clamps	
					clamps d=1,8mm (SBT ch. 9.54)	
	$F_{v,Rd} = k_{mod}*F_{v,Rk}/\gamma_m$ =		0,54	kN	>! $F_{vd,Ch}$	
c. 2) covering:						
	K = 35*t/b_{net} =		1,30	< 1,0	reduction factor	
	$\tau_d = F_{vd}/(a*t)$ =		0,01	kN/cm^2	shear force	
	k_{1v} =		0,83		slotted cover	
	k_{2v} =		0,33		covering just one side	
	$\tau_d/(k_{1v}*k_{2v}*\ K*f_{vd})$ =		0,33	<! 1		

The bolt connection between the modules also just needs to resist the reduced loads according to EC 5. Since the bolts are inside the roof modules, they are not directly exposed to fire in the beginning of a fire. After 20 mins the OSB-covering is damaged. If asked the reduced values of the bolt connection can be distinguished as given in the equations below.

$$R_{k,fi} = k_{conn,fi} \cdot f_{h,1,k} \cdot (t_1 - 30 \cdot \beta_n) \cdot d \cdot \eta$$

$k_{conn,fi}$	Faktor zur Berücksichtigung der Erwärmung des Holzes im Brandfall (inkl. Umrechnung zum 20%-Fraktilwert: k_{fi})
$f_{h,1,k}$	charakteristischer Wert der Lochleibungsfestigkeit des Seitenholzes
t_1	Seitenholzdicke in mm
β_n	Abbrandgeschwindigkeit nach Feuerwiderstandsdauer
d	Durchmesser des Verbindungsmittels in mm
η	Abminderungsfaktor

$$R_{k,fi,Bo} = 0,75 \cdot R_{k,fi,Pb}$$

6.3 Pillar – load transmission in case of fire

Burning rate:

$d_{ef} = d_{charakt.} + k_0 * d_0$

k_0 = 1,0 (t=30min > 20min); d_0 = 7mm

$ß_n$ = 0,7 mm/min (glulam)

$d_{charakt} = ß_n * t = 0,7 * 30 = 21$ mm

$\underline{d_{ef} = 28 \text{ mm}}$

Dimensions and loads:

G24h, NKL 2

b = 200 mm; h = 160 mm

Considering conservatively fire from 4 sides and still horizontal loads gathered by the closed glass facade (where ½ of the horizontal load is considered to be transmitted by the pillars, the other ½ goes in to Floor and Roof modules)

A_{Netto} = 10.4cm * 14.4cm =149.8 cm^2

W_{Netto} = 259.6 cm^3

l = 3,081 m

characteristic vertical loads:

$N_{g,roof,}$ =	2*2.56kN= 5.12	kN
$N_{g,Pillar,}$ =	0.41	kN
$N_{g,facade,}$ =	2*1.1kN= 2.20	kN

$N_{q,roof,}$ =	2*1.315 kN= 5.99	kN
$N_{q,wind,}$ =	$N_{q,wind,roof}$ + $N_{q,facade}$= 0.52	kN

characteristic horizontal loads:

$V_{q,facade,wind}$ =	2*0.57kN= 1.14	kN
$V_{q,pillar/glass\ facade,wind}$ =	0.68kN/m*1.75m/2= 0.60	kNm

$E_{d,\ fi} = 1,0 * g_k + 0,5 * q_{k,w} + 0,3\ q_k$

$N_{Ed,fi}$ = 1.0*7.734kN+ 0.3*5.99kN+0.5*0.52kN= 9.79kN

$M_{Ed,fi}$ = 1.148 kNm

Design:

$F_{c,Rd,fi} = (k_{mod,fi} * k_{fi} *(f_{c,k} / \gamma_{M,fi}))* A_{netto}$ = 361.8kN << $N_{Ed,fi}$

$k_{mod,fi}$=1.0-1/125*u_r/A_r =1.0

k_{fi} = 1,15 (gluelam)

W_{fi} = 149.8cm^3;

$M_{Rd,fi} = (k_{mod,fi} * k_{fi} *(f_k / \gamma_{M,fi}))* W_{fi}$ =(1,0 * 1,15 * (24 N/mm²)/1,0)) * 149.8cm^3= 4,13 kNm

$M_{Ed,fi}$ = 1.148 kNm < $M_{Rd,fi}$ = 4.13 kNm

6.4 Walls – load transmission in case of fire

The Walls W1 and W2 are covered with OSB-covering on both sides, inner and outer side.

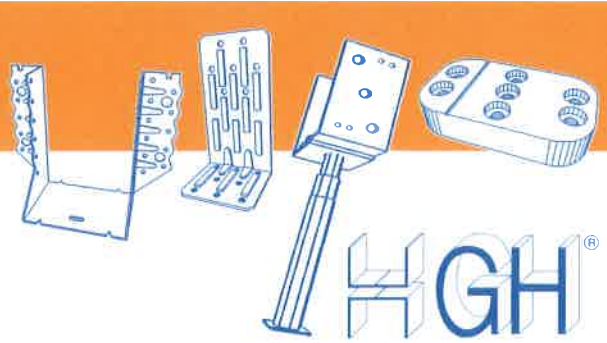
There are no doubts that the outer covering will be able to transmit the reduced loads in case of fire, especially since in the calculations for the bracing just one cover has been considered.

6.5 Floor – load transmission in case of fire

Most critical member is Floor beam FB2. It needs to be proofed in detail if it can withstand the loads in case of fire. Since the beam is covered by a 22mm thick OSB-plate the proof via calculation will be don easily.

7 Appendix A

7.1 Technical approvals and permissions



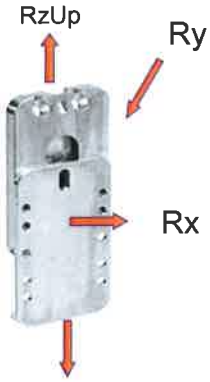
GH Top UV Verbinder

Charakteristische Tragfähigkeit TOP UV



CE 0769

Belastungsrichtungen



$R_{z,Down,Rk}$ nach unten gerichtete Last
$R_{z,Up,Rk}$ nach oben gerichtete Last
$R_{y,Rk}$ 2-achsige beanspruchung
$R_{x,Rk}$ Belastung auf Zug

Anschlußarten:

Haupt-/Nebenträgeranschluß	90 Grad
Haupt-/Nebenträgeranschluß	30 Grad nach unten
Haupt-/Nebenträgeranschluß	90 Grad nach oben
Haupt-/Nebenträgeranschluß	± 45 Grad (links/rechts)

Riegelanschlüsse

Stützenanschlüsse (am HT nur Teilausschraubung bzw. Teilausnagelung)

Nebenträger an Hauptträger

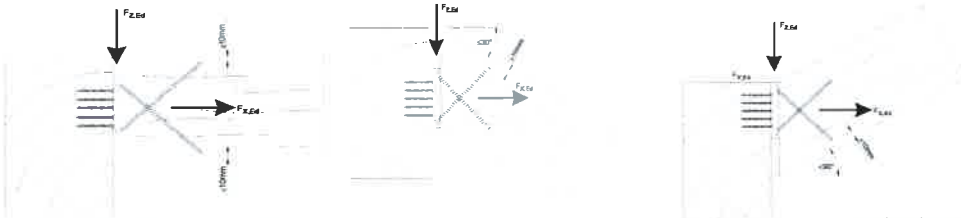
$R_{z,Down,Rk}$ mindestens 2 Schrauben am Nebenträger
$R_{z,Up,Rk}$ 4 Schrauben am Nebenträger zzgl. Schraube zur Abhebesicherung
$R_{y,Rk}$ 4 Schrauben am Nebenträger
$R_{x,Rk}$ 4 Schrauben am Nebenträger

Vollausschraubung am Hauptträger

Min. Höhe Nebenträger [mm]			110			140	165	200
Montagehöhe ab Oberkante Nebenträger [mm]			0			12	27	41
		Nebenträger UV VG Schraube Ø 6,0 x Länge						
		L = [mm]	100	120	140	160	180	200
		TF pro Verbinder in kN						
Schraubenlänge am Hauptträger	5x40	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,50	4,84	4,32
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	5x50	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,68	5,23	4,67
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	5x60	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,68	5,25	4,74
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	5x70	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,68	5,25	4,74
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00

Vollausnagellung am Hauptträger

Min. Höhe Nebenträger [mm]			110			140	165	200
Montagehöhe ab Oberkante Nebenträger [mm]			0			12	27	41
		Nebenträger UV VG Schraube Ø 6,0 x						
		L = [mm]	100	120	140	160	180	200
		TF pro Verbinder in kN						
Nagellänge am Hauptträger	4x40	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	15,88
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	5,94	5,37	4,66	4,11	3,67
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x50	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	5,85	5,07	4,46	3,98
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x60	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,43	4,77	4,26
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x75	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,68	5,24	4,67
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x100	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	15,34	17,13
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	6,16	6,04	5,68	5,25	4,74
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00



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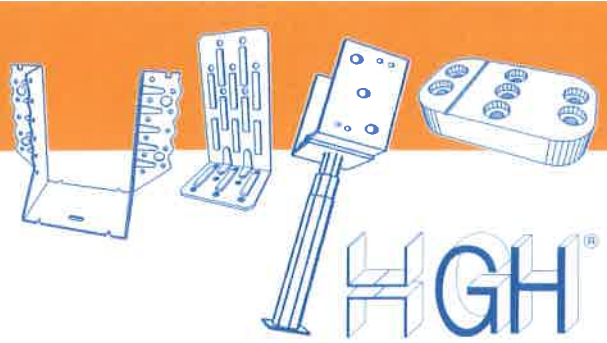
Steuernummer 2869/068/54792
USt.-IdNr. DE811307662
IBAN DE 25 6129 0120 0368 3820 01
BIC GENODESINUE

Erfüllungsort und Gerichtsstand
für beide Teile ist Kirchheim/Teck
Geschäftsführer Dirk Weiss
Amtsgericht Stuttgart HRB Nr. 722555

Es gelten unsere allgemeinen Geschäftsbedingungen



Teilausschraubung 6 Verbindungsmitteln am Hauptträger

Min. Höhe Nebenträger [mm]			110			140	165	200
Montagehöhe ab Oberkante Nebenträger [mm]			0			12	27	41
Nebenträger UV VG Schraube Ø 6,0 x Länge								
		L = [mm]	100	120	140	160	180	200
		TF pro Verbinder in kN						
Schraubenlänge am Hauptträger	5x40	$R_{z,Down,Rk}$	8,21	9,99	11,69	11,69	11,69	11,69
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	4,62	4,62	4,19	3,65	3,23	2,90
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	5x50	$R_{z,Down,Rk}$	8,21	9,99	11,78	12,83	12,83	12,83
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,01	5,01	4,54	3,95	3,49	3,13
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	5x60	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	13,90	13,90
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,39	5,39	4,88	4,25	3,75	3,36
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	5x70	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	14,93	14,93
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,71	5,77	5,22	4,54	4,01	3,59
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00

Anschluß an Stütze

Teilausnagelung mit 6 Verbindungsmitteln an Stütze

Min. Höhe Nebenträger [mm]			110			140	165	200
Montagehöhe ab Oberkante Nebenträger [mm]			0			12	27	41
Nebenträger UV VG Schraube Ø 6,0 x Länge								
		L = [mm]	100	120	140	160	180	200
		TF pro Verbinder in kN						
Nagellänge am Hauptträger	4x40	$R_{z,Down,Rk}$	8,21	9,64	9,64	9,64	9,64	9,64
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	3,89	3,89	3,53	3,09	2,74	2,46
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x50	$R_{z,Down,Rk}$	8,21	9,99	10,76	10,76	10,76	10,76
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	4,26	4,26	3,86	3,37	2,98	2,67
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x60	$R_{z,Down,Rk}$	8,21	9,99	11,69	11,69	11,69	11,69
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	4,57	4,57	4,14	3,61	3,19	2,86
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x75	$R_{z,Down,Rk}$	8,21	9,99	11,78	12,97	12,97	12,97
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,03	5,03	4,55	3,96	3,50	3,13
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00
	4x100	$R_{z,Down,Rk}$	8,21	9,99	11,78	13,56	14,20	14,20
		$R_{z,Up,Rk}$	4,08	4,97	5,85	6,74	7,63	8,52
		$R_{y,Rk}$	5,48	5,48	4,96	4,31	3,81	3,41
		$R_{x,Rk}$	4,00	4,00	4,00	4,00	4,00	4,00

Es gelten unsere allgemeinen Geschäftsbedingungen.

GH-Baubeschläge GmbH
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Kirchheim-Nürtingen eG
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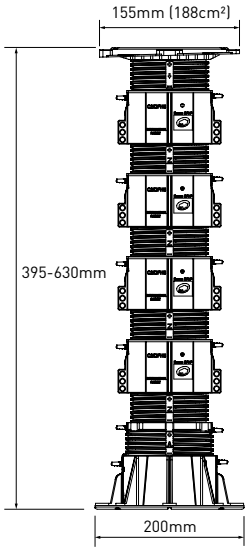
Steuernummer 2869/068/54792
USt.-IdNr. DE811307662
IBAN DE 25 6129 0120 0368 3820 01
BIC GENODES1NUE

Erfüllungsort und Gerichtsstand
für beide Teile ist Kirchheim/Teck
Geschäftsführer Dirk Weiss
Amtsgericht Stuttgart HRB Nr. 722555

Technisches Datenblatt

DPH-9 - Höhe 395-630 mm





Feststellschlüssel: Diese Schlüssel können die Bodenträger in der einmal eingestellten Höhe festgestellt werden.

Verstellbare Höhe

Ohne Unterbrechung einstellbar von 395 bis 630mm mit integrierter Neigungsausgleicher von 0% bis 5%.

Teile

Der DPH-9 besteht aus 8 Teile (Neigungsausgleicher + Kopf + Verstellring + Basis + 4x Verbindungszylinder) + 12 Feststells-chlüssel.

Material

Polypropylen-Copolymer (PP-C), Stärke des Materials von 2 bis 5mm.

Aus 80% wiederverwendbarem PP-C produziert, mit 20% Talk und Master Batch Schwarz (Farbstoff). Zu 100% wiederverwendbar.

Maße vom Stelzlager DPH-9

Durchmesser vom Kopf 145 mm, Oberfläche 165 cm².

Durchmesser der Basis 200 mm, Oberfläche 314 cm².

Leistungen

Beständig gegenüber Alterungen, Unwetter, UV, Chemikalien und Fäulniswidriges Produkt.

Temperaturen : -50°C bis +90°C.

Anwendungen

Bodenträger für Außenterrassen und Flachdächer. Geeignet für : Holz, Stein, Keramik, Glasfaser, Verbundmaterial, Metall. Steht auf allen stabilen Unterböden, einschließlich auf Dämmungsmaterialen.



Neigungsausgleicher PH5

Auf dem Kopf des Stelzlagers integriert. Kompensiert eine Neigung von 0 bis 5% (durch Intervalle von 0,5%).

Zubehör

Fugenteiler: Um einheitliche Fugen zwischen die Platten zu haben. Verfügbar in 2-4,5-6-8 und 10 mm. Auf der Oberfläche des Stützkopfes festgeclipst. Höhe der Fugenteiler : 25 mm

 2 mm

 4,5 mm

 6 mm

 8 mm

 10 mm

Trägerbalkenauflage: Trägt Balken aus Holz, Aluminium oder Verbundmaterial für die meisten Plattformensysteme.

 Balken max. 65 mm
Stärke 4 mm

Ausgleicher: Verbessert die akustische Leistung und ermöglicht den Ausgleich von unterschiedlichen Materialstärken.

 Stärke 1 mm und 2 mm
EPDM-60 Shore

Drucktest : 1 daN = 1kg/f = 2,23 lb/f

Ausgeführt auf der kompletten Oberfläche des Kopfes (1/1), auf einer Hälfte (1/2) und auf einem Viertel (1/4).

Position	Höhe (mm)	Gefälle	Bruchlast (daN)	Bruchlast (lbf)
1/1	630	0%	1420	3167
1/2	630	0%	1000	2230
1/4	630	0%	665	1483
1/1	630	5%	1350	3011
1/2	630	5%	1020	2275
1/4	630	5%	550	1227

Wichtige Bemerkung :

a) Für die Fußgängerzonen muss der durchschnittliche Wert der Belastbarkeit (daN und lbf), die in die Tabelle angegeben ist, durch 2 geteilt werden und einem Sicherheitskoeffizient von -15% reduzieren.

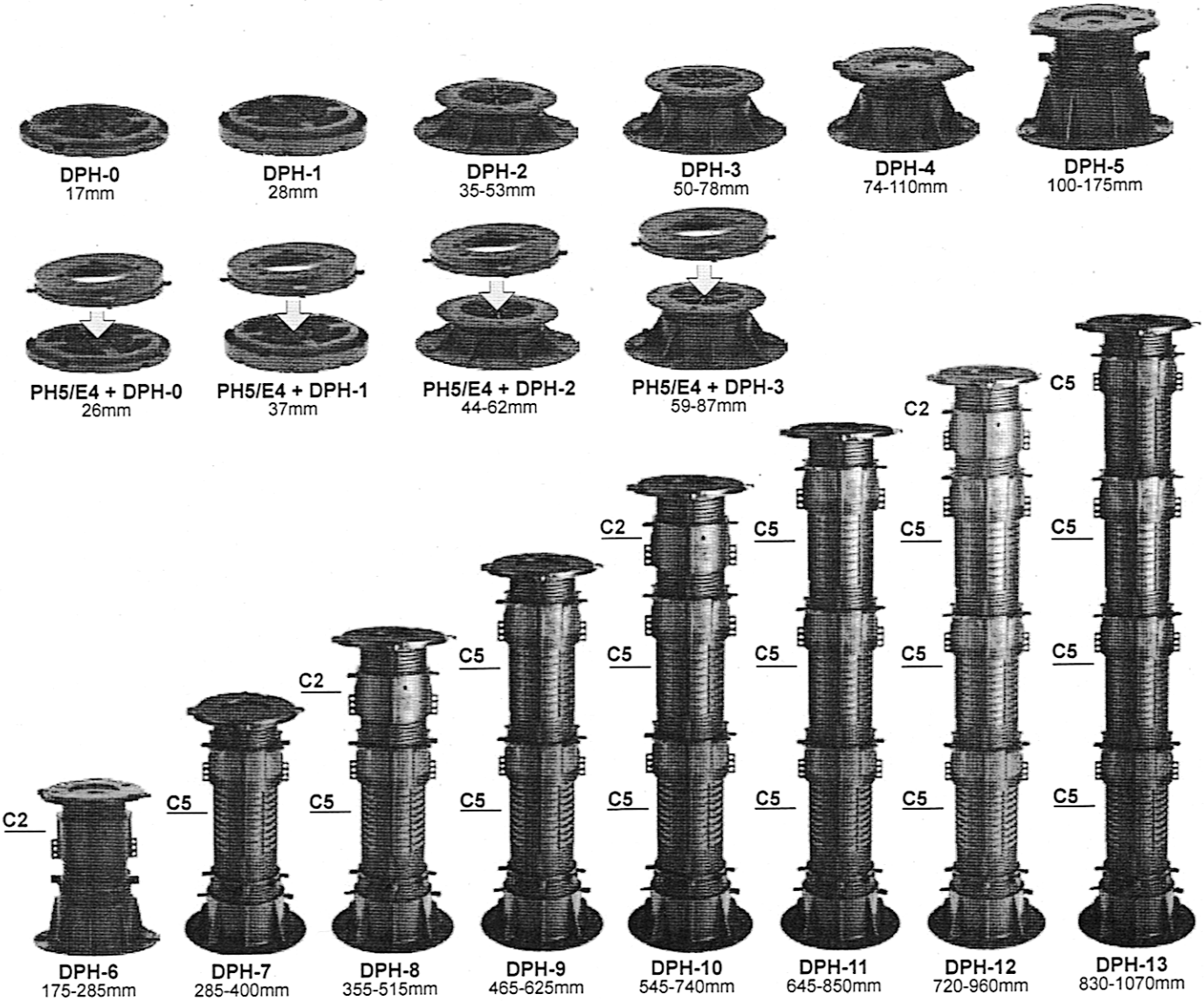
b) Für die technisch erhöhten Böden muss der Wert durch 4 geteilt werden und einem Sicherheitskoeffizient von -15% reduzieren.

Buzon Pedestal International s.a. / n.v.
Z.I. des Hauts-Sarts, Zone 1 – Prolongement rue de l'Abbaye, 134 – B-4040 Herstal – Belgien
Tel. +32 (0) 4 248 39 83 **Fax** +32 (0) 4 264 82 38 **E-Mail** info@buzon-world.com **www.buzon-world.com**

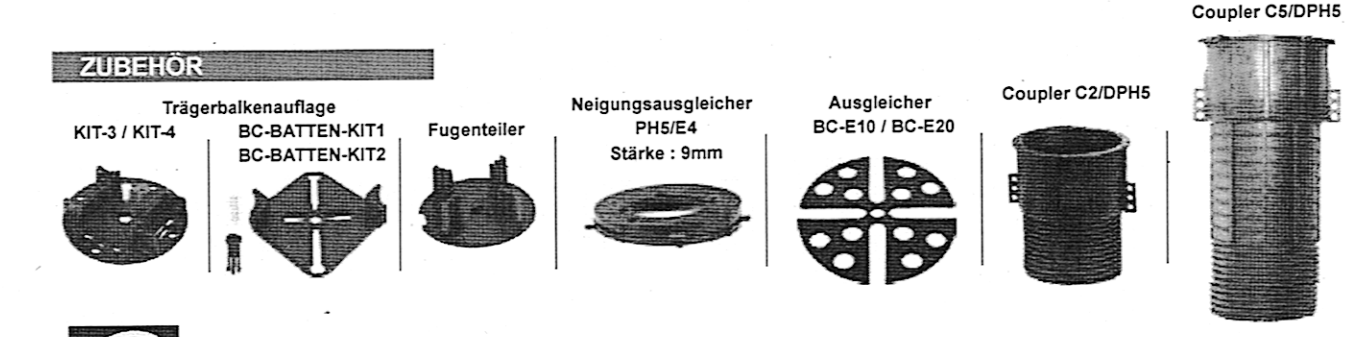
BUZON® DPH-Serie

Verkauf pro Stück oder kartonweise

Die Stelzlager der **DPH-Serie** BUZON zeichnen sich durch den integrierte Neigungsausgleicher (ab DPH-4), der eine Neigung von 0% bis zu 5% ausgleichen kann, und einen Verstellring (ab DPH-5). Es können verschiedene Zubehörteile auf dem Kopf befestigt werden um verschiedene Materialien zu befestigen.



ZUBEHÖR



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HECO SCHRAUBEN

HECO-FIX-plus®
HECO-TOPIX®

Allgemeine bauaufsichtliche Zulassung Z-9.1-453

HECO-FIX-plus®-Schrauben und HECO-TOPIX®-Schrauben
als Holzverbindungsmittel



DIBt

Allgemeine bauaufsichtliche Zulassung

Deutsches Institut für Bautechnik
ANSTALT DES ÖFFENTLICHEN RECHTS

Zulassungsstelle für Bauprodukte und Bauarten
Bautechnisches Prüfamt
Mitglied der Europäischen Organisation für Technische Zulassungen EOTA und der Europäischen Union für das Agrément im Bauwesen UEAtc

Tel.: +49 30 78730-0
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E-Mail: dibt@dibt.de

Datum: 30. September 2009

Geschäftszeichen: II 23-1.9.1-453/09

Zulassungsnummer:
Z-9.1-453

Geltungsdauer bis:
31. August 2014

Antragsteller:
HECO-Schrauben GmbH & Co. KG
Dr.-Kurt-Steim-Straße 28, 78713 Schramberg

Zulassungsgegenstand:
HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben als Holzverbindungsmittel

Deutsches Institut für Bautechnik 33

Der oben genannte Zulassungsgegenstand wird hiermit allgemein bauaufsichtlich zugelassen.
Diese allgemeine bauaufsichtliche Zulassung umfasst zwölf Seiten und 31 Anlagen.
Diese allgemeine bauaufsichtliche Zulassung ersetzt die allgemeine bauaufsichtliche Zulassung Nr. Z-9.1-453 vom 12. Oktober 2005, ergänzt durch den Bescheid vom 23. April 2009. Der Gegenstand ist erstmals am 2. September 1999 allgemein bauaufsichtlich zugelassen worden.

I. ALLGEMEINE BESTIMMUNGEN

1 Mit der allgemeinen bauaufsichtlichen Zulassung ist die Verwendbarkeit bzw. Anwendbarkeit des Zulassungsgegenstandes im Sinne der Landesbauordnungen nachgewiesen.

2 Sofern in der allgemeinen bauaufsichtlichen Zulassung Anforderungen an die besondere Sachkunde und Erfahrung der mit der Herstellung von Bauprodukten und Bauarten betrauten Personen nach den § 17 Abs. 5 Musterbauordnung entsprechenden Länderregelungen gestellt werden, ist zu beachten, dass diese Sachkunde und Erfahrung auch durch gleichwertige Nachweise anderer Mitgliedstaaten der Europäischen Union belegt werden kann. Dies gilt ggf. auch für im Rahmen des Abkommens über den Europäischen Wirtschaftsraum (EWR) oder anderer bilateraler Abkommen vorgelegte gleichwertige Nachweise.

3 Die allgemeine bauaufsichtliche Zulassung ersetzt nicht die für die Durchführung von Bauvorhaben gesetzlich vorgeschriebenen Genehmigungen, Zustimmungen und Bescheinigungen.

4 Die allgemeine bauaufsichtliche Zulassung wird unbeschadet der Rechte Dritter, insbesondere privater Schutzrechte, erteilt.

5 Hersteller und Vertreiber des Zulassungsgegenstandes haben, unbeschadet weiter gehender Regelungen in den "Besonderen Bestimmungen", dem Verwender bzw. Anwender des Zulassungsgegenstandes Kopien der allgemeinen bauaufsichtlichen Zulassung zur Verfügung zu stellen und darauf hinzuweisen, dass die allgemeine bauaufsichtliche Zulassung an der Verwendungsstelle vorliegen muss. Auf Anforderung sind den beteiligten Behörden Kopien der allgemeinen bauaufsichtlichen Zulassung zur Verfügung zu stellen.

6 Die allgemeine bauaufsichtliche Zulassung darf nur vollständig vervielfältigt werden. Eine auszugsweise Veröffentlichung bedarf der Zustimmung des Deutschen Instituts für Bautechnik. Texte und Zeichnungen von Werbeschriften dürfen der allgemeinen bauaufsichtlichen Zulassung nicht widersprechen. Übersetzungen der allgemeinen bauaufsichtlichen Zulassung müssen den Hinweis "Vom Deutschen Institut für Bautechnik nicht geprüfte Übersetzung der deutschen Originalfassung" enthalten.

7 Die allgemeine bauaufsichtliche Zulassung wird widerruflich erteilt. Die Bestimmungen der allgemeinen bauaufsichtlichen Zulassung können nachträglich ergänzt und geändert werden, insbesondere, wenn neue technische Erkenntnisse dies erfordern.



II. BESONDERE BESTIMMUNGEN

1 Zulassungsgegenstand und Anwendungsbereich

1.1 Zulassungsgegenstand

Die HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben nach dieser allgemeinen bauaufsichtlichen Zulassung sind Holzverbindungsmittel aus verzinktem oder nichtrostendem Stahl. Sie dienen zum Anschluss von Holzbauteilen aus Vollholz (Nadelholz) und Brettschichtholz, aus allgemein bauaufsichtlich zugelassenem Furnierschichtholz, Brett- oder Balkenlagenholz, aus Holzwerkstoffen oder von Stahlteilen an Holzbauteile aus Vollholz (Nadelholz) und Brettschichtholz oder aus Furnierschichtholz, Brett- oder Balkenlagenholz.

1.2 Anwendungsbereich

Die HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben dürfen als Holzverbindungsmittel für tragende Holzkonstruktionen angewendet werden, die nach den Normen DIN 1052[1] zu bemessen und auszuführen sind, soweit in dieser allgemeinen bauaufsichtlichen Zulassung nichts anderes bestimmt ist.

Die Bemessung darf auch nach DIN V ENV 1995-1-1:1994-06-Eurocode 5: Entwurf, Berechnung und Bemessung von Holzbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau in Verbindung mit dem Nationalen Anwendungsdokument "Richtlinie zur Anwendung von DIN V ENV 1995-1-1", Ausgabe Februar 1995, erfolgen, soweit nachstehend nichts anderes bestimmt ist.

Die Schrauben dürfen für Verbindungen von Holzbauteilen nach allgemeinen bauaufsichtlichen Zulassungen verwendet werden, wenn nach der jeweiligen für das Holzbauteil erteilten allgemeinen bauaufsichtlichen Zulassung die Herstellung von Holzverbindungen mit allgemein bauaufsichtlich zugelassenen Schrauben zulässig ist.

Holzbauteile, an die der Anschluss erfolgt, müssen eine Mindestdicke von $4 \cdot d_1$ (d_1 = Gewindeaußendurchmesser der jeweiligen Schraube) aufweisen.

Die HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben dürfen nicht für Anschlüsse an nachfolgend genannte Holzwerkstoffe eingesetzt werden. Mit den HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben dürfen jedoch die nachfolgend genannten Holzwerkstoffplatten an Holzbauteile nach Abschnitt 1.1 angeschlossen werden:

- Sperrholz nach DIN EN 13986[2] (DIN EN 636[3]) und DIN V 20000-1[4] oder nach allgemeiner bauaufsichtlicher Zulassung
- Kunstharzgebundene Spanplatten nach DIN EN 13986 (DIN EN 312[5]) und DIN V 20000-1 oder nach allgemeiner bauaufsichtlicher Zulassung

Deutsches Institut für Bautechnik

[1] Es gelten die Technischen Bestimmungen:

DIN 1052-1:1988-04	Holzbauwerke; Berechnung und Ausführung
DIN 1052-2:1988-04	Holzbauwerke; Mechanische Verbindungen
DIN 1052-3:1988-04	Holzbauwerke; Holzhäuser in Tafelbauart; Berechnung und Ausführung
DIN 1052-1/A1 bis -3/A1:1996-10	Änderung A1
oder DIN 1052:2008-12	Entwurf, Berechnung und Bemessung von Holzbauwerken; Allgemeine Bemessungsregeln und Bemessungsregeln für den Hochbau

Die Anwendbarkeit der zitierten Normen richtet sich nach den Technischen Baubestimmungen der Länder.

[2] DIN EN 13986:2005-03 Holzwerkstoffe zur Verwendung im Bauwesen – Eigenschaften, Bewertung der Konformität und Kennzeichnung

[3] DIN EN 636:2003-11 Sperrholz - Anforderungen

[4] DIN V 20000-1:2005-12 Anwendung von Bauprodukten in Bauwerken – Teil 1: Holzwerkstoffe

[5] DIN EN 312:2003-11 Spanplatten - Anforderungen

- OSB-Platten (Oriented Strand Board) des Typs OSB/3 und OSB/4 nach DIN EN 13986 (DIN EN 300[6]) und DIN V 20000-1 oder OSB-Platten nach allgemeiner bauaufsichtlicher Zulassung
- Faserplatten nach DIN EN 13986 (DIN EN 622-2[7] und 622-3[8]) und DIN V 20000-1 bzw. nach allgemeiner bauaufsichtlicher Zulassung, Mindestrohdichte 650 kg/m^3
- Zementgebundene Spanplatten nach allgemeiner bauaufsichtlicher Zulassung.

In Holzbauteile aus Vollholz, Brettschichtholz und aus Furnierschichtholz, Brett- oder Balkenlagenholz dürfen Schrauben mit einem Gewindeaußendurchmesser $d_1 \geq 8$ mm nur bei Verwendung der Holzarten Fichte, Kiefer oder Tanne eingeschraubt werden. Dies gilt auch für das Einschrauben in Holzbauteile nach allgemeinen bauaufsichtlichen Zulassungen.

Die Schrauben dürfen nur für vorwiegend ruhende Belastungen (siehe DIN 1055-3: 2006-03) verwendet werden.

Für den Anwendungsbereich der Schrauben je nach den Umweltbedingungen gilt bei Schrauben aus verzinktem Stahl die Norm DIN 1052-2:1988-04, Abschnitt 3.6, mit Tabelle 1 oder DIN 1052:2008-12 mit Tabelle 2, bei Schrauben aus nichtrostendem Stahl die allgemeine bauaufsichtliche Zulassung Nr. Z-30.3-6[9]. Schrauben aus verzinktem Stahl dürfen im Anwendungsbereich nach DIN 1052-2:1988-04, Tabelle 1, letzte Spalte, oder DIN 1052: 2008-12, Tabelle 2, Spalte 3 nicht verwendet werden.

2 Bestimmungen für die HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben

2.1 Eigenschaften und Zusammensetzung

2.1.1 Form, Maße und Abmaße der Schrauben müssen den Anlagen 1 bis 29 entsprechen.

2.1.2 Die Schrauben müssen den beim Deutschen Institut für Bautechnik hinterlegten Produktspezifikationen entsprechen.

2.1.3 Die Schrauben müssen als charakteristische Werte der Zugtragfähigkeit mindestens die Werte der Tabelle 1 aufweisen.

Tabelle 1: Charakteristische Werte der Zugtragfähigkeit $R_{t,u,k}$

Verzinkte Schrauben		Schrauben aus nichtrostendem Stahl	
Gewindeaußendurchmesser d_1	Charakteristische Werte der Zugtragfähigkeit $R_{t,u,k}$	Gewindeaußendurchmesser d_1	Charakteristische Werte der Zugtragfähigkeit $R_{t,u,k}$
mm	kN	mm	kN
3,5	3,7	3,5	2,7
4,0	4,8	4,0	3,5
4,5	6,0	4,5	4,5
5,0	7,5	5,0	5,5
6,0	11,0	6,0	7,9
8,0	19,0	8,0	14,0
10,0	30,0	10,0	22,0

Deutsches Institut für Bautechnik

6 DIN EN 300:1997-06 Platten aus langen, schlanken, ausgerichteten Spänen (OSB) – Definitionen – Klassifizierung und Anforderungen

7 DIN EN 622-2:2003-10 Faserplatten – Anforderungen – Teil 2: Anforderungen an harte Platten

8 DIN EN 622-3:2003-10 Faserplatten – Anforderungen – Teil 3: Anforderungen an mittelharte Platten

9 Z-30.3-6 Erzeugnisse, Verbindungsmittel und Bauteile aus nichtrostenden Stählen

2.1.4 Der charakteristische Wert des Bruchdrehmomentes muss für jeden Gewindeaußendurchmesser folgende Bedingung erfüllen:

$M_{t,u,k} \geq 1{,}5 \cdot M_{E,k}$ (1)

Hierin bedeuten:

$M_{t,u,k}$ charakteristischer Wert des Bruchdrehmomentes der Schraube

$M_{E,k}$ charakteristischer Wert des Einschraubdrehmomentes der Schraube

Die Schrauben müssen als charakteristische Werte des Bruchdrehmomentes mindestens die Werte der Tabelle 2 aufweisen.

Tabelle 2: Charakteristische Werte des Bruchdrehmomentes $M_{t,u,k}$

Verzinkte Schrauben		Schrauben aus nichtrostendem Stahl	
Gewindeaußendurchmesser d_1	Charakteristische Werte des Bruchdrehmomentes $M_{t,u,k}$	Gewindeaußendurchmesser d_1	Charakteristische Werte des Bruchdrehmomentes $M_{t,u,k}$
mm	Nm	mm	Nm
3,5	2,0	3,5	1,8
4,0	2,6	4,0	2,7
4,5	4,0	4,5	3,8
5,0	5,8	5,0	5,1
6,0	10,0	6,0	8,4
8,0	22,0	8,0	18,0
10,0	37,0	10,0	31,0

2.1.5 Die Schrauben müssen ohne abzubrechen um einen Winkel von 45° biegbar sein.

2.1.6 Form, Maße und Abmaße der Unterlegscheiben (HECO – Rosetten) müssen den Anlagen 30 und 31 entsprechen. Die Unterlegscheiben müssen aus Stahl sein. Die Unterlegscheiben dürfen auch Scheiben nach DIN 436 oder DIN EN ISO 7094 mit entsprechender Nenngröße sein.

2.2 Kennzeichnung

Die Verpackung der Schrauben oder der Lieferschein der Schrauben müssen vom Hersteller mit dem Übereinstimmungszeichen (Ü-Zeichen) nach den Übereinstimmungszeichen-Verordnungen der Länder gekennzeichnet werden. Die Kennzeichnung darf nur erfolgen, wenn die Voraussetzungen nach Abschnitt 2.3 erfüllt sind.

Darüber hinaus müssen die Verpackung oder der Lieferschein folgende Angaben enthalten:

- Bezeichnung des Zulassungsgegenstandes (bei Schrauben aus nichtrostendem Stahl ist die Bezeichnung "nichtrostend" und die Bezeichnung der Stahlsorte zur Einordnung in die Widerstandsklassen nach der allgemeinen bauaufsichtlichen Zulassung Nr. Z-30.3-6 hinzuzufügen)
- Schraubengröße

2.3 Übereinstimmungsnachweis

2.3.1 Allgemeines

Die Bestätigung der Übereinstimmung der Schrauben mit den Bestimmungen dieser allgemeinen bauaufsichtlichen Zulassung muss für jedes Herstellwerk mit einem Übereinstimmungszertifikat auf der Grundlage einer werkseigenen Produktionskontrolle und einer regelmäßigen Fremdüberwachung einschließlich einer Erstprüfung der Schrauben nach Maßgabe der folgenden Bestimmungen erfolgen.

Deutsches Institut für Bautechnik

Für die Erteilung des Übereinstimmungszertifikats und die Fremdüberwachung einschließlich der dabei durchzuführenden Produktprüfungen hat der Hersteller der Schrauben eine hierfür anerkannte Zertifizierungsstelle sowie eine hierfür anerkannte Überwachungsstelle einzuschalten.

Dem Deutschen Institut für Bautechnik ist von der Zertifizierungsstelle eine Kopie des von ihr erteilten Übereinstimmungszertifikats zur Kenntnis zu geben.

2.3.2 Werkseigene Produktionskontrolle

In jedem Herstellwerk ist eine werkseigene Produktionskontrolle einzurichten und durchzuführen. Unter werkseigener Produktionskontrolle wird die vom Hersteller vorzunehmende kontinuierliche Überwachung der Produktion verstanden, mit der dieser sicherstellt, dass die von ihm hergestellten Bauprodukte den Bestimmungen dieser allgemeinen bauaufsichtlichen Zulassung entsprechen.

Die werkseigene Produktionskontrolle soll mindestens die im Folgenden aufgeführten Maßnahmen einschließen:

- Der Rohdraht ist mindestens mit Werkszeugnis "2.2" nach DIN EN 10204[10] zu beziehen; anhand der Prüfbescheinigung ist die Einhaltung der Anforderungen nach Abschnitt 2.1.2 zu überprüfen
- Prüfung der Zugtragfähigkeit und des Bruchdrehmomentes der Schrauben, auf eine dieser Prüfungen darf verzichtet werden, wenn in Abstimmung mit der Überwachungsstelle aus der durchgeführten Prüfung auch auf die Einhaltung der Anforderungen an die nicht geprüfte Eigenschaft geschlossen werden kann
- 45° - Biegeprüfung
- Prüfung der Maße der Schrauben

Weitere Einzelheiten der werkseigenen Produktionskontrolle sind im Überwachungsvertrag zu regeln.

Die Ergebnisse der werkseigenen Produktionskontrolle sind aufzuzeichnen und auszuwerten. Die Aufzeichnungen müssen mindestens folgende Angaben enthalten:

- Bezeichnung des Bauprodukts bzw. des Ausgangsmaterials und der Bestandteile
- Art der Kontrolle oder Prüfung
- Datum der Herstellung und der Prüfung des Bauprodukts bzw. des Ausgangsmaterials oder der Bestandteile
- Ergebnis der Kontrollen und Prüfungen und, soweit zutreffend, Vergleich mit den Anforderungen
- Unterschrift des für die werkseigene Produktionskontrolle Verantwortlichen

Die Aufzeichnungen sind mindestens fünf Jahre aufzubewahren und der für die Fremdüberwachung eingeschalteten Überwachungsstelle vorzulegen. Sie sind dem Deutschen Institut für Bautechnik und der zuständigen obersten Bauaufsichtsbehörde auf Verlangen vorzulegen.

Bei ungenügendem Prüfergebnis sind vom Hersteller unverzüglich die erforderlichen Maßnahmen zur Abstellung des Mangels zu treffen. Bauprodukte, die den Anforderungen nicht entsprechen, sind so zu handhaben, dass Verwechslungen mit übereinstimmenden ausgeschlossen werden. Nach Abstellung des Mangels ist - soweit technisch möglich und zum Nachweis der Mängelbeseitigung erforderlich - die betreffende Prüfung unverzüglich zu wiederholen.

2.3.3 Fremdüberwachung

In jedem Herstellwerk ist die werkseigene Produktionskontrolle durch eine Fremdüberwachung regelmäßig zu überprüfen, mindestens jedoch zweimal jährlich.

Deutsches Institut für Bautechnik
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[10] DIN EN 10204:2005-01 Metallische Erzeugnisse – Arten von Prüfbescheinigungen

Im Rahmen der Fremdüberwachung ist eine Erstprüfung der Schrauben durchzuführen und können auch Proben für Stichprobenprüfungen entnommen werden. Die Probenahme und Prüfungen obliegen jeweils der anerkannten Überwachungsstelle.

Die Einhaltung der Anforderung nach Gleichung (1) ist bei der Fremdüberwachung zumindest an Schrauben aus nichtrostendem Stahl mit Gewindeaußendurchmessern $d_1 \geq 6$ mm zu überprüfen.

Die Ergebnisse der Zertifizierung und Fremdüberwachung sind mindestens fünf Jahre aufzubewahren. Sie sind von der Zertifizierungsstelle bzw. der Überwachungsstelle dem Deutschen Institut für Bautechnik und der zuständigen obersten Bauaufsichtsbehörde auf Verlangen vorzulegen.

3 Bestimmungen für die Bemessung

3.1 Allgemeines

Für die Bemessung von Holzkonstruktionen unter Verwendung der HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben gilt DIN 1052, soweit im Folgenden nichts anderes bestimmt ist. Für die Holzbauteile sind gegebenenfalls die allgemeinen bauaufsichtlichen Zulassungen zu beachten.

Die Bemessung darf unter Berücksichtigung der entsprechenden nachstehenden Bestimmungen auch nach DIN V ENV 1995-1-1:1994-06 (in Verbindung mit dem Nationalen Anwendungsdokument) erfolgen.

Einschraubtiefen $s_g < 4 \cdot d_1$ (d_1 = Gewindeaußendurchmesser) dürfen nicht in Rechnung gestellt werden.

Tragende Verbindungen mit HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben müssen mindestens zwei Schrauben enthalten.

3.2 Bemessung nach DIN 1052-1 bis -3:1988-04

3.2.1 Beanspruchung rechtwinklig zur Schraubenachse

Die zulässige Schraubenbelastung im Lastfall H bei Beanspruchung rechtwinklig zur Schraubenachse darf mit

$$\text{zul } N = 4 \cdot a_1 \cdot d_1, \text{ höchstens } 17 \cdot d_1^2 \text{ (in N)} \quad (2)$$

und beim Aufschrauben von Stahlteilen auf Holz mit

$$\text{zul } N = 1{,}25 \cdot 17 \cdot d_1^2 \text{ (in N)}, \quad (3)$$

in Rechnung gestellt werden,

mit dem Gewindeaußendurchmesser d_1 gemäß den Anlagen 1 bis 29 in mm und a_1 als Dicke des anzuschließenden Holzes bzw. Holzwerkstoffes in mm.

Sofern die Einschraubtiefe s (siehe DIN 1052-2:1988-04, Bild 21) nicht mindestens $8 \cdot d_1$ beträgt, ist die zulässige Belastung im Verhältnis der Einschraubtiefe s zur Solltiefe $8 \cdot d_1$ zu mindern.

3.2.2 Beanspruchung auf Herausziehen

Die zulässige Schraubenbelastung im Lastfall H für unter einem Winkel $45° \leq \alpha \leq 90°$ (α = Winkel zwischen Schraubenachse und Holzfaserrichtung) eingedrehte Schrauben bei kurzfristiger und ständiger Beanspruchung auf Herausziehen darf mit

$$\text{zul } N_Z = 6{,}0 \cdot s_g \cdot d_1 \text{ (in N)} \quad \text{für } 3{,}5 \text{ mm} \leq d_1 \leq 5{,}0 \text{ mm} \quad (4)$$

$$\text{zul } N_Z = 5{,}0 \cdot s_g \cdot d_1 \text{ (in N)} \quad \text{für } 6{,}0 \text{ mm} \leq d_1 \leq 10{,}0 \text{ mm} \quad (5)$$

in Rechnung gestellt werden.

Hierin sind d_1 der Gewindeaußendurchmesser gemäß den Anlagen 1 bis 29 in mm und s_g die Einschraubtiefe (siehe DIN 1052-2:1988-04, Bild 21) in mm. Als Einschraubtiefe s_g darf höchstens die Gewindelänge L_V bzw. L_T gemäß den Anlagen 1 bis 29 in Rechnung gestellt werden.

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Aufgrund der Kopf-Durchziehgefahr darf die zulässige Schraubenbelastung höchstens

zul $N_Z = 5{,}0 \cdot d_k^2$ (in N) (6)

und beim Anschluss von Holzbauteilen mit Dicken von ≥ 12 bis ≤ 20 mm höchstens

zul $N_Z = 4{,}0 \cdot d_k^2$ (in N) (7)

betragen.

Hierin ist d_k der Kopfdurchmesser der Schraube bzw. der Außendurchmesser der Unterlegscheibe gemäß den Anlagen 1 bis 31 in mm.

Beim Anschluss von Platten aus Holzwerkstoffen dürfen bei Plattendicken unter 12 mm höchstens 200 N in Rechnung gestellt werden, wobei die Mindestdicken nach Abschnitt 3.1 einzuhalten sind.

Für Stahlblech-Holz-Verbindungen sind die Gleichungen (6) und (7) nicht maßgebend.

Aufgrund der Zugtragfähigkeit darf die Schraubenbelastung die Werte nach Tabelle 3 nicht überschreiten.

Tabelle 3: Zulässige Belastung der Schrauben auf Zug

Verzinkte Schrauben		Schrauben aus nichtrostendem Stahl	
Gewindeaußendurchmesser d_1	Zulässige Belastung auf Zug	Gewindeaußendurchmesser d_1	Zulässige Belastung auf Zug
mm	kN	mm	kN
3,5	1,8	3,5	1,2
4,0	2,3	4,0	1,6
4,5	2,8	4,5	1,9
5,0	3,8	5,0	2,3
6,0	5,0	6,0	3,3
8,0	7,5	8,0	5,0
10,0	12,0	10,0	8,0

3.2.3 Kombinierte Beanspruchung

Für kombinierte Beanspruchung gilt:

$$\left(\frac{N_Z}{\text{zul } N_Z}\right)^2 + \left(\frac{N}{\text{zul } N}\right)^2 \leq 1 \qquad (8)$$

3.3 Bemessung nach DIN 1052:2008-12 oder nach DIN V ENV 1995-1-1 (in Verbindung mit dem Nationalen Anwendungsdokument)

3.3.1 Beanspruchung rechtwinklig zur Schraubenachse

Als Schraubennenndurchmesser d darf bei der Bemessung nach DIN 1052:2008-12 oder nach DIN V ENV 1995-1-1:1994-06 der Gewindeaußendurchmesser d_1 nach den Anlagen 1 bis 29 in Rechnung gestellt werden.



Für die charakteristischen Werte des Fließmomentes der Schrauben gilt Tabelle 4:

Tabelle 4: Charakteristische Werte des Fließmomentes der Schrauben $M_{y,k}$

Verzinkte Schrauben		Schrauben aus nichtrostendem Stahl	
Gewindeaußen-durchmesser d_1	Charakteristische Werte des Fließ-momentes $M_{y,k}$	Gewindeaußen-durchmesser d_1	Charakteristische Werte des Fließ-momentes $M_{y,k}$
mm	Nm	mm	Nm
3,5	2,3	3,5	1,9
4,0	3,3	4,0	2,8
4,5	4,5	4,5	3,7
5,0	5,9	5,0	4,9
6,0	9,5	6,0	7,9
8,0	20,0	8,0	17,0
10,0	36,0	10,0	30,0

3.3.2 Beanspruchung in Schraubenschaftrichtung

Der charakteristische Wert des Ausziehwiderstandes für unter einem Winkel $45° \le \alpha \le 90°$ (α = Winkel zwischen Schraubenachse und Holzfaserrichtung) eingedrehte Schrauben darf mit:

$$R_{ax,k} = \frac{f_{1,k} \cdot \ell_{ef} \cdot d_1}{\sin^2 \alpha + \frac{4}{3}\cos^2 \alpha} \quad \text{(in N)} \qquad (9)$$

in Rechnung gestellt werden.

Hierin bedeuten:

d_1 = Gewindeaußendurchmesser der Schraube in mm

l_{ef} = Gewindelänge im Holzteil mit der Schraubenspitze in mm. Einschraubtiefen l_{ef} kleiner als $4 \cdot d_1$ dürfen nicht in Rechnung gestellt werden

$f_{1,k}$ = charakteristischer Wert des Ausziehparameters in N/mm²

$100 \cdot 10^{-6} \cdot \rho_k^2$ für 3,5 mm $\le d_1 \le$ 5,0 mm

$80 \cdot 10^{-6} \cdot \rho_k^2$ für 6,0 mm $\le d_1 \le$ 10,0 mm

ρ_k = charakteristische Rohdichte in kg/m³, die charakteristische Rohdichte ρ_k für Furnierschichtholz ist mit maximal 420 kg/m³ in Rechnung zu stellen

α = Winkel zwischen Schraubenachse und Holzfaserrichtung, $45° \le \alpha \le 90°$

ρ_k = charakteristische Rohdichte des Holzes in kg/m³

Aufgrund der Kopf-Durchziehgefahr darf der charakteristische Wert des Ausziehwiderstandes höchstens mit

$$R_{ax,k} = 80 \cdot 10^{-6} \cdot \rho_k^2 \cdot d_k^2 \text{ (in N)}, \qquad (10a)$$

bei Verwendung von Unterlegscheiben und bei Sechskant- und Tellerkopfschrauben mit

$$R_{ax,k} = 100 \cdot 10^{-6} \cdot \rho_k^2 \cdot d_k^2 \text{ (in N)}, \qquad (10b)$$

in Rechnung gestellt werden.

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Hierin bedeuten:

d_k = Kopfdurchmesser der Schraube bzw. Außendurchmesser der Unterlegscheibe gemäß den Anlagen 1 bis 31 in mm.

ρ_k = charakteristische Rohdichte des Holzes in kg/m³

Beim Anschluss von Holzbauteilen mit Dicken von ≥ 12 bis ≤ 20 mm sind die Werte nach den Gleichungen (10a) und (10b) mit dem Faktor 0,8 abzumindern. Dabei ist ρ_k mit 380 kg/m³ in Rechnung zu stellen.

Beim Anschluss von Platten aus Holzwerkstoffen dürfen bei Plattendicken unter 12 mm höchstens 400 N in Rechnung gestellt werden, wobei die Mindestdicken nach Abschnitt 3.1 einzuhalten sind.

Für Stahlblech-Holz-Verbindungen sind die Gleichungen (10a) und (10b) nicht maßgebend.

Aufgrund der Zugtragfähigkeit darf die Schraubenbelastung die aus den charakteristischen Werten der Zugtragfähigkeit $R_{t,u,k}$ nach Tabelle 1 ermittelten Bemessungswerte nicht überschreiten.

3.3.3 Kombinierte Beanspruchung

Bei Verbindungen, die sowohl durch eine Einwirkung in Schaftrichtung der Schraube (F_{ax}) als auch rechtwinklig dazu (F_{la}) beansprucht werden, ist nachzuweisen, dass

$$\left(\frac{F_{ax,d}}{R_{ax,d}}\right)^2 + \left(\frac{F_{la,d}}{R_{la,d}}\right)^2 \leq 1 \qquad (11)$$

ist. Hierin sind $F_{ax,d}$ und $F_{la,d}$ die Bemessungswerte der Einwirkungen in bzw. rechtwinklig zur Schraubenschaftrichtung und $R_{ax,d}$ und $R_{la,d}$ die Bemessungswerte der Tragfähigkeit der Verbindungen im Falle der alleinigen Beanspruchung in bzw. rechtwinklig zur Schraubenschaftrichtung.

4 Bestimmungen für die Ausführung

4.1 Für die Ausführung gilt DIN 1052 soweit im Folgenden nichts anderes bestimmt ist. Für die Holzbauteile sind gegebenenfalls die allgemeinen bauaufsichtlichen Zulassungen zu beachten.

4.2 Die Schrauben dürfen nur zum Anschluss von Holzbauteilen aus Vollholz (Nadelholz) und Brettschichtholz, aus Furnierschichtholz, Brett- oder Balkenlagenholz, aus Holzwerkstoffen nach Abschnitt 3.1 oder von Stahlteilen an Holzbauteile aus Vollholz (Nadelholz) und Brettschichtholz oder aus Furnierschichtholz, Brett- oder Balkenlagenholz verwendet werden.

Die Schrauben dürfen für Verbindungen von Holzbauteilen nach allgemeinen bauaufsichtlichen Zulassungen verwendet werden, wenn nach der jeweiligen für das Holzbauteil erteilten allgemeinen bauaufsichtlichen Zulassung die Herstellung von Holzverbindungen mit allgemein bauaufsichtlich zugelassenen Schrauben zulässig ist.

Holzbauteile, an die der Anschluss erfolgt, müssen eine Mindestdicke von $4 \cdot d_1$ (d_1 = Gewindeaußendurchmesser der jeweiligen Schraube) aufweisen.

Diese allgemeine bauaufsichtliche Zulassung umfasst nicht Anschlüsse an Spanplatten inkl. OSB-Platten, Faserplatten oder Sperrholz.

In Holzbauteile aus Vollholz, Brettschichtholz und aus Furnierschichtholz, Brett- oder Balkenlagenholz dürfen Schrauben mit einem Gewindeaußendurchmesser $d_1 \geq 8$ mm nur bei Verwendung der Holzarten Fichte, Kiefer oder Tanne eingeschraubt werden. Dies gilt sinngemäß auch für das Einschrauben in Holzbauteile nach allgemeinen bauaufsichtlichen Zulassungen.

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4.3 Für das Einschrauben der Schrauben dürfen nur die vom Hersteller empfohlenen Einschraubgeräte verwendet werden.

Die Schraubenlöcher in Stahlteilen müssen mit einem geeigneten Durchmesser vorgebohrt werden. Die Schraubenlöcher in zementgebundenen Spanplatten müssen mit $0,7 \cdot d_1$ vorgebohrt werden. In Holzbauteile sind die Schrauben ohne Vorbohren einzuschrauben.

Das Schraubengewinde darf auch im aufgeschraubten Holzbauteil sein.

Die Schrauben sind bei Holzbauteilen so zu versenken, dass der Schraubenkopf mit der Oberfläche des angeschlossenen Teils bündig ist. Ein tieferes Versenken ist unzulässig.

Die Senkkopfschrauben der Durchmesser d_1 = 6mm, 8 mm und 10 mm dürfen zusammen mit Rosetten nach den Anlagen 30 und 31 verwendet werden. Die Sechskant- und die Tellerkopfschrauben dürfen zusammen mit Unterlegscheiben nach Abschnitt 2.1.6 zum Einsatz kommen. Rosetten und Unterlegscheiben müssen in Form und Werkstoff zu den Schrauben passen und nach dem Einschrauben vollflächig am Holz anliegen. Unterlegscheiben aus Kohlenstoffstahl dürfen nur mit Schrauben aus Kohlenstoffstahl und Unterlegscheiben aus nichtrostendem Stahl dürfen nur mit Schrauben aus nichtrostendem Stahl verwendet werden.

4.4 Als Mindestabstände der Schrauben müssen die Werte nach DIN 1052, wie bei Nägeln mit nicht vorgebohrten Nagellöchern, eingehalten werden, wobei als Schraubendurchmesser der Gewindeaußendurchmesser d_1 nach den Anlagen 1 bis 29 in Rechnung zu stellen ist.

Bei Douglasie sind die Mindestabstände in Faserrichtung um 50 % zu erhöhen.

Bei Schrauben mit einem Gewindeaußendurchmesser $d_1 \geq 8$ mm muss der Abstand vom beanspruchten und unbeanspruchten Rand parallel der Faserrichtung mindestens $15 \cdot d_1$ betragen.

Wenn der Abstand in Faserrichtung untereinander und zum Hirnholzende mindestens $25 \cdot d_1$ beträgt, darf der Abstand zum unbeanspruchten Rand rechtwinklig zur Faserrichtung auf $3 \cdot d_1$ verringert werden.

Für die Mindestabstände bei Holzbauteilen nach allgemeinen bauaufsichtlichen Zulassungen gelten die Bestimmungen der allgemeinen bauaufsichtlichen Zulassungen.

Bei planmäßig ausschließlich in Schaftrichtung beanspruchten HECO-TOPIX-Schrauben dürfen bei Einhaltung einer Mindestholzdicke von $t = 12 \cdot d_1$ folgende Mindestabstände zugrunde gelegt werden:

Achsabstand a_1 der Schrauben untereinander in einer Ebene parallel zur Faserrichtung: $a_1 = 5 \cdot d_1$

Achsabstand a_2 der Schrauben untereinander rechtwinklig zu einer Ebene parallel zur Faserrichtung: $a_2 = 5 \cdot d_1$

Abstand $a_{1,c}$ des Schwerpunktes des im Holz eingedrehten Schraubenteils von der Hirnholzfläche: $a_{1,c} = 5 \cdot d_1$

Abstand $a_{2,c}$ des Schwerpunktes des im Holz eingedrehten Schraubenteils von der Seitenholzfläche: $a_{2,c} = 4 \cdot d_1$

Der Achsabstand a_2 darf bis auf $2,5 \cdot d_1$ verringert werden, wenn für jede Schraube eine Anschlussfläche $a_1 \cdot a_2 = 25 \cdot d_1^2$ eingehalten ist.

4.5 Bei Schrauben mit einem Gewindeaußendurchmesser d_1 = 8 mm muss die Dicke der anzuschließenden Holzbauteile mindestens 30 mm, bei Schrauben mit einem Gewindeaußendurchmesser d_1 = 10 mm mindestens 40 mm betragen.

Beim Anschluss von Holzwerkstoffplatten mit HECO-Fix-plus-Schrauben und HECO-TOPIX-Schrauben an Holzbauteile nach Abschnitt 1.1 muss deren Plattendicke mindestens $1,2 \cdot d_1$ betragen (d_1 = Gewindeaußendurchmesser der Schraube).

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Darüber hinaus muss die Plattendicke mindestens

6 mm bei Sperrholz und Faserplatten und

8 mm bei kunstharzgebundene Spanplatten, OSB-Platten und zementgebundenen Spanplatten betragen.

Für die Mindestdicken von Holzbauteilen nach allgemeinen bauaufsichtlichen Zulassungen gelten die Bestimmungen der allgemeinen bauaufsichtlichen Zulassungen.

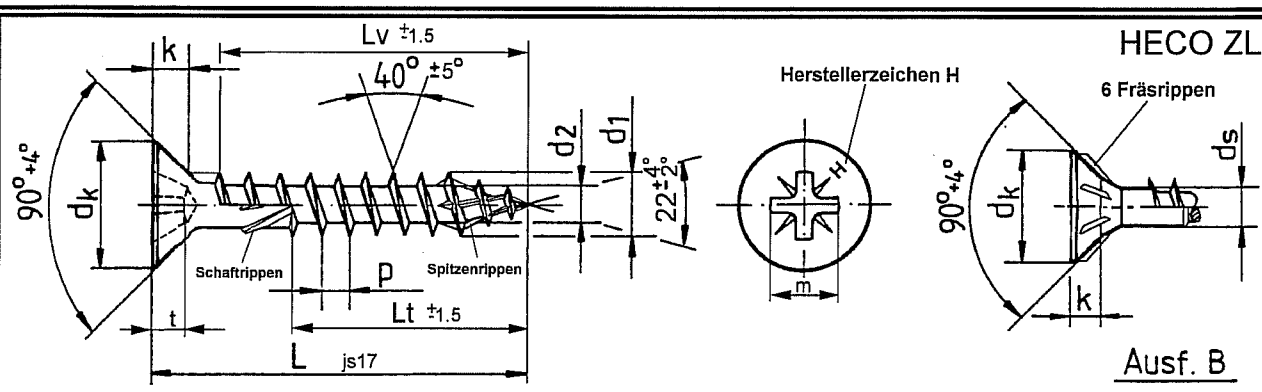
Henning



HECO-TOPIX

Senkkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,05	2,3	2,55	3,0	3,55	5,05	6,2
	untere Tol	2,4	2,65	2,95	3,4	3,95	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,45	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,65	4,4	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,7	2,05	2,64	3,0	3,0	3,86	5,2
	untere Tol	2,06	2,51	3,1	3,45	3,45	4,32	5,65
m		4,0	4,4	4,9	5,3	6,6	8,5	9,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*" ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

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andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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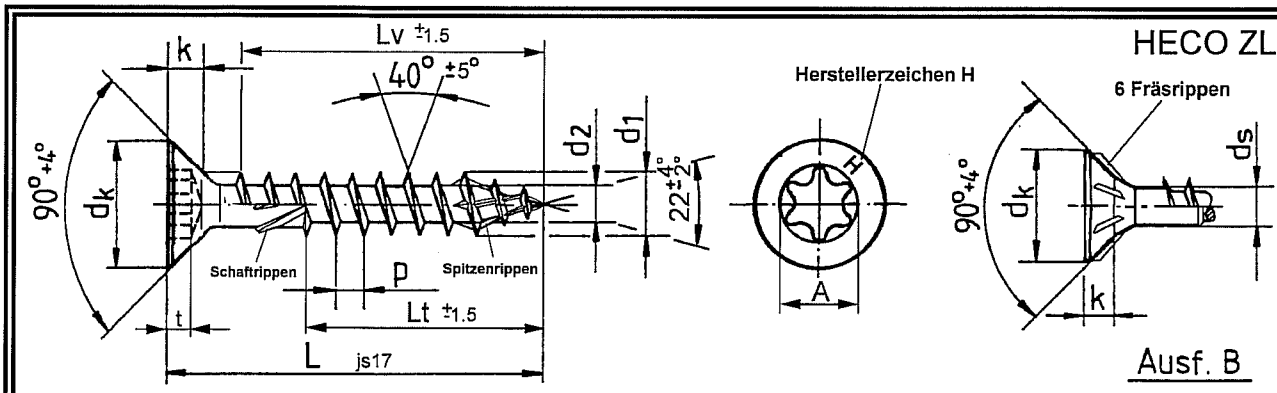
Anlage 1
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Senkkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,05	2,3	2,55	3,0	3,55	5,05	6,2
	untere Tol	2,4	2,65	2,95	3,4	3,95	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,45	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,65	4,4	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*" ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

Deutsches Institut

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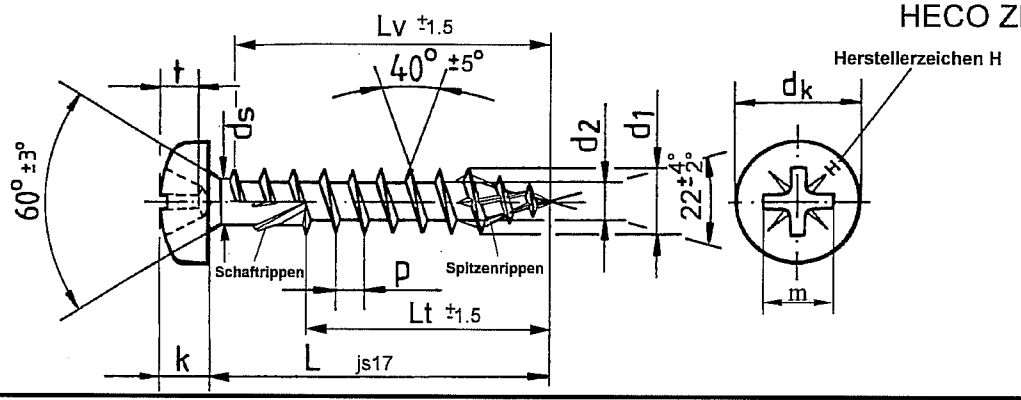
Anlage 2
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Rundkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,05	2,3	2,55	3,0	3,55	5,05	6,2
	untere Tol	2,4	2,65	2,95	3,4	3,95	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,45	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,65	4,4	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,6	2,2	2,26	2,59	3,02	3,71	5,23
	untere Tol	1,85	2,46	2,72	3,15	3,48	4,17	5,69
m		3,8	4,4	4,6	5,1	6,7	8,5	9,9

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*“ ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

Deutsches Institut für Bautechnik
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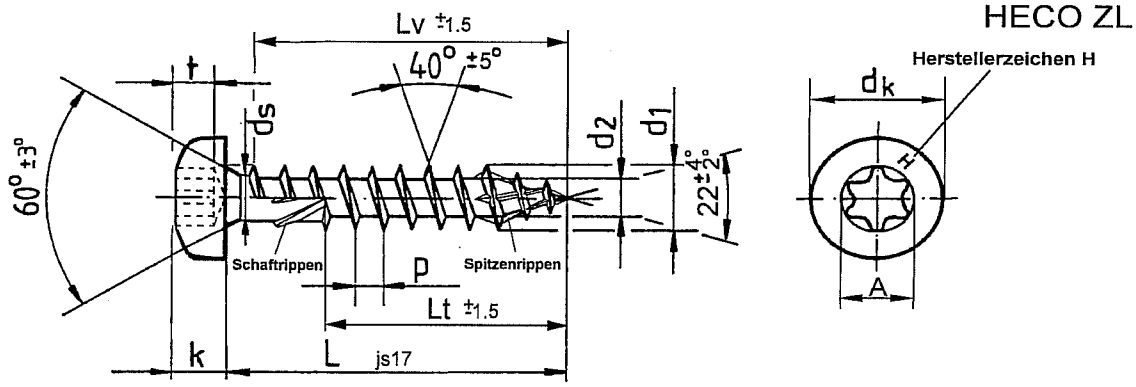
Anlage 3
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Rundkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		Ø 3,5	Ø 4,0	Ø 4,5	Ø 5,0	Ø 6,0	Ø 8,0	Ø 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,05	2,3	2,55	3,0	3,55	5,05	6,2
	untere Tol	2,4	2,65	2,95	3,4	3,95	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,45	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,65	4,4	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,6	2,2	2,26	2,69	3,02	2,85	3,4
	untere Tol	1,85	2,46	2,72	3,15	3,48	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*“ ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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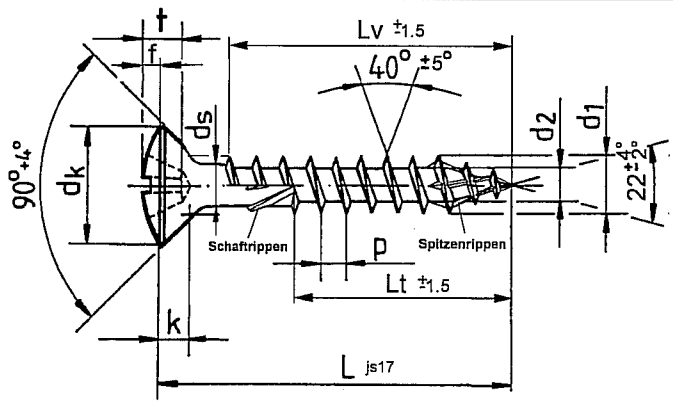
Anlage 4
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

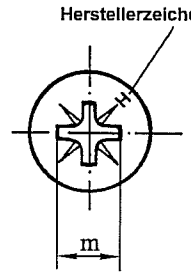
HECO-TOPIX

Linsenkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



HECO ZL



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,35	4,0 +0,35	4,5 +0,35	5,0 +0,4	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,20	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,9	1,0	1,15	1,15	1,55	1,7	2,8
	untere Tol	1,2	1,3	1,55	1,55	1,95	2,2	3,3
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,65	2,26	2,69	2,89	3,4	4,06	5,71
	untere Tol	2,11	2,72	3,15	3,35	3,86	4,52	6,17
m		4,0	4,6	5,1	5,3	7,1	8,8	10,4

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*“ ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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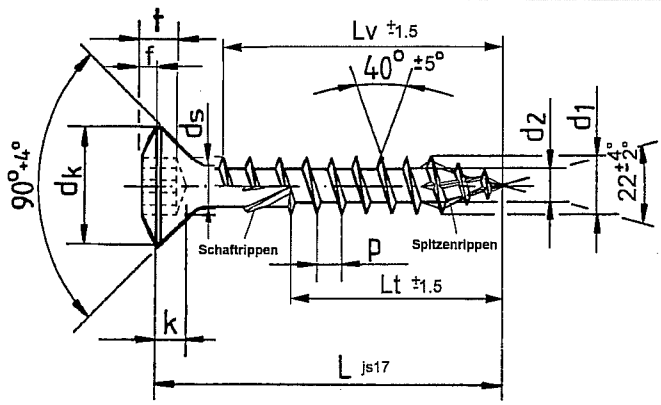
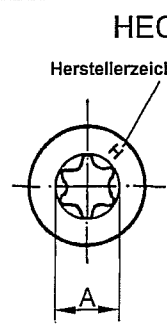
Anlage 5
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Linsenkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl





Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,05	2,3	2,55	3,0	3,55	5,05	6,2
	untere Tol	2,4	2,65	2,95	3,4	3,95	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,45	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,65	4,4	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,75	1,0	0,95	0,95	1,55	1,7	2,8
	untere Tol	1,05	1,3	1,35	1,35	1,95	2,2	3,3
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45	60		60	
90								55		55	60		60	
100								60		60	60		80	
110								60		60	70		80	
120								60		60	70		80	
130										60	70		80	
140		Lv und „*" ohne Schaftrippen								60	70		80	
150										60	70		80	
160										60	70		100	
180										60	100		100	
190										60	100		100	
200										60	100		100	
220 - 300	in 20mm Abstufung									60	100		100	
320 - 400	in 20mm Abstufung									60	100		100	
420 - 500	in 20mm Abstufung									60	100		100	

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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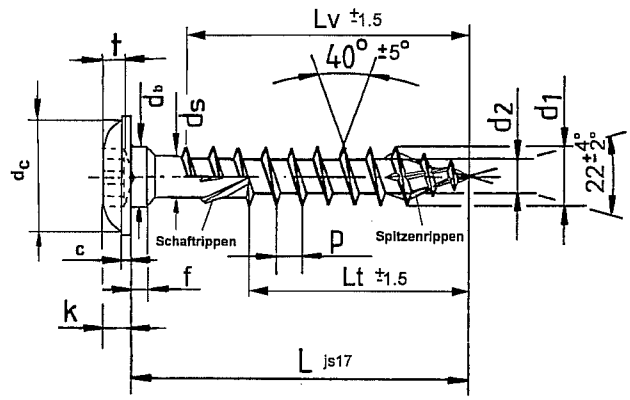
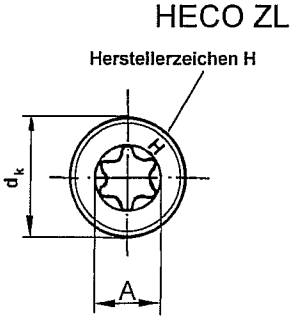
Anlage 6
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Tellerkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl





Nenngröße					∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol. untere Tol				6 +0,4 -0,1	8 +0,4 -0,1	10 +0,45 -0,1
d_2	obere Tol. untere Tol				3,95 3,55	5,05 5,45	6,2 6,65
d_c	obere Tol. untere Tol				14 +1 -1	17,5 +1 -1	22,5 +1 -1
d_b	obere Tol. untere Tol				6 +0,4 -0,1	8 +0,5 -0,5	10 +0,5 -0,5
d_s	obere Tol. untere Tol				4,4 4,2	5,6 5,8	6,9 7,1
dk					ca. 12	ca. 16	ca. 20
P ±10%					4,5	6,0	7,5
k	obere Tol. untere Tol				2,9 2,2	3,3 4,0	3,5 4,2
f	obere Tol. untere Tol				1,8 1,1	2,0 2,6	2,0 2,6
c	obere Tol. untere Tol				1,7 1,2	2,0 1,5	2,3 1,7
Antrieb Gr.					T25	T40	T40
t	obere Tol. untere Tol				2,7 2,4	3,5 2,6	4,0 3,0
A					4,5	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
40							33					
50							43		40			
60							53		50			
70							60		60			
80							70	60	70	60		60
90								70	80	60		60
100								70	80	60		60
120								70	100	70		80
140								70		70		80
160								70		100		100
180								70		100		100
200								70		100		100
220								70		100		100
240								70		100		100
260								70		100		100
280								70		100		100
300-400	in 20mm Abstufung							70		100		100

Deutsches Institut für Bautechnik
33

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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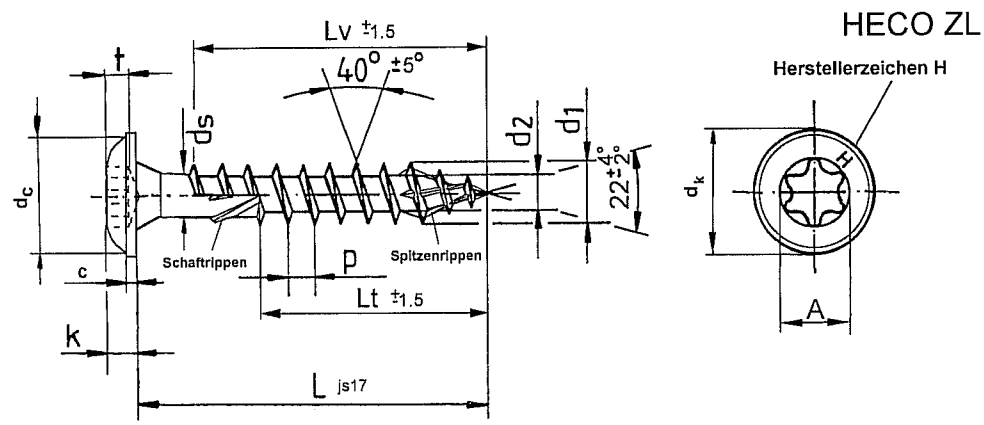
Anlage 7
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Tellerkopfschraube mit T-Drive, Variante

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße						Ø 8,0	Ø 10,0
d_1	obere Tol. untere Tol					8 +0,4 -0,1	10 +0,45 -0,1
d_2	obere Tol. untere Tol					5,05 5,45	6,2 6,65
d_k	obere Tol. untere Tol					23 +1 -1	28 +1 -1
d_s	obere Tol. untere Tol					5,6 5,8	6,9 7,1
d_c						ca. 13	ca. 16
P ±10%						6,0	7,5
k	obere Tol. untere Tol					3,3 4,0	3,5 4,2
f	obere Tol. untere Tol					2,0 2,6	2,0 2,6
c	obere Tol. untere Tol					2,0 1,5	2,3 1,7
Antrieb Gr.						T40	T40
t	obere Tol. untere Tol					3,5 2,6	4,0 3,0
A						6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt			Lv	Lt	Lv	Lt
40												
50									40			
60									50			
70									60			
80									70	60		60
90									80	60		60
100									80	60		60
120									100	70		80
140										70		80
160										100		100
180										100		100
200										100		100
220										100		100
240										100		100
260										100		100
280										100		100
300-400	in 20mm Abstufung									100		100

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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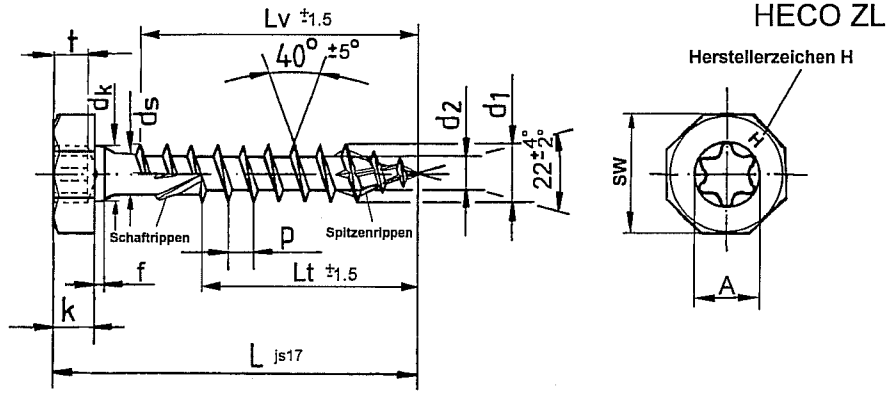
Anlage 8
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Sechskantkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße								∅ 10,0
d_1	obere Tol. untere Tol							10 +0,45 -0,1
d_2	obere Tol. untere Tol							6,2 6,65
SW	obere Tol. untere Tol							15 +0 -0,33
d_k	obere Tol. untere Tol							10 +0 -0,2
d_s	obere Tol. untere Tol							6,9 7,1
P ±10%								7,5
k	obere Tol. untere Tol							5,3 4,7
f	obere Tol. untere Tol							1,7 2,3
Antrieb Gr.								T40
t	obere Tol. untere Tol							3,1 3,6
A								6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
80														60
90														60
100														60
120														70
140														70
160														100
180														100
200														100
220														100
240														100
260														100
280														100
300														100
320														100
340														100
360														100
400														100

Deutsches Institut für Bautechnik 33

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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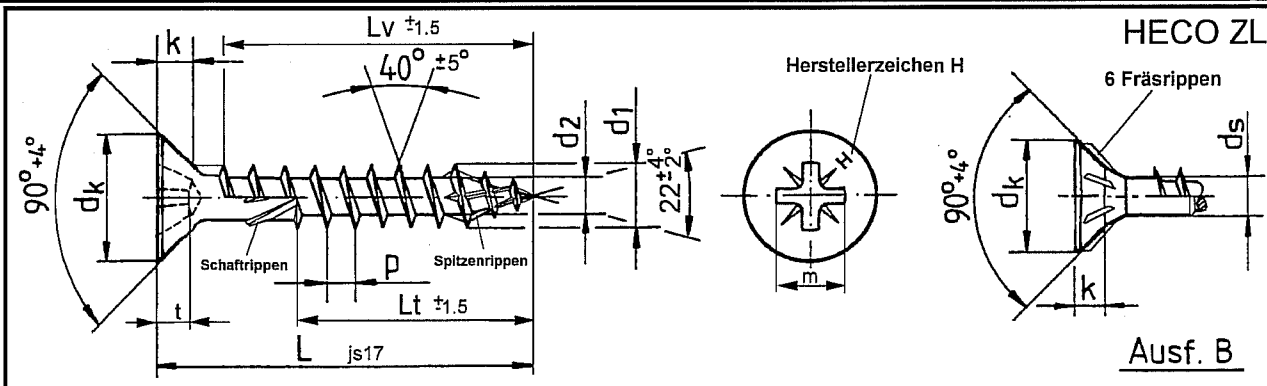
Anlage 9
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Senkkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,2	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,7	2,05	2,64	3,0	3,0	3,86	5,2
	untere Tol	2,06	2,51	3,1	3,45	3,45	4,32	5,65
m		4,0	4,4	4,9	5,3	6,6	8,5	9,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*" ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

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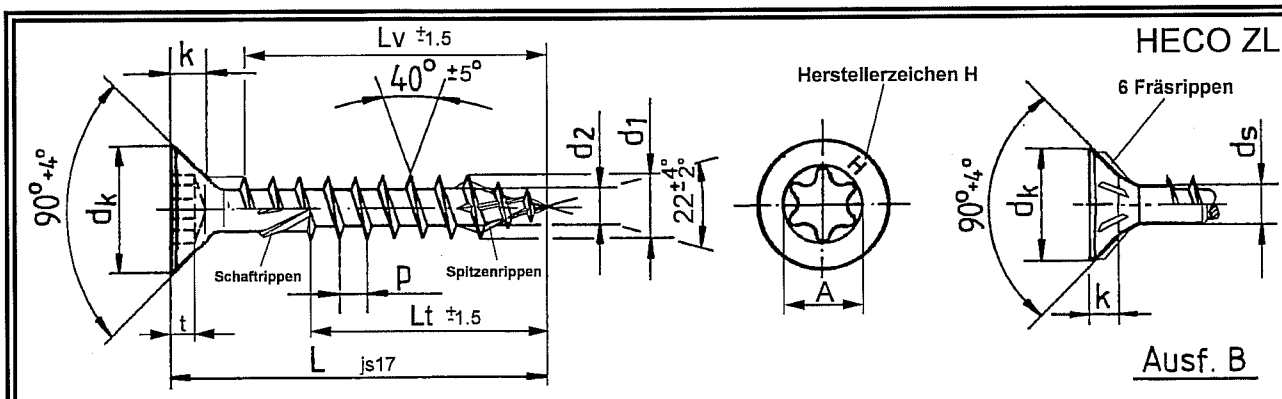
Anlage 10
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Senkkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,2	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*" ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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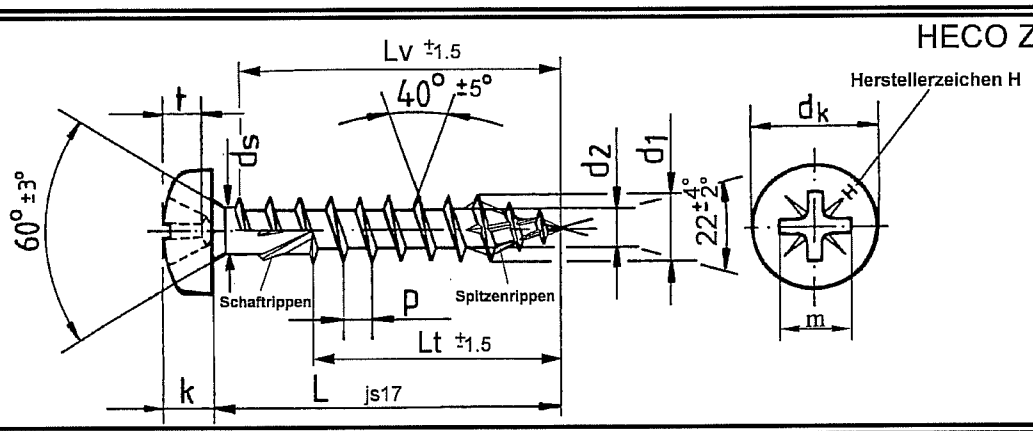
Anlage 11
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Rundkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,2	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,6	2,2	2,26	2,59	3,02	3,71	5,23
	untere Tol	1,85	2,46	2,72	3,15	3,48	4,17	5,69
m		3,8	4,4	4,6	5,1	6,7	8,5	9,9

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*" ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

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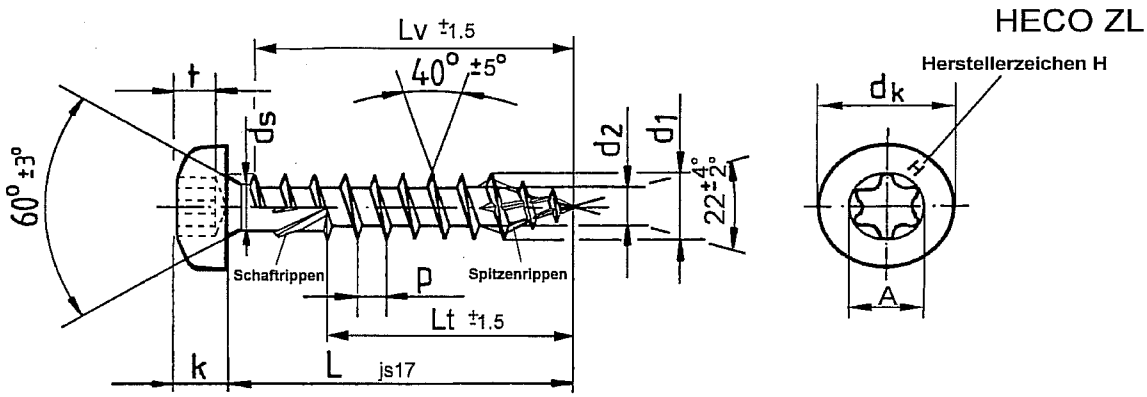
Anlage 12
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Rundkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		Ø 3,5	Ø 4,0	Ø 4,5	Ø 5,0	Ø 6,0	Ø 8,0	Ø 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,2	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,6	2,2	2,26	2,69	3,02	2,85	3,4
	untere Tol	1,85	2,46	2,72	3,15	3,48	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*“ ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

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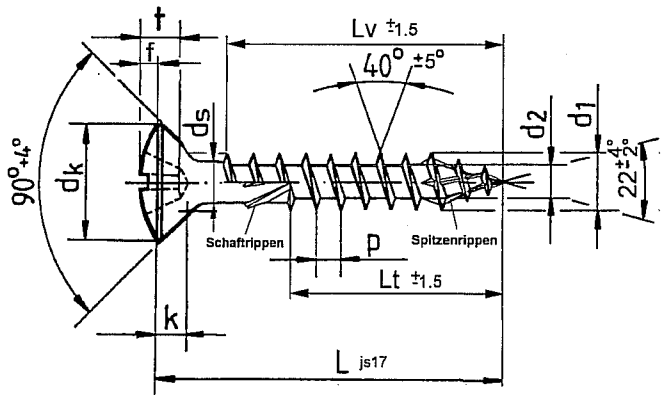
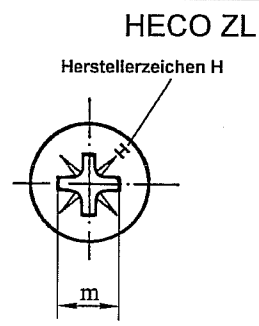
Anlage 13
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Linsenkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl





Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,35	4,0 +0,35	4,5 +0,35	5,0 +0,4	6,0 +0,4	8,0 +0,4	10 +0,45
	untere Tol	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,2	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,9	1,0	1,15	1,15	1,55	1,7	2,8
	untere Tol	1,2	1,3	1,55	1,55	1,95	2,2	3,3
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,65	2,26	2,69	2,89	3,4	4,06	5,71
	untere Tol	2,11	2,72	3,15	3,35	3,86	4,52	6,17
m		4,0	4,6	5,1	5,3	7,1	8,8	10,4

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*" ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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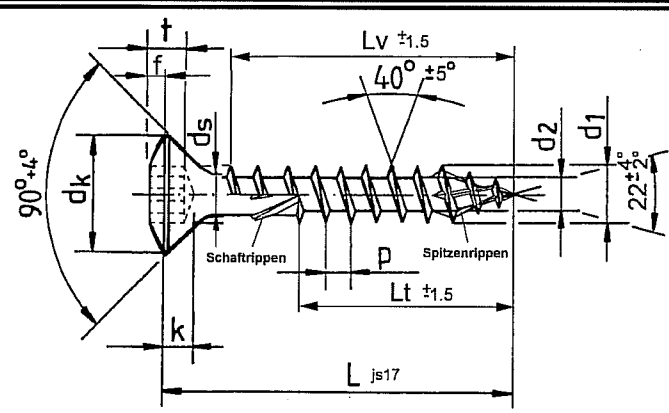
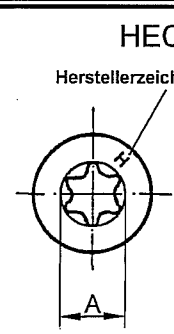
Anlage 14
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Linsenkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl





Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,3	4,0 +0,3	4,5 +0,3	5,0 +0,35	6,0 +0,4	8,0 +0,4	10 +0,45
	untere	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
d_2	obere Tol.	2,2	2,6	2,85	3,35	4,05	5,05	6,2
	untere Tol	2,55	2,95	3,25	3,7	4,4	5,45	6,65
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,55	2,95	3,25	3,7	4,5	5,6	6,9
	untere Tol	2,75	3,15	3,45	3,9	4,7	5,8	7,1
P ±10%		2,6	3,0	3,4	3,8	4,5	6,0	7,5
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,75	1,0	0,95	0,95	1,55	1,7	2,8
	untere Tol	1,05	1,3	1,35	1,35	1,95	2,2	3,3
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
20	16													
25	21		20		20		20							
30	26	18*	25	20	24	20	24		24					
35	31	21*	30	20	29	20	29	20	28					
40	36	24*	35	25	34	25	34	23	33					
45	41	27*	40	25	39	25	39	28	38					
50	46	31*	45	30	44	30	44	28	43	30				
55			50	35	49	30	49	38	48	30				
60			54	35	54	35	54	38	53	35				
65				40	60	35	60	38	58	35				
70				40	60	40	60	42	60	40				
75						40	60	42	60	40				
80						50	60	47	60	45		60		60
90								55		55		60		60
100								60		60		60		80
110								60		60		70		80
120								60		60		70		80
130										60		70		80
140		Lv und „*“ ohne Schaftrippen								60		70		80
150										60		70		80
160										60		70		100
180										60		100		100
190										60		100		100
200										60		100		100
220 - 300	in 20mm Abstufung									60		100		100
320 - 400	in 20mm Abstufung									60		100		100
420 - 500	in 20mm Abstufung									60		100		100

Deutsches Institut für Bautechnik

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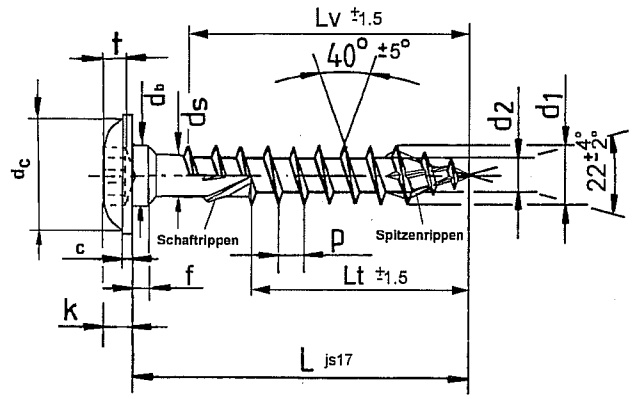
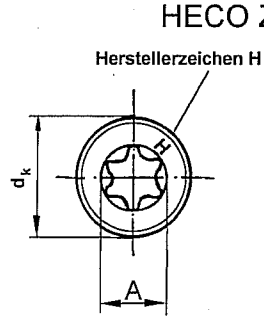
Anlage 15
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Tellerkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl





Nenngröße					∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol. untere Tol				6 +0,4 -0,1	8 +0,4 -0,1	10 +0,45 -0,1
d_2	obere Tol. untere Tol				3,95 3,55	5,05 5,45	6,2 6,65
d_c	obere Tol. untere Tol				14 +1 -1	17,5 +1 -1	22,5 +1 -1
d_b	obere Tol. untere Tol				6 +0,4 -0,1	8 +0,5 -0,5	10 +0,5 -0,5
d_s	obere Tol. untere Tol				4,4 4,2	5,6 5,8	6,9 7,1
dk					ca. 12	ca. 16	ca. 20
P ±10%					4,5	6,0	7,5
k	obere Tol. untere Tol				2,9 2,2	3,3 4,0	3,5 4,2
f	obere Tol. untere Tol				1,8 1,1	2,0 2,6	2,0 2,6
c	obere Tol. untere Tol				1,7 1,2	2,0 1,5	2,3 1,7
Antrieb Gr.					T25	T40	T40
t	obere Tol. untere Tol				2,7 2,4	3,5 2,6	4,0 3,0
A					4,5	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
40							33					
50							43		40			
60							53		50			
70							60		60			
80							70	60	70	60		60
90								70	80	60		60
100								70	80	60		60
120								70	100	70		80
140								70		70		80
160								70		100		100
180								70		100		100
200								70		100		100
220								70		100		100
240								70		100		100
260								70		100		100
280								70		100		100
300-400	in 20mm Abstufung							70		100		100

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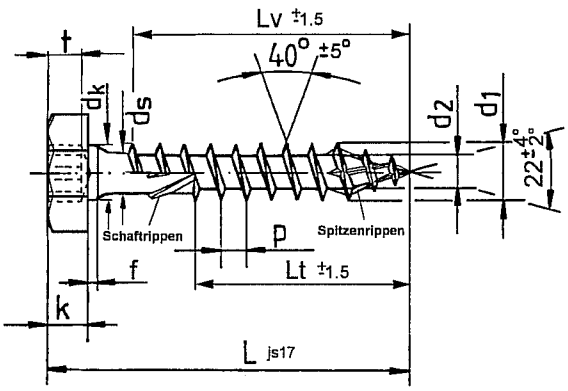
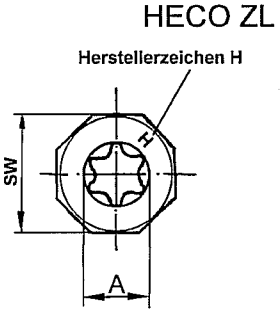
Anlage 16
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-TOPIX

Sechskantkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl





Nenngröße								⌀ 10,0
d_1	obere Tol. untere Tol							10 +0,45 -0,1
d_2	obere Tol. untere Tol							6,2 6,65
SW	obere Tol. untere Tol							15 +0 -0,33
d_k	obere Tol. untere Tol							10 +0 -0,2
d_s	obere Tol. untere Tol							6,9 7,1
P ±10%								7,5
k	obere Tol. untere Tol							5,3 4,7
f	obere Tol. untere Tol							1,7 2,3
Antrieb Gr.								T40
t	obere Tol. untere Tol							3,1 3,6
A								6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
80														60
90														60
100														60
120														70
140														70
160														100
180														100
200														100
220														100
240														100
260														100
280														100
300														100
320														100
340														100
360														100
400														100

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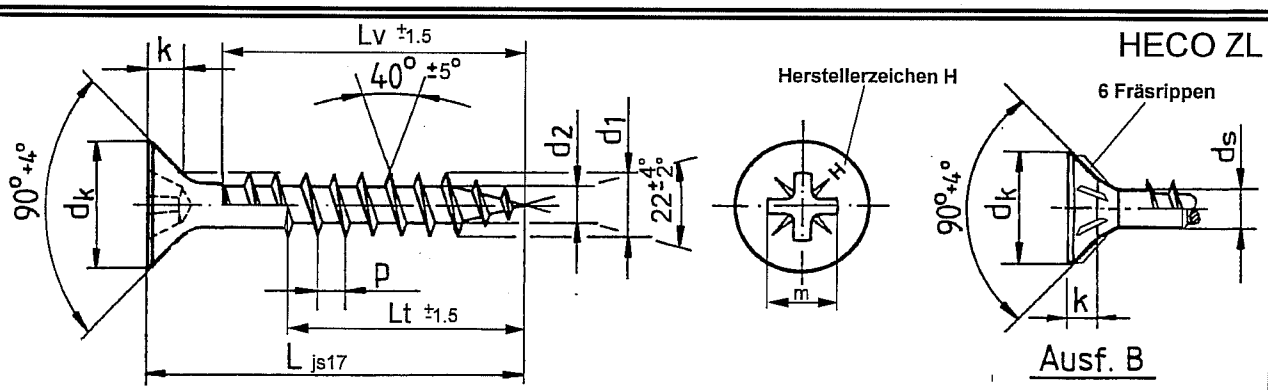
Anlage 17
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Senkkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,2	4,0 +0,2	4,5 +0,2	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,35	-0,35	-0,4	-0,5	-0,5
d_2	obere Tol.	2,0	2,25	2,5	2,8	3,5	4,7	6,0
	untere Tol	2,35	2,6	2,9	3,2	3,95	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,5	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,5	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,7	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,7	2,05	2,64	3,0	3,0	3,86	5,2
	untere Tol	2,06	2,51	3,1	3,45	3,45	4,32	5,65
m		4,0	4,4	4,9	5,3	6,6	8,5	9,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

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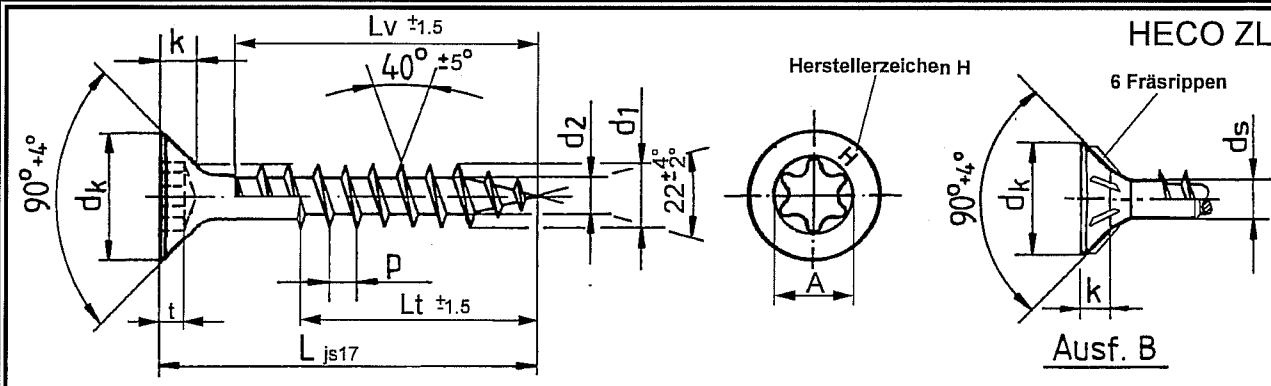
Anlage 18
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Senkkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,2	4,0 +0,2	4,5 +0,2	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,35	-0,35	-0,4	-0,5	-0,5
d_2	obere Tol.	2,0	2,25	2,5	2,8	3,5	4,7	6,0
	untere Tol	2,35	2,6	2,9	3,2	3,95	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,5	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,5	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,7	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

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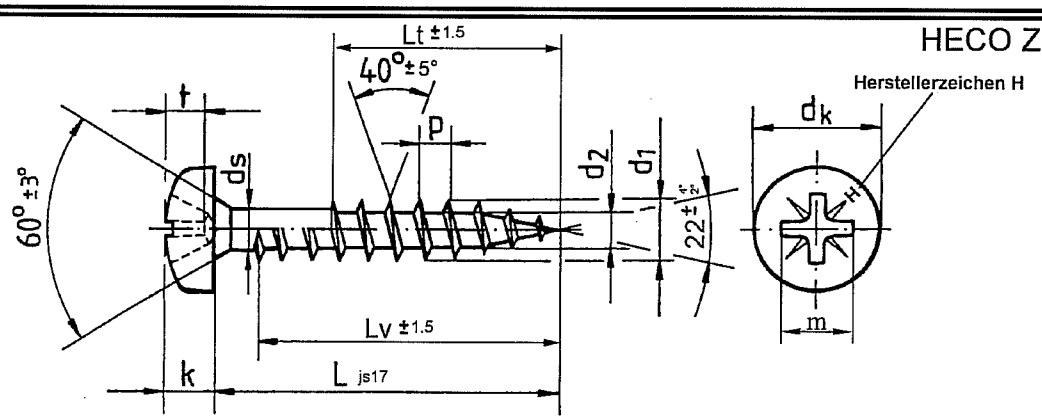
Anlage 19
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Rundkopf-Schraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol. untere Tol	3,5 +0,2 -0,3	4,0 +0,2 -0,3	4,5 +0,2 -0,35	5,0 +0,25 -0,35	6,0 +0,3 -0,4	8,0 +0,2 -0,5	10 +0,2 -0,5
d_2	obere Tol. untere Tol	2,0 2,35	2,25 2,6	2,5 2,9	2,8 3,2	3,5 3,95	4,7 5,2	6,0 6,5
d_k	obere Tol. untere Tol	7,0 +0 -0,4	8,0 +0 -0,5	9,0 +0 -0,5	9,7 +0 -0,5	11,8 +0 -0,6	14,8 +0 -0,5	18,5 +0 -0,5
d_s	obere Tol. untere Tol	2,45 2,65	2,75 2,95	3,1 3,3	3,5 3,7	4,2 4,4	5,6 5,8	6,9 7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol. untere Tol	2,35 2,6	2,55 2,9	2,75 3,05	3,1 3,4	3,7 4,0	5,0 5,4	6,1 6,5
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol. untere Tol	1,6 1,85	2,2 2,46	2,26 2,72	2,69 3,15	3,02 3,48	3,71 4,17	5,23 5,69
m		3,8	4,4	4,6	5,1	6,7	8,5	9,9

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	22	15	22		22		22							
30	27	18	27	18	27		27		27					
35	32	21	32	22	32	22	32	22	32					
40	37	23	37	25	37	24	37	24	37	24				
45	42	28	42	27	42	27	42	27	42	28				
50	47	31	47	30	46	29	47	29	46	31				
55			50	37	50	37	51	37	51	33				
60			55	37	54	37	54	37	54	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60		60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung											80		100
320 – 460	in 20 mm Abstufung											120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik
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andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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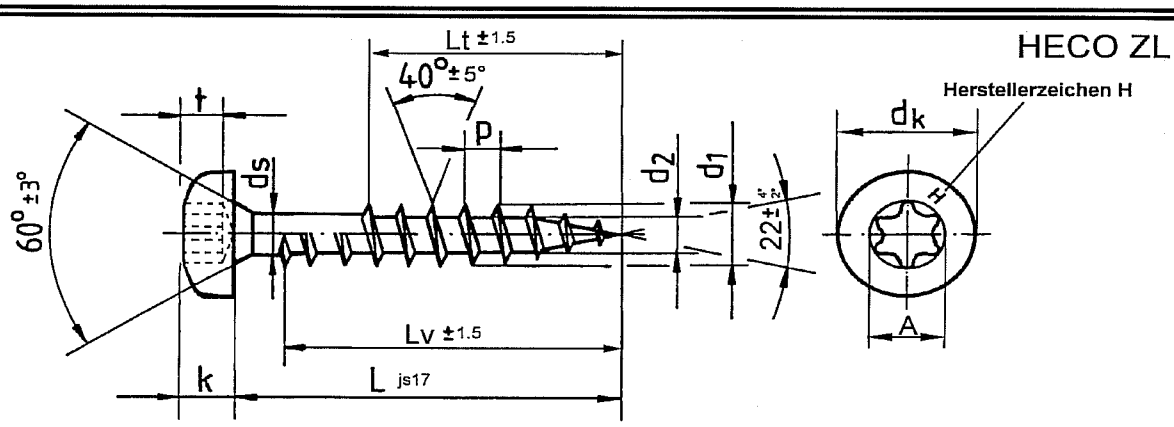
Anlage 20
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Rundkopf-Schraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		Ø 3,5	Ø 4,0	Ø 4,5	Ø 5,0	Ø 6,0	Ø 8,0	Ø 10,0
d_1	obere Tol.	3,5 +0,2	4,0 +0,2	4,5 +0,2	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,35	-0,35	-0,4	-0,5	-0,5
d_2	obere Tol.	2,0	2,25	2,5	2,8	3,5	4,7	6,0
	untere Tol	2,35	2,6	2,9	3,2	3,95	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,5	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,7	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,2	1,3	1,4	1,8	2,2	2,85	3,4
	untere Tol	1,5	1,7	1,9	2,2	2,7	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	22	15	22		22		22							
30	27	18	27	18	27		27		27					
35	32	21	32	22	32	22	32	22	32					
40	37	23	37	25	37	24	37	24	37	24				
45	42	28	42	27	42	27	42	27	42	28				
50	47	31	47	30	46	29	47	29	46	31				
55			50	37	50	37	51	37	51	33				
60			55	37	54	37	54	37	54	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60		60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		80		100
320 – 460	in 20 mm Abstufung											120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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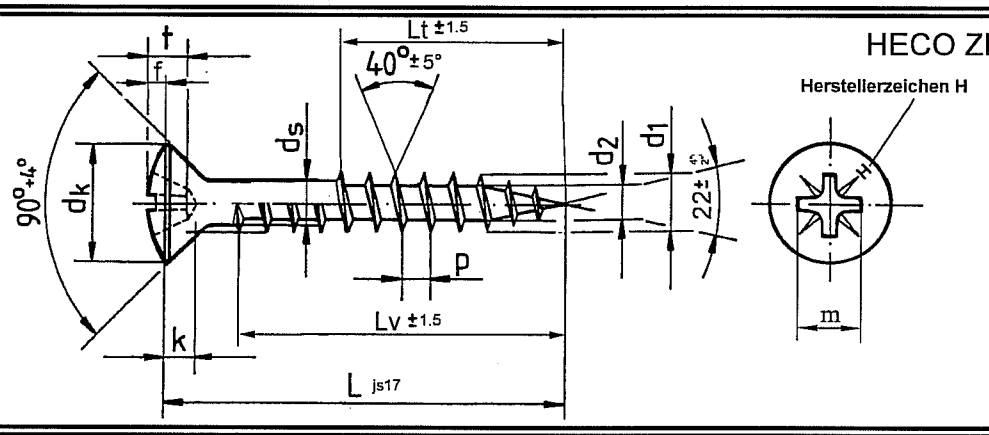
Anlage 21
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Linsenkopfschraube mit POZI-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,2	4,0 +0,2	4,5 +0,2	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,35	-0,35	-0,4	-0,5	-0,5
d_2	obere Tol.	2,0	2,25	2,5	2,8	3,5	4,7	6,0
	untere Tol	2,35	2,6	2,9	3,2	3,95	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,5	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,7	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,9	1,0	1,15	1,15	1,55	1,7	2,8
	untere Tol	1,2	1,3	1,45	1,55	1,95	2,2	3,3
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,6	2,26	2,6	2,89	3,4	4,06	5,71
	untere Tol	2,11	2,72	3,15	3,35	3,86	4,52	6,17
m		4,0	4,6	5,1	5,3	7,1	8,8	10,4

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

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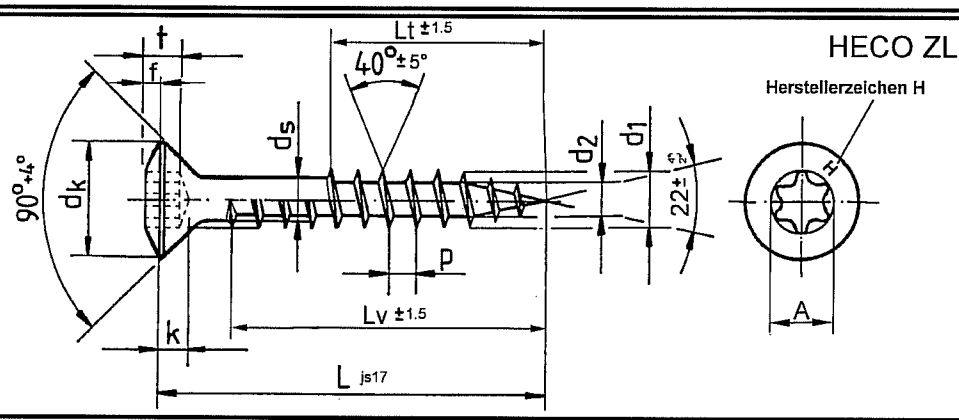
Anlage 22
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Linsenkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Kohlenstoffstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,2	4,0 +0,2	4,5 +0,2	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,35	-0,35	-0,4	-0,5	-0,5
d_2	obere Tol.	2,0	2,25	2,5	2,8	3,5	4,7	6,0
	untere Tol	2,35	2,6	2,9	3,2	3,95	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,45	2,75	3,1	3,5	4,2	5,6	6,9
	untere Tol	2,65	2,95	3,3	3,7	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,7	1,0	0,9	0,9	1,55	1,7	2,8
	untere Tol	1,0	1,3	1,2	1,3	1,95	2,1	3,3
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

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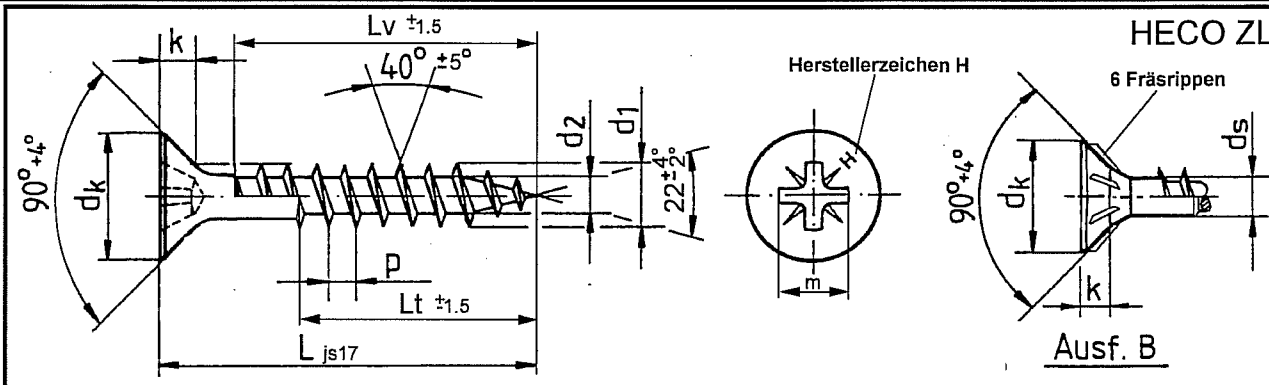
Anlage 23
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Senkkopfschraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,25	4,0 +0,25	4,5 +0,25	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,3	-0,3	-0,4	-0,5	-0,5
d_2	obere Tol.	2,2	2,55	2,7	3,05	3,65	4,7	6,0
	untere Tol	2,5	2,9	3,1	3,5	4,1	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,6	2,95	3,25	3,58	4,2	5,6	6,9
	untere Tol	2,7	3,15	3,45	3,78	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,7	2,05	2,64	3,0	3,0	3,86	5,2
	untere Tol	2,06	2,51	3,1	3,45	3,45	4,32	5,65
m		4,0	4,4	4,9	5,3	6,6	8,5	9,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

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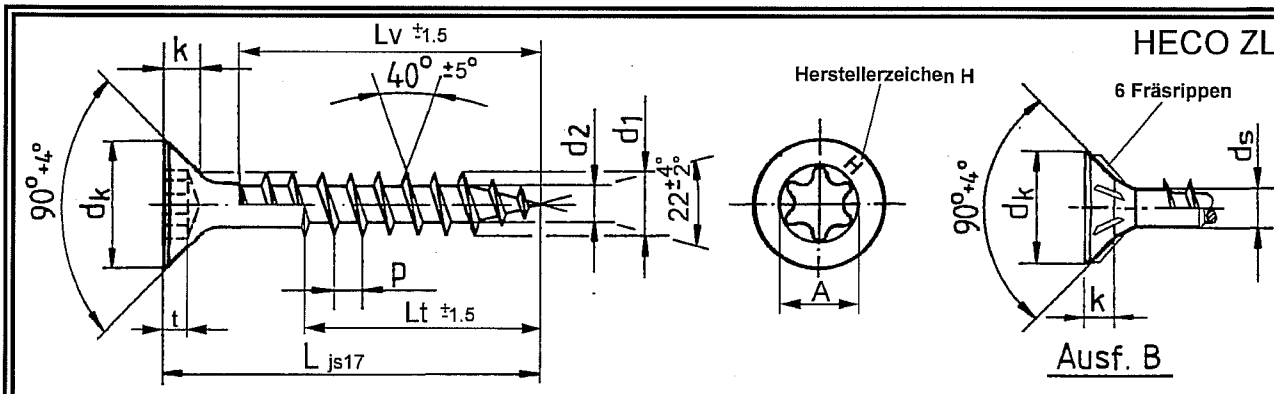
Anlage 24
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Senkkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,25	4,0 +0,25	4,5 +0,25	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,3	-0,3	-0,4	-0,5	-0,5
d_2	obere Tol.	2,2	2,55	2,7	3,05	3,65	4,7	6,0
	untere Tol	2,5	2,9	3,1	3,5	4,1	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,6	2,95	3,25	3,58	4,2	5,6	6,9
	untere Tol	2,7	3,15	3,45	3,78	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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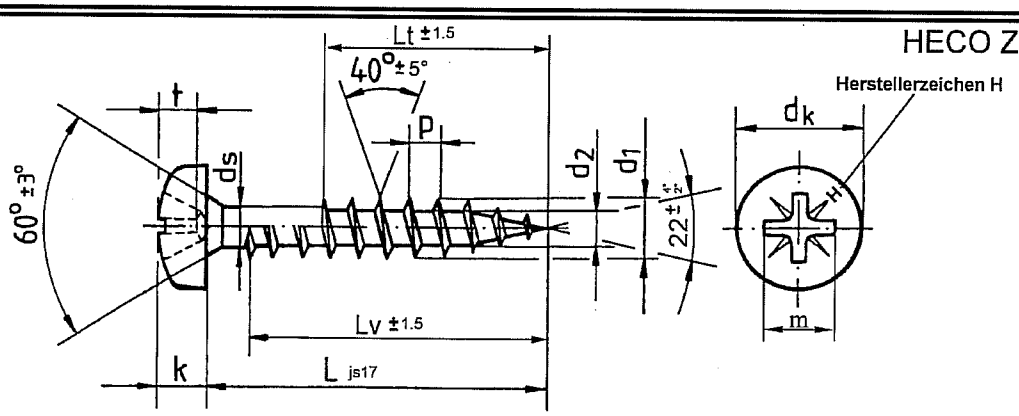
Anlage 25
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Rundkopf-Schraube mit Pozi-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,25	4,0 +0,25	4,5 +0,25	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,3	-0,3	-0,4	-0,5	-0,5
d_2	obere Tol.	2,2	2,55	2,7	3,05	3,65	4,7	6,0
	untere Tol	2,5	2,9	3,1	3,5	4,1	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,6	2,95	3,25	3,58	4,2	5,6	6,9
	untere Tol	2,7	3,15	3,45	3,78	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,6	2,2	2,26	2,69	3,02	3,71	5,23
	untere Tol	1,85	2,46	2,72	3,15	3,48	4,17	5,69
m		3,8	4,4	4,6	5,1	6,7	8,5	9,9

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	22	15	22		22		22							
30	27	18	27	18	27		27		27					
35	32	21	32	22	32	22	32	22	32					
40	37	23	37	25	37	24	37	24	37	24				
45	42	28	42	27	42	27	42	27	42	28				
50	47	31	47	30	46	29	47	29	46	31				
55			50	37	50	37	51	37	51	33				
60			55	37	54	37	54	37	54	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60		60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		120		120
320 – 460	in 20 mm Abstufung													
480 – 500	in 20 mm Abstufung													

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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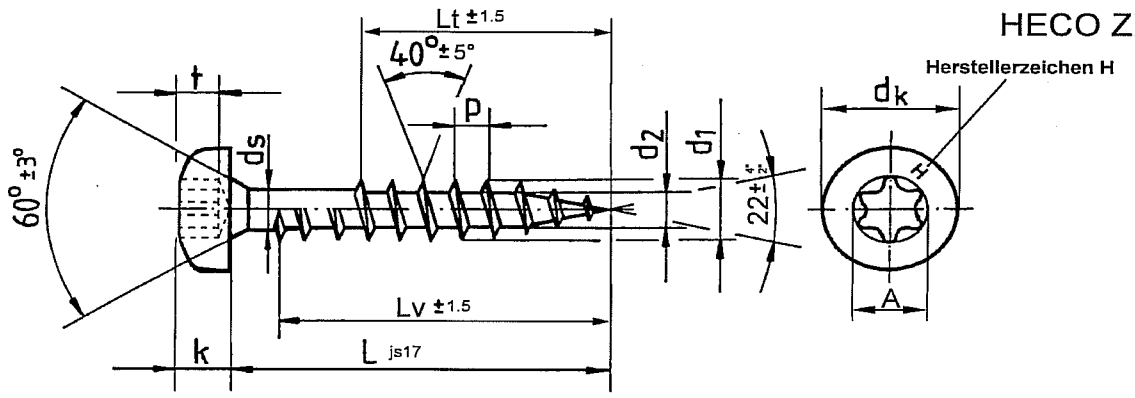
Anlage 26
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Rundkopf-Schraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,25	4,0 +0,25	4,5 +0,25	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,3	-0,3	-0,4	-0,5	-0,5
d_2	obere Tol.	2,2	2,55	2,7	3,05	3,65	4,7	6,0
	untere Tol	2,5	2,9	3,1	3,5	4,1	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,6	2,95	3,25	3,58	4,2	5,6	6,9
	untere Tol	2,7	3,15	3,45	3,78	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	2,35	2,55	2,75	3,1	3,7	5,0	6,1
	untere Tol	2,6	2,9	3,05	3,4	4,0	5,4	6,5
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,6	2,2	2,26	2,69	3,02	2,85	3,4
	untere Tol	1,85	2,46	2,72	3,15	3,48	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	22	15	22		22		22							
30	27	18	27	18	27		27		27					
35	32	21	32	22	32	22	32	22	32					
40	37	23	37	25	37	24	37	24	37	24				
45	42	28	42	27	42	27	42	27	42	28				
50	47	31	47	30	46	29	47	29	46	31				
55			50	37	50	37	51	37	51	33				
60			55	37	54	37	54	37	54	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60		60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		80		100
320 – 460	in 20 mm Abstufung											120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

andere Gewindelängen im Bereich lg ≥ 4*d1 bis zur max. Standardgewindelänge sind zulässig

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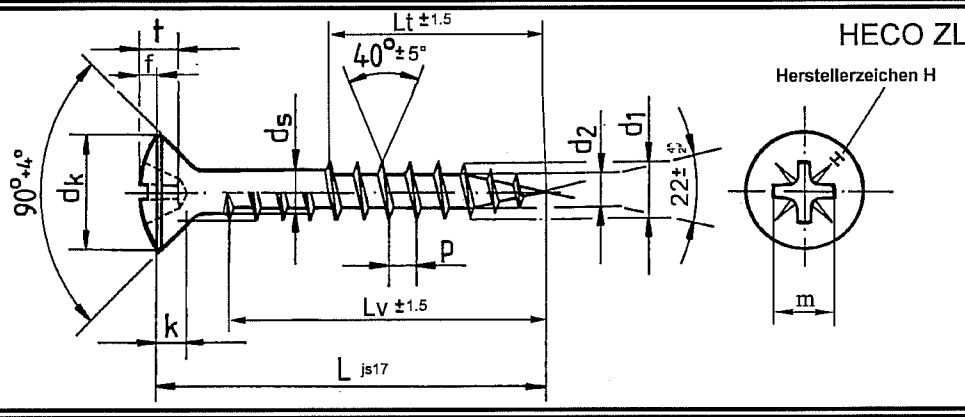
Anlage 27
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Linsenkopfschraube mit POZI-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		∅ 3,5	∅ 4,0	∅ 4,5	∅ 5,0	∅ 6,0	∅ 8,0	∅ 10,0
d_1	obere Tol.	3,5 +0,25	4,0 +0,25	4,5 +0,25	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,3	-0,3	-0,4	-0,5	-0,5
d_2	obere Tol.	2,2	2,55	2,7	3,05	3,65	4,7	6,0
	untere Tol	2,5	2,9	3,1	3,5	4,1	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,6	2,95	3,25	3,58	4,2	5,6	6,9
	untere Tol	2,7	3,15	3,45	3,78	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,9	1,0	1,15	1,15	1,55	1,7	2,8
	untere Tol	1,2	1,3	1,45	1,55	1,95	2,2	3,3
Antrieb Z		2	2	2	2	3	4	4
t	obere Tol.	1,65	2,26	2,69	2,89	3,4	4,06	5,71
	untere Tol	2,11	2,72	3,15	3,35	3,86	4,52	6,17
m		4,0	4,6	5,1	5,3	7,1	8,8	10,4

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

Deutsches Institut für Bautechnik

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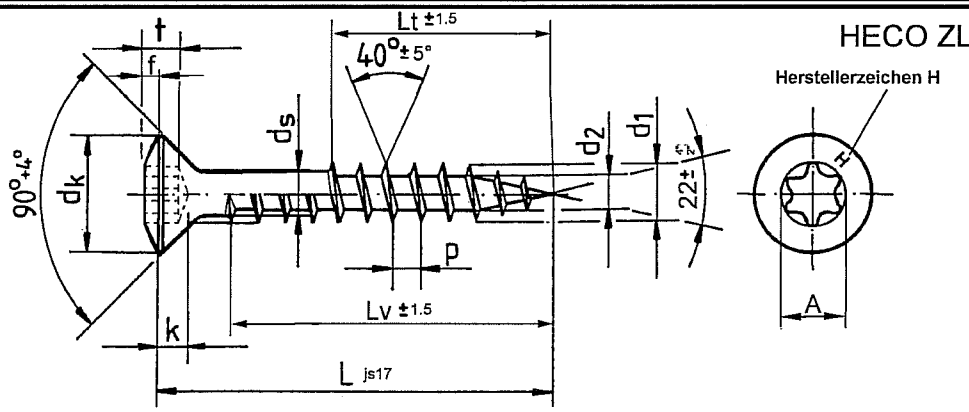
Anlage 28
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-FIX-plus

Linsenkopfschraube mit T-Drive

Werkstoff: Kaltstauchdraht nach HECO Werksnorm
Edelstahl



Nenngröße		⌀ 3,5	⌀ 4,0	⌀ 4,5	⌀ 5,0	⌀ 6,0	⌀ 8,0	⌀ 10,0
d_1	obere Tol.	3,5 +0,25	4,0 +0,25	4,5 +0,25	5,0 +0,25	6,0 +0,3	8,0 +0,2	10 +0,2
	untere Tol	-0,3	-0,3	-0,3	-0,3	-0,4	-0,5	-0,5
d_2	obere Tol.	2,2	2,55	2,7	3,05	3,65	4,7	6,0
	untere Tol	2,5	2,9	3,1	3,5	4,1	5,2	6,5
d_k	obere Tol.	7,0 +0	8,0 +0	9,0 +0	9,7 +0	11,8 +0	14,8 +0	18,5 +0
	untere Tol	-0,4	-0,5	-0,5	-0,5	-0,6	-0,5	-0,5
d_s	obere Tol.	2,6	2,95	3,25	3,58	4,2	5,6	6,9
	untere Tol	2,7	3,15	3,45	3,78	4,4	5,8	7,1
P ±10%		1,75-2,1	2,0-2,5	2,25-2,8	2,5-3,1	3,0-3,75	4,0	5,0
k	obere Tol.	1,8	2,1	2,3	2,6	3,1	4,0	5,2
	untere Tol	2,1	2,5	2,7	3,0	3,6	4,7	6,0
f	obere Tol.	0,7	1,0	0,9	0,9	1,55	1,7	2,8
	untere Tol	1,0	1,3	1,2	1,3	1,95	2,1	3,3
Antrieb Gr.		T15	T15	T25	T25	T25	T40	T40
t	obere Tol.	1,27	1,4	1,5	1,85	2,3	2,85	3,4
	untere Tol	1,47	1,65	1,8	2,15	2,6	3,15	3,85
A		3,35	3,35	4,53	4,53	4,53	6,8	6,8

L	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt	Lv	Lt
25	21	15	20		19		20							
30	26	18	25	18	24		24		24					
35	31	21	30	22	29	22	29	22	28					
40	36	23	35	25	34	24	34	24	33	24				
45	41	28	40	27	39	27	39	27	38	28				
50	46	31	45	30	44	29	44	29	43	31				
55			50	37	59	37	49	37	48	33				
60			54	37	54	37	54	37	53	36		42		
65			60	42	60	42	60	42	60	43				
70			60	42	60	42	60	42	60	43		42		
75			60	47	60	47	60	48	60	48				
80			60	47	60	47	60	48	60	48		60		60
90						60	60	54	60	53		60		60
100						60		60	60	60		80		80
110								70		70				
120								70		70		80		80
130										70				
140										70		80		100
150										70				
160										80		80		100
180										80		80		100
190										80				
200										80		100		100
220										80		100		100
240										80		100		100
260 - 300	in 20 mm Abstufung									80		100		120
320 – 460	in 20 mm Abstufung									80		120		120
480 – 500	in 20 mm Abstufung													120

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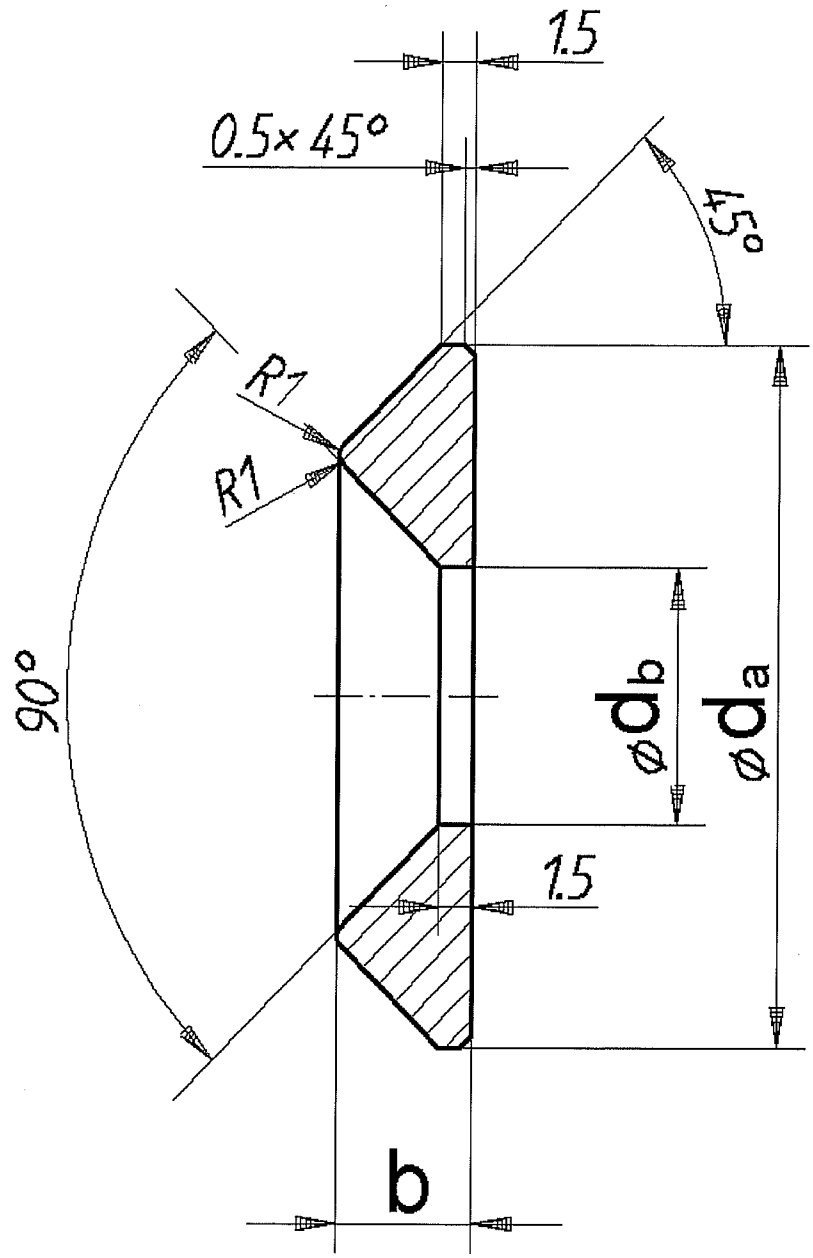
Anlage 29
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-ZUBEHÖR	**Rosette** Werkstoff: Kaltstauchdraht nach HECO Werksnorm Kohlenstoffstahl



Nenngröße		∅ 6,0	∅ 8,0	∅ 10,0			
d_b	obere Tol. untere Tol	6,5 +0,2 -0,2	8,5 +0,2 -0,2	11 +0,2 -0,2			
d_a	obere Tol. untere Tol	20 +0,5 -0,5	25 +0,5 -0,5	30 +0,5 -0,5			
b	obere Tol. untere Tol	4,3 4,7	4,8 5,2	5,8 6,2			

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33

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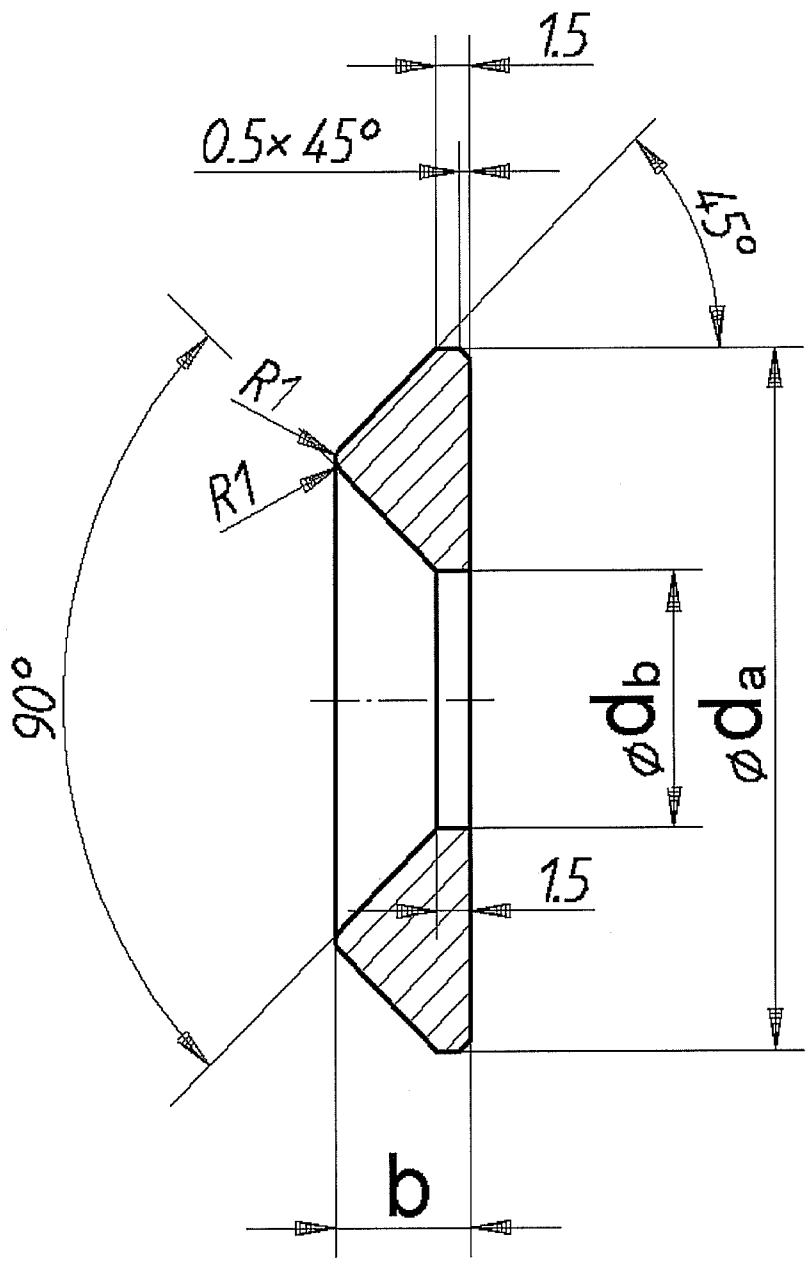
Anlage 30
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

HECO-ZUBEHÖR	**Rosette** Werkstoff: Kaltstauchdraht nach HECO Werksnorm Edelstahl



Nenngröße		∅ 6,0	∅ 8,0	∅ 10,0				
d_b	obere Tol. untere Tol	6,5 +0,2 -0,2	8,5 +0,2 -0,2	11 +0,2 -0,2				
d_a	obere Tol. untere Tol	20 +0,5 -0,5	25 +0,5 -0,5	30 +0,5 -0,5				
b	obere Tol. untere Tol	4,3 4,7	4,8 5,2	5,8 6,2				

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Anlage 31
zum Zulassungsbescheid Z-9.1-453
vom 30. September 2009

GH - Balkenschuhe Typ 04

ETA 08/0264

CE 0769



Stahlgüte S250GD, Oberflächenschutz Z 275g/m² beidseitig ca. 20 µm
Edelstahl der Güte 1.4301, 1.4401, 1.4541 oder 1.4571

Festigkeitsklasse Holz
350kg/m³ charktr. Rohdichte

Befestigungsmittel

in Holz

GH Rillennägel 4,0 x Länge; CE nach EN 14592 / Einstufungsschein KA 295
GH Schraube 5,0 x Länge; CE / EN 14592 / Z-9.1-375

Nagelbild

T = Teillausnagelung
V = Vollausnagelung
Die Nagelanordung ist unbedingt zu beachten

in Beton / Stahl

Dübel u. Schrauben

* Bei Befestigungen in Mauerwerk und Beton ist der Nachweis im Untergrund gesondert zu führen.
Angegebenen $F_{l,Bo}$ und $F_{ax,Bo}$ Werte beim Verbinder = mind. Tagfähigkeit pro Verbindungsmittel

Anschlussarten

Holz/ Holz	Holz/Holz über Zwischenschicht	Holz/ Beton*	Holz/ Mauerwerk*	Holz/ Stahl

Berechnung der Bemessungswerte der Tragfähigkeiten gem. DIN 1052:2008.12 und Zulassung

B	=	Nebenträgerbreite in mm
H	=	Nebenträgerhöhe in mm
t	=	Blechstärke des Balkenschuhs in mm
n_H	=	Anzahl der Verbindungsmittel im Hauptträger
n_{Bo}	=	Anzahl der Bolzen im Hauptträger
n_J	=	Anzahl der Verbindungsmittel im Nebenträger
		Charakteristische Tragfähigkeit der Winkelverbinder
$F_{z,Rd}$	=	Bemessungswert der Tragfähigkeit des Balkenschuhs für eine Belastung parallel zur Symmetrieachse, in Richtung Platte
$F_{z,Rk}$	=	Charakteristische Tragfähigkeit des Balkenschuhs für eine Belastung prrallel zur Symmetrieachse, in Richtung Platte
$F_{z,NT,Rd}$	=	Bemessungswert der Tragfähigkeit des Balkenschuhs am Nebenträger für eine Belastung parallel zur Symmetrieachse, in Richtung Platte
$F_{z,NT,Rk}$	=	Charakteristische Tragfähigkeit des Balkenschuhs am Nebenträger für eine Belastung parallel zur Symmetrieachse, in Richtung Platte
$F_{y,Rd}$	=	Bemessungswert der Tragfähigkeit des Balkenschuhs für eine Belastung senkrecht zur Symmetrieachse (Annahme des Lastangriffpunktes 20mm oberhalb der Balkenschuhoberkante)
$F_{y,Rk}$	=	Charakteristische Tragfähigkeit des Balkenschuhs für eine Belastung senkrecht zur Symmetrieachse (Annahme des Lastangriffpunktes 20mm oberhalb der Balkenschuhoberkante)
$F_{z,Up,Rd}$	=	Bemessungswert der Tragfähigkeit des Balkenschuhs für eine Belastung parallel zur Symmetrieachse, von der Platte weg
$F_{z,up,Rk}$	=	Charakteristische Tragfähigkeit des Balkenschuhs für eine Belastung parallel zur Symmetrieachse, von der Platte weg
$F_{l,Bo,Rd}$	=	Bemessungswert der lateralen Tragfähigkeit des Bolzen im Balkenschuh
$F_{l,Bo,Ed}$	=	Bemessungswert der lateralen Beanspruchung des Bolzen infolge der Beanspruchung $F_{z,Ed}$

GH - Balkenschuhe Typ 04

ETA 08/0264

CE 0769



Stahlgüte S250GD, Oberflächenschutz Z 275g/m² beidseitig ca. 20 µm
Edelstahl der Güte 1.4301, 1.4401, 1.4541 oder 1.4571

Festigkeitsklasse Holz
350kg/m³ charktr. Rohdichte

$F_{ax,Bo,Ed}$ = Bemessungswert der axialen Beanspruchung des Bolzen infolge der Beanspruchung $F_{z,Ed}$

$F_{ax,Bo,Ek}$ = Charakteristische, axiale Beanspruchung des Bolzen infolge der Beanspruchung $F_{z,Ek}$

$F_{l,Bo,Rk}$ = Charakteristischen, lateralen Tragfähigkeit des Bolzen im Balkenschuh

$F_{l,Bo,Ek}$ = Charakteristische, laterale Beanspruchung des Bolzen infolge der Beanspruchung $F_{z,Ek}$

Tragfähigkeit bei Befestigung auf Beton/Stahl:

$F_{z,Rd} = (n_{Bo} \times F_{l,Bo,Rd}) \leq F_{z,NT,Rd}$ mit $F_{ax,Bo,Rd} \geq F_{ax,Bo,Ed} \cdot F_{z,Rd} / F_{z,NT,Rd}$

Kombinierte Beanspruchung/Interaktionsnachweis:

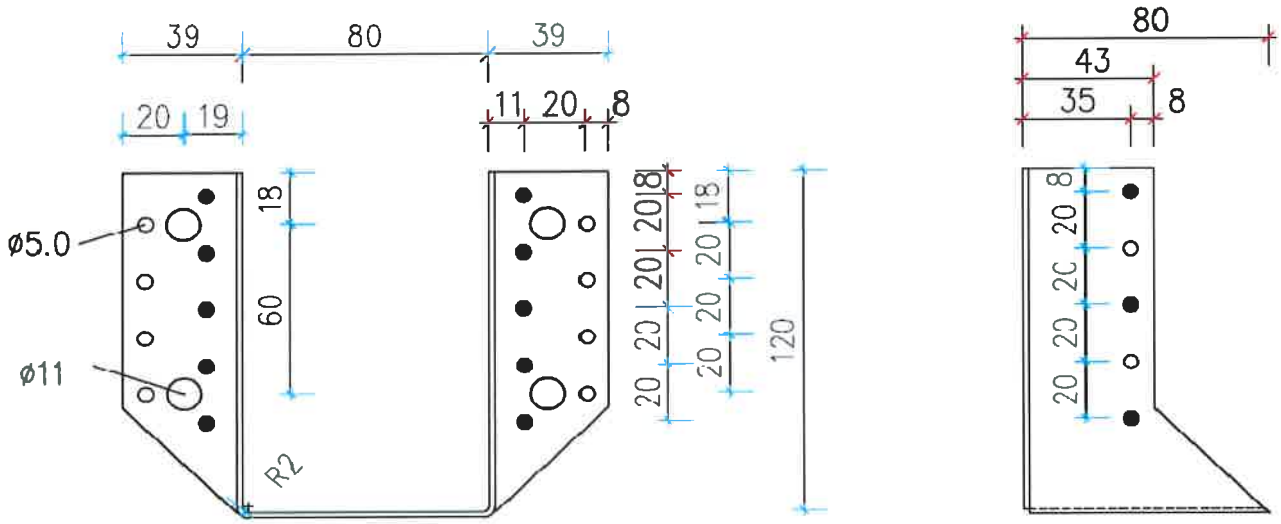
$(F_{z,Ed} / F_{z,Rd})^2 + (F_{y,Ed} / F_{y,Rd})^2 \leq 1$

$(F_{z,Up,Ed} / F_{z,Up,Rd})^2 + (F_{y,Ed} / F_{y,Rd})^2 \leq 1$

Alle Berechnungen und Werte sind ausschließlich für GH Produkte und deren Verbindungsmittel.
Die Tragfähigkeiten wurden aufgrund der entsprechenden Zulassung sowie der darin enthaltenen Spezifikationen berechnet. Das übertragen der Werte auf Fremdfabrikate ist nicht möglich

Haftungsausschluss
Trotz sorgfältigen Berechnungen und Prüfungen wird für die technischen Angaben keine Haftung übernommen.
Technische Änderungen vorbehalten

Technische Zeichnung



Abblidung beispielhaft

GH - Balkenschuhe Typ 04 Kombi

		n_H	n_J		Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
					$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
40x110x2	V	14	8	4,0x40 [2(4)]	6,54	1,49	2,75	7,88	1,83	3,43	6,54	1,28	4,22	7,88	1,54	5,28
				4,0x50												
				5,0x40 [2(4)]	8,71	3,09	5,81	10,08	3,63	6,72	8,71	1,65	4,22	10,08	1,97	5,28
				5,0x50												
	T	8	4	4,0x40 [2(4)]	4,55	1,49	1,69	5,63	1,83	2,10	6,54	1,28	4,22	7,88	1,54	5,28
				4,0x50												
				5,0x40 [2(4)]	8,71	3,09	5,67	10,08	3,63	6,72	8,71	1,65	4,22	10,08	1,97	5,28
				5,0x50												
40x140x2	V	18	10	4,0x40 [2(5)]	7,63	1,83	4,22	9,19	2,26	5,27	7,63	1,19	5,28	9,19	1,44	6,60
				4,0x50												
				5,0x40 [2(5)]	10,17	3,73	7,26	11,76	4,38	8,40	10,17	1,59	5,28	11,76	1,84	6,60
				5,0x50												
	T	10	6	4,0x40 [2(5)]	6,43	1,83	2,48	7,93	2,26	3,09	7,63	1,19	5,28	9,19	1,44	6,60
				4,0x50												
				5,0x40 [2(5)]	10,17	3,73	7,26	11,76	4,38	8,40	10,17	1,59	5,28	11,76	1,84	6,60
				5,0x50												
40x170x2	V	22	12	4,0x40 [2(6)]	8,72	2,21	6,54	10,50	2,72	7,88	8,72	1,01	5,28	10,50	1,22	6,60
				4,0x50												
				5,0x40 [2(6)]	11,62	4,53	8,71	13,44	5,32	10,08	11,62	1,23	5,28	13,44	1,53	6,60
				5,0x50												
	T	12	6	4,0x40 [2(6)]	8,72	2,21	3,80	10,50	2,72	4,73	8,72	1,01	5,28	10,50	1,22	6,60
				4,0x50												
				5,0x40 [2(6)]	11,62	4,53	8,71	13,44	5,32	10,08	11,62	1,23	5,28	13,44	1,53	6,60
				5,0x50												
44x108x2	V	14	8	4,0x40 [2(4)]	6,54	1,52	2,81	7,88	1,88	3,51	6,54	1,31	4,22	7,88	1,58	5,28
				4,0x50												
				5,0x40 [2(4)]	8,71	3,28	5,81	10,08	3,86	6,72	8,71	1,69	4,22	10,08	2,02	5,28
				5,0x50												
	T	8	4	4,0x40 [2(4)]	4,44	1,52	1,72	5,49	1,88	2,15	6,54	1,31	4,22	7,88	1,58	5,28
				4,0x50												
				5,0x40 [2(4)]	8,71	3,28	5,77	10,08	3,86	6,72	8,71	1,69	4,22	10,08	2,02	5,28
				5,0x50												
44x138x2	V	18	10	4,0x40 [2(5)]	7,63	1,89	4,29	9,19	2,33	5,35	7,63	1,21	5,28	9,19	1,46	6,60
				4,0x50												
				5,0x40 [2(5)]	10,17	4,02	7,26	11,76	4,73	8,40	10,17	1,62	5,28	11,76	1,87	6,60
				5,0x50												
	T	10	6	4,0x40 [2(5)]	6,31	1,89	2,51	7,78	2,33	3,13	7,63	1,21	5,28	9,19	1,46	6,60
				4,0x50												
				5,0x40 [2(5)]	10,17	4,02	7,26	11,76	4,73	8,40	10,17	1,62	5,28	11,76	1,87	6,60
				5,0x50												
48x136x2	V	18	10	4,0x40 [2(5)]	7,63	1,93	4,36	9,19	2,39	5,44	7,63	1,24	5,28	9,19	1,49	6,60
				4,0x50 [2(5)]	8,47	2,43	5,75	9,61	2,93	6,86	8,47	1,37	5,28	9,61	1,56	6,60
				5,0x40 [2(5)]	10,17	4,28	7,26	11,76	5,04	8,40	10,17	1,65	5,28	11,76	1,91	6,60
				5,0x50 [2(5)]	11,07	4,85	7,91	12,89	5,72	9,21	11,07	1,71	5,28	12,89	2,09	6,60
	T	10	6	4,0x40 [2(5)]	6,21	1,93	2,55	7,67	2,39	3,19	7,63	1,24	5,28	9,19	1,49	6,60
				4,0x50 [2(5)]	7,74	2,43	3,37	9,28	2,93	4,17	8,47	1,37	5,28	9,61	1,56	6,60
				5,0x40 [2(5)]	10,17	4,28	7,26	11,76	5,04	8,40	10,17	1,65	5,28	11,76	1,91	6,60
				5,0x50 [2(5)]	11,07	4,85	7,91	12,89	5,72	9,21	11,07	1,71	5,28	12,89	2,09	6,60
48x166x2	V	22	12	4,0x40 [2(6)]	8,72	2,31	6,54	10,50	2,85	7,88	8,72	1,04	5,28	10,50	1,26	6,60
				4,0x50 [2(6)]	9,68	2,90	7,26	10,98	3,50	8,23	9,68	1,16	5,28	10,98	1,31	6,60
				5,0x40 [2(6)]	11,62	5,07	8,71	13,44	5,97	10,08	11,62	1,26	5,28	13,44	1,58	6,60
				5,0x50 [2(6)]	12,65	5,74	9,49	14,74	6,77	11,05	12,65	1,26	5,28	14,74	1,58	6,60
	T	12	6	4,0x40 [2(6)]	8,72	2,31	3,89	10,50	2,85	4,85	8,72	1,04	5,28	10,50	1,26	6,60
				4,0x50 [2(6)]	9,68	2,90	5,09	10,98	3,50	6,28	9,68	1,16	5,28	10,98	1,31	6,60
				5,0x40 [2(6)]	11,62	5,07	8,71	13,44	5,97	10,08	11,62	1,26	5,28	13,44	1,58	6,60
				5,0x50 [2(6)]	12,65	5,74	9,49	14,74	6,77	11,05	12,65	1,26	5,28	14,74	1,58	6,60

GH - Balkenschuhe Typ 04 Kombi

					Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
		n_H	n_J		$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
50x105x2	V	14	8	4,0x40 [2(4)]	6,54	1,56	2,90	7,88	1,93	3,62	6,54	1,36	4,22	7,88	1,64	5,28
				4,0x50 [2(4)]	7,26	1,97	3,84	8,23	2,38	4,78	7,26	1,51	4,22	8,23	1,71	5,28
				5,0x40 [2(4)]	8,71	3,52	5,81	10,08	4,15	6,72	8,71	1,76	4,22	10,08	2,09	5,28
				5,0x50 [2(4)]	9,49	4,00	6,33	11,05	4,72	7,37	9,49	1,76	4,22	11,05	2,19	5,28
	T	8	4	4,0x40 [2(4)]	4,26	1,56	1,78	5,28	1,93	2,22	6,54	1,36	4,22	7,88	1,64	5,28
				4,0x50 [2(4)]	5,40	1,97	2,35	6,54	2,38	2,92	7,26	1,51	4,22	8,23	1,71	5,28
				5,0x40 [2(4)]	8,71	3,52	5,81	10,08	4,15	6,72	8,71	1,76	4,22	10,08	2,09	5,28
				5,0x50 [2(4)]	9,49	4,00	6,33	11,05	4,72	7,37	9,49	1,76	4,22	11,05	2,19	5,28
50x135x2	V	18	10	4,0x40 [2(5)]	7,63	1,95	4,41	9,19	2,41	5,50	7,63	1,25	5,28	9,19	1,50	6,60
				4,0x50 [2(5)]	8,47	2,46	5,81	9,61	2,98	6,86	8,47	1,39	5,28	9,61	1,57	6,60
				5,0x40 [2(5)]	10,17	4,40	7,26	11,76	5,19	8,40	10,17	1,66	5,28	11,76	1,92	6,60
				5,0x50 [2(5)]	11,07	5,00	7,91	12,89	5,90	9,21	11,07	1,73	5,28	12,89	2,11	6,60
	T	10	6	4,0x40 [2(5)]	6,13	1,95	2,58	7,57	2,41	3,21	7,63	1,25	5,28	9,19	1,50	6,60
				4,0x50 [2(5)]	7,66	2,46	3,39	9,19	2,98	4,21	8,47	1,39	5,28	9,61	1,57	6,60
				5,0x40 [2(5)]	10,17	4,40	7,26	11,76	5,19	8,40	10,17	1,66	5,28	11,76	1,92	6,60
				5,0x50 [2(5)]	11,07	5,00	7,91	12,89	5,90	9,21	11,07	1,73	5,28	12,89	2,11	6,60
50x165x2	V	22	12	4,0x40 [2(6)]	8,72	2,33	6,54	10,50	2,88	7,88	8,72	1,05	5,28	10,50	1,26	6,60
				4,0x50 [2(6)]	9,68	2,93	7,26	10,98	3,54	8,23	9,68	1,17	5,28	10,98	1,32	6,60
				5,0x40 [2(6)]	11,62	5,18	8,71	13,44	6,11	10,08	11,62	1,27	5,28	13,44	1,59	6,60
				5,0x50 [2(6)]	12,65	5,88	9,49	14,74	6,93	11,05	12,65	1,27	5,28	14,74	1,59	6,60
	T	12	6	4,0x40 [2(6)]	8,72	2,33	3,91	10,50	2,88	4,88	8,72	1,05	5,28	10,50	1,26	6,60
				4,0x50 [2(6)]	9,68	2,93	5,12	10,98	3,54	6,31	9,68	1,17	5,28	10,98	1,32	6,60
				5,0x40 [2(6)]	11,62	5,18	8,71	13,44	6,11	10,08	11,62	1,27	5,28	13,44	1,59	6,60
				5,0x50 [2(6)]	12,65	5,88	9,49	14,74	6,93	11,05	12,65	1,27	5,28	14,74	1,59	6,60
50x195x2	V	26	14	4,0x40 [2(7)]	9,81	2,79	7,63	11,82	3,46	9,19	9,81	0,94	5,28	11,82	1,13	6,60
				4,0x50 [2(7)]	10,89	3,55	8,47	12,35	4,30	9,61	10,89	1,01	5,28	12,35	1,18	6,60
				5,0x40 [2(7)]	13,07	6,56	10,17	15,12	7,76	11,76	13,07	1,01	5,28	15,12	1,26	6,60
				5,0x50 [2(7)]	14,24	7,49	11,07	16,58	8,86	12,89	14,24	1,01	5,28	16,58	1,26	6,60
	T	14	8	4,0x40 [2(7)]	9,81	2,79	5,45	11,82	3,46	6,78	9,81	0,94	5,28	11,82	1,13	6,60
				4,0x50 [2(7)]	10,89	3,55	7,07	12,35	4,30	8,68	10,89	1,01	5,28	12,35	1,18	6,60
				5,0x40 [2(7)]	13,07	6,56	10,17	15,12	7,76	11,76	13,07	1,01	5,28	15,12	1,26	6,60
				5,0x50 [2(7)]	14,24	7,49	11,07	16,58	8,86	12,89	14,24	1,01	5,28	16,58	1,26	6,60
60x80x2	V	10	6	4,0x40	4,14	2,48	1,36	5,15	3,08	1,69	8,72	2,68	5,28	10,50	3,23	6,60
				4,0x50 [2(3)]	5,35	1,60	1,80	6,56	1,95	2,25	6,05	1,86	5,28	6,86	2,11	6,60
				5,0x40	11,02	6,39	4,86	13,16	7,61	6,02	11,62	3,25	5,28	13,44	4,06	6,60
				5,0x50 [2(3)]	7,91	3,70	4,75	9,21	4,40	5,53	7,91	2,43	5,28	9,21	2,83	6,60
	T	6	4	4,0x40	2,56	1,65	0,90	3,18	2,06	1,13	6,54	2,01	5,28	7,88	2,42	6,60
				4,0x50 [2(3)]	3,30	1,60	1,20	4,03	1,95	1,50	6,05	1,86	5,28	6,86	2,11	6,60
				5,0x40	6,70	4,26	3,21	7,99	5,07	3,97	8,71	2,68	5,28	10,08	3,10	6,60
				5,0x50 [2(3)]	7,80	3,70	4,07	9,21	4,40	5,01	7,91	2,43	5,28	9,21	2,83	6,60
60x100x2	V	14	8	4,0x40	6,74	3,31	3,07	8,36	4,11	3,84	10,90	1,88	4,22	13,13	2,35	5,28
				4,0x50 [2(4)]	7,26	2,13	4,06	8,23	2,60	5,05	7,26	1,61	4,22	8,23	1,83	5,28
				5,0x40	14,52	8,52	10,25	16,80	10,14	12,55	14,52	1,88	4,22	16,80	2,35	5,28
				5,0x50 [2(4)]	9,49	4,94	6,33	11,05	5,87	7,37	9,49	1,88	4,22	11,05	2,35	5,28
	T	8	4	4,0x40	3,94	1,65	1,89	4,89	2,06	2,35	6,54	1,45	4,22	7,88	1,75	5,28
				4,0x50 [2(4)]	5,03	2,13	2,49	6,12	2,60	3,09	7,26	1,61	4,22	8,23	1,83	5,28
				5,0x40	8,71	4,26	5,81	10,08	5,07	6,72	8,71	1,88	4,22	10,08	2,24	5,28
				5,0x50 [2(4)]	9,49	4,94	6,33	11,05	5,87	7,37	9,49	1,88	4,22	11,05	2,35	5,28
60x130x2	V	18	10	4,0x40	10,34	4,04	4,57	12,79	5,01	5,71	13,08	1,81	5,28	15,75	2,26	6,60
				4,0x50 [2(5)]	8,47	2,58	6,03	9,61	3,14	6,86	8,47	1,45	5,28	9,61	1,65	6,60
				5,0x40	17,43	9,80	14,52	20,16	11,62	16,80	17,43	1,81	5,28	20,16	2,26	6,60
				5,0x50 [2(5)]	11,07	5,63	7,91	12,89	6,66	9,21	11,07	1,81	5,28	12,89	2,21	6,60
	T	10	6	4,0x40	5,84	2,42	2,68	7,22	3,01	3,35	8,72	1,50	5,28	10,50	1,80	6,60
				4,0x50 [2(5)]	7,34	2,58	3,53	8,83	3,14	4,37	8,47	1,45	5,28	9,61	1,65	6,60
				5,0x40	11,62	5,88	8,49	13,44	6,97	10,08	11,62	1,81	5,28	13,44	2,26	6,60
				5,0x50 [2(5)]	11,07	5,63	7,91	12,89	6,66	9,21	11,07	1,81	5,28	12,89	2,21	6,60

GH - Balkenschuhe Typ 04 Kombi

					Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
		n_H	n_J		$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
60x160x2	V	22	12	4,0x40	15,26	4,94	7,09	18,38	6,13	8,83	15,26	1,32	5,28	18,38	1,65	6,60
				4,0x50 [2(6)]	9,68	3,17	7,26	10,98	3,87	8,23	9,68	1,21	5,28	10,98	1,37	6,60
				5,0x40	20,33	12,54	17,43	23,52	14,91	20,16	20,33	1,32	5,28	23,52	1,65	6,60
				5,0x50 [2(6)]	12,65	7,25	9,49	14,74	8,61	11,05	12,65	1,32	5,28	14,74	1,65	6,60
	T	12	6	4,0x40	8,50	2,47	4,04	10,45	3,07	5,03	8,72	1,09	5,28	10,50	1,31	6,60
				4,0x50 [2(6)]	9,68	3,17	5,28	10,98	3,87	6,50	9,68	1,21	5,28	10,98	1,37	6,60
				5,0x40	11,62	6,27	8,71	13,44	7,46	10,08	11,62	1,32	5,28	13,44	1,65	6,60
				5,0x50 [2(6)]	12,65	7,25	9,49	14,74	8,61	11,05	12,65	1,32	5,28	14,74	1,65	6,60
60x190x2	V	26	14	4,0x40	17,44	5,74	9,99	21,01	7,13	12,43	17,44	1,04	5,28	21,01	1,30	6,60
				4,0x50 [2(7)]	10,89	3,69	8,47	12,35	4,50	9,61	10,89	1,04	5,28	12,35	1,22	6,60
				5,0x40	23,23	14,48	20,33	26,88	17,21	23,52	23,23	1,04	5,28	26,88	1,30	6,60
				5,0x50 [2(7)]	14,24	8,36	11,07	16,58	9,93	12,89	14,24	1,04	5,28	16,58	1,30	6,60
	T	14	8	4,0x40	10,90	3,28	5,56	13,13	4,08	6,91	10,90	1,04	5,28	13,13	1,30	6,60
				4,0x50 [2(7)]	10,89	3,69	7,20	12,35	4,50	8,84	10,89	1,04	5,28	12,35	1,22	6,60
				5,0x40	14,52	8,07	11,62	16,80	9,34	13,44	14,52	1,04	5,28	16,80	1,30	6,60
				5,0x50 [2(7)]	14,24	8,36	11,07	16,58	9,93	12,89	14,24	1,04	5,28	16,58	1,30	6,60
60x220x2	V	30	16	4,0x40	19,62	6,62	13,03	23,63	8,22	16,18	19,62	0,88	5,28	23,63	1,10	6,60
				4,0x50 [2(8)]	12,10	4,26	9,68	13,72	5,20	10,98	12,10	0,88	5,28	13,72	1,10	6,60
				5,0x40	26,14	17,04	23,23	30,24	20,29	26,88	26,14	0,88	5,28	30,24	1,10	6,60
				5,0x50 [2(8)]	15,82	9,88	12,65	18,42	11,74	14,74	15,82	0,88	5,28	18,42	1,10	6,60
	T	16	8	4,0x40	10,90	3,31	7,14	13,13	4,11	8,87	10,90	0,88	5,28	13,13	1,09	6,60
				4,0x50 [2(8)]	12,10	4,26	9,18	13,72	5,20	10,98	12,10	0,88	5,28	13,72	1,10	6,60
				5,0x40	14,52	8,52	11,62	16,80	10,14	13,44	14,52	0,88	5,28	16,80	1,10	6,60
				5,0x50 [2(8)]	15,82	9,88	12,65	18,42	11,74	14,74	15,82	0,88	5,28	18,42	1,10	6,60
64x98x2	V	14	8	4,0x40	6,51	3,34	3,15	8,08	4,15	3,93	10,90	1,93	4,22	13,13	2,41	5,28
				4,0x50 [2(4)]	7,26	2,16	4,16	8,23	2,64	5,16	7,26	1,66	4,22	8,23	1,88	5,28
				5,0x40	14,52	8,84	10,43	16,80	10,55	12,76	14,52	1,93	4,22	16,80	2,41	5,28
				5,0x50 [2(4)]	9,49	5,15	6,33	11,05	6,14	7,37	9,49	1,93	4,22	11,05	2,41	5,28
	T	8	4	4,0x40	3,82	1,67	1,93	4,73	2,08	2,41	6,54	1,49	4,22	7,88	1,80	5,28
				4,0x50 [2(4)]	4,88	2,16	2,55	5,94	2,64	3,16	7,26	1,66	4,22	8,23	1,88	5,28
				5,0x40	8,71	4,42	5,81	10,08	5,28	6,72	8,71	1,93	4,22	10,08	2,30	5,28
				5,0x50 [2(4)]	9,49	5,15	6,33	11,05	6,14	7,37	9,49	1,93	4,22	11,05	2,41	5,28
64x128x2	V	18	10	4,0x40	10,09	4,08	4,66	12,48	5,06	5,81	13,08	1,85	5,28	15,75	2,31	6,60
				4,0x50 [2(5)]	8,47	2,61	6,05	9,61	3,18	6,86	8,47	1,48	5,28	9,61	1,68	6,60
				5,0x40	17,43	10,12	14,52	20,16	12,02	16,80	17,43	1,85	5,28	20,16	2,31	6,60
				5,0x50 [2(5)]	11,07	5,83	7,91	12,89	6,91	9,21	11,07	1,85	5,28	12,89	2,26	6,60
	T	10	6	4,0x40	5,70	2,45	2,73	7,06	3,04	3,40	8,72	1,53	5,28	10,50	1,84	6,60
				4,0x50 [2(5)]	7,18	2,61	3,59	8,66	3,18	4,44	8,47	1,48	5,28	9,61	1,68	6,60
				5,0x40	11,62	6,07	8,59	13,44	7,21	10,08	11,62	1,85	5,28	13,44	2,31	6,60
				5,0x50 [2(5)]	11,07	5,83	7,91	12,89	6,91	9,21	11,07	1,85	5,28	12,89	2,26	6,60
70x125x2	V	18	10	4,0x40	9,74	4,12	4,78	12,06	5,12	5,96	13,08	1,91	5,28	15,75	2,38	6,60
				4,0x50	12,33	5,30	6,29	14,91	6,47	7,80	14,52	1,91	5,28	16,47	2,38	6,60
				5,0x40	17,43	10,52	14,52	20,16	12,52	16,80	17,43	1,91	5,28	20,16	2,38	6,60
				5,0x50	18,98	12,17	15,82	22,10	14,47	18,42	18,98	1,91	5,28	22,10	2,38	6,60
	T	10	6	4,0x40	5,50	2,47	2,80	6,81	3,07	3,49	8,72	1,57	5,28	10,50	1,89	6,60
				4,0x50	6,96	3,18	3,68	8,40	3,88	4,56	9,68	1,75	5,28	10,98	1,98	6,60
				5,0x40	11,62	6,31	8,71	13,44	7,51	10,08	11,62	1,91	5,28	13,44	2,38	6,60
				5,0x50	12,65	7,30	9,49	14,74	8,68	11,05	12,65	1,91	5,28	14,74	2,38	6,60
70x155x2	V	22	12	4,0x40	14,83	5,05	7,32	18,26	6,28	9,12	15,26	1,37	5,28	18,38	1,71	6,60
				4,0x50	16,94	6,54	9,57	19,21	8,01	11,80	16,94	1,37	5,28	19,21	1,71	6,60
				5,0x40	20,33	13,65	17,43	23,52	16,31	20,16	20,33	1,37	5,28	23,52	1,71	6,60
				5,0x50	22,14	15,96	18,98	25,79	19,04	22,10	22,14	1,37	5,28	25,79	1,71	6,60
	T	12	6	4,0x40	8,19	2,52	4,17	10,08	3,14	5,19	8,72	1,13	5,28	10,50	1,36	6,60
				4,0x50	9,68	3,27	5,44	10,98	4,01	6,70	9,68	1,26	5,28	10,98	1,43	6,60
				5,0x40	11,62	6,82	8,71	13,44	8,16	10,08	11,62	1,37	5,28	13,44	1,71	6,60
				5,0x50	12,65	7,98	9,49	14,74	9,52	11,05	12,65	1,37	5,28	14,74	1,71	6,60

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					Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
		n_H	n_J		$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
72x124x2	V	18	10	4,0x40	9,62	4,13	4,82	11,91	5,14	6,01	13,08	1,93	5,28	15,75	2,41	6,60
				4,0x50	12,19	5,32	6,35	14,75	6,50	7,86	14,52	1,93	5,28	16,47	2,41	6,60
				5,0x40	17,43	10,64	14,52	20,16	12,66	16,80	17,43	1,93	5,28	20,16	2,41	6,60
				5,0x50	18,98	12,33	15,82	22,10	14,65	18,42	18,98	1,93	5,28	22,10	2,41	6,60
	T	10	6	4,0x40	5,45	2,48	2,83	6,74	3,08	3,52	8,72	1,59	5,28	10,50	1,91	6,60
				4,0x50	6,89	3,19	3,71	8,33	3,90	4,60	9,68	1,76	5,28	10,98	2,00	6,60
				5,0x40	11,62	6,38	8,71	13,44	7,60	10,08	11,62	1,93	5,28	13,44	2,41	6,60
				5,0x50	12,65	7,40	9,49	14,74	8,75	11,05	12,65	1,93	5,28	14,74	2,41	6,60
72x154x2	V	22	12	4,0x40	14,71	5,06	7,40	18,13	6,30	9,22	15,26	1,38	5,28	18,38	1,73	6,60
				4,0x50	16,94	6,56	9,66	19,21	8,05	11,91	16,94	1,38	5,28	19,21	1,73	6,60
				5,0x40	20,33	13,82	17,43	23,52	16,54	20,16	20,33	1,38	5,28	23,52	1,73	6,60
				5,0x50	22,14	16,20	18,98	25,79	19,34	22,10	22,14	1,38	5,28	25,79	1,73	6,60
	T	12	6	4,0x40	8,12	2,53	4,20	10,00	3,15	5,23	8,72	1,14	5,28	10,50	1,38	6,60
				4,0x50	9,68	3,28	5,47	10,98	4,03	6,74	9,68	1,27	5,28	10,98	1,44	6,60
				5,0x40	11,62	6,91	8,71	13,44	8,27	10,08	11,62	1,38	5,28	13,44	1,73	6,60
				5,0x50	12,65	8,10	9,49	14,74	9,67	11,05	12,65	1,38	5,28	14,74	1,73	6,60
72x184x2	V	26	14	4,0x40	17,44	5,85	10,32	21,01	7,28	12,84	17,44	1,08	5,28	21,01	1,35	6,60
				4,0x50	19,36	7,57	13,37	21,96	9,26	16,40	19,36	1,08	5,28	21,96	1,35	6,60
				5,0x40	23,23	15,55	20,33	26,88	18,56	23,52	23,23	1,08	5,28	26,88	1,35	6,60
				5,0x50	25,31	17,69	22,14	29,47	20,60	25,79	25,31	1,08	5,28	29,47	1,35	6,60
	T	14	8	4,0x40	10,80	3,35	5,74	13,13	4,16	7,14	10,90	1,08	5,28	13,13	1,35	6,60
				4,0x50	12,10	4,32	7,43	13,72	5,29	9,10	12,10	1,08	5,28	13,72	1,35	6,60
				5,0x40	14,52	8,29	11,62	16,80	9,59	13,44	14,52	1,08	5,28	16,80	1,35	6,60
				5,0x50	15,82	9,03	12,65	18,42	10,51	14,74	15,82	1,08	5,28	18,42	1,35	6,60
76x122x2	V	18	10	4,0x40	9,38	4,16	4,91	11,62	5,16	6,12	13,08	1,97	5,28	15,75	2,46	6,60
				4,0x50	11,91	5,36	6,45	14,44	6,55	7,99	14,52	1,97	5,28	16,47	2,46	6,60
				5,0x40	17,43	10,84	14,52	20,16	12,92	16,80	17,43	1,97	5,28	20,16	2,46	6,60
				5,0x50	18,98	12,60	15,82	22,10	14,99	18,42	18,98	1,97	5,28	22,10	2,46	6,60
	T	10	6	4,0x40	5,33	2,49	2,88	6,60	3,10	3,58	8,72	1,62	5,28	10,50	1,96	6,60
				4,0x50	6,75	3,22	3,78	8,17	3,93	4,67	9,68	1,80	5,28	10,98	2,04	6,60
				5,0x40	11,62	6,50	8,71	13,44	7,75	10,08	11,62	1,97	5,28	13,44	2,46	6,60
				5,0x50	12,65	7,56	9,49	14,74	8,83	11,05	12,65	1,97	5,28	14,74	2,46	6,60
76x152x2	V	22	12	4,0x40	14,47	5,09	7,48	17,83	6,33	9,31	15,26	1,41	5,28	18,38	1,76	6,60
				4,0x50	16,94	6,61	9,76	19,21	8,12	12,03	16,94	1,41	5,28	19,21	1,76	6,60
				5,0x40	20,33	14,13	17,43	23,52	16,94	20,16	20,33	1,41	5,28	23,52	1,76	6,60
				5,0x50	22,14	16,63	18,98	25,79	19,88	22,10	22,14	1,41	5,28	25,79	1,76	6,60
	T	12	6	4,0x40	7,99	2,54	4,27	9,84	3,17	5,32	8,72	1,16	5,28	10,50	1,40	6,60
				4,0x50	9,68	3,31	5,57	10,98	4,06	6,85	9,68	1,29	5,28	10,98	1,46	6,60
				5,0x40	11,62	7,07	8,71	13,44	8,47	10,08	11,62	1,41	5,28	13,44	1,76	6,60
				5,0x50	12,65	8,32	9,49	14,74	9,94	11,05	12,65	1,41	5,28	14,74	1,76	6,60
76x182x2	V	26	14	4,0x40	17,44	5,88	10,43	21,01	7,31	12,97	17,44	1,10	5,28	21,01	1,37	6,60
				4,0x50	19,36	7,61	13,51	21,96	9,32	16,56	19,36	1,10	5,28	21,96	1,37	6,60
				5,0x40	23,23	15,80	20,33	26,88	18,88	23,52	23,23	1,10	5,28	26,88	1,37	6,60
				5,0x50	25,31	17,82	22,14	29,47	20,75	25,79	25,31	1,10	5,28	29,47	1,37	6,60
	T	14	8	4,0x40	10,69	3,36	5,81	13,11	4,18	7,23	10,90	1,10	5,28	13,13	1,36	6,60
				4,0x50	12,10	4,35	7,51	13,72	5,33	9,20	12,10	1,10	5,28	13,72	1,37	6,60
				5,0x40	14,52	8,36	11,62	16,80	9,67	13,44	14,52	1,10	5,28	16,80	1,37	6,60
				5,0x50	15,82	9,10	12,65	18,42	10,60	14,74	15,82	1,10	5,28	18,42	1,37	6,60
80x100x2	V	14	8	4,0x40	6,40	3,41	2,90	7,95	4,25	3,62	10,90	2,49	5,28	13,13	3,10	6,60
				4,0x50	8,22	4,44	3,84	10,03	5,46	4,77	12,10	2,49	5,28	13,72	3,12	6,60
				5,0x40	14,52	9,67	9,79	16,80	11,61	12,00	14,52	2,49	5,28	16,80	3,12	6,60
				5,0x50	15,82	11,43	12,16	18,42	13,68	14,74	15,82	2,49	5,28	18,42	3,12	6,60
	T	8	4	4,0x40	3,76	1,71	1,78	4,66	2,12	2,22	6,54	1,54	5,28	7,88	1,86	6,60
				4,0x50	4,81	2,22	2,35	5,86	2,73	2,92	7,26	1,71	5,28	8,23	1,94	6,60
				5,0x40	8,71	4,83	5,81	10,08	5,80	6,72	8,71	2,06	5,28	10,08	2,38	6,60
				5,0x50	9,49	5,71	6,33	11,05	6,84	7,37	9,49	2,24	5,28	11,05	2,61	6,60

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		n_H	n_J		Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
					$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
80x120x2	V	18	10	4,0x40	9,10	4,25	4,99	11,28	5,29	6,22	13,08	2,01	5,28	15,75	2,51	6,60
				4,0x50	11,59	5,53	6,56	14,07	6,79	8,12	14,52	2,01	5,28	16,47	2,51	6,60
				5,0x40	17,43	11,91	14,52	20,16	14,28	16,80	17,43	2,01	5,28	20,16	2,51	6,60
				5,0x50	18,98	14,04	15,82	22,10	16,79	18,42	18,98	2,01	5,28	22,10	2,51	6,60
	T	10	6	4,0x40	5,18	2,55	2,93	6,41	3,17	3,65	8,72	1,66	5,28	10,50	2,00	6,60
				4,0x50	6,58	3,32	3,84	7,98	4,08	4,75	9,68	1,84	5,28	10,98	2,09	6,60
				5,0x40	11,62	7,14	8,71	13,44	8,57	10,08	11,62	2,01	5,28	13,44	2,51	6,60
				5,0x50	12,65	8,42	9,49	14,74	10,08	11,05	12,65	2,01	5,28	14,74	2,51	6,60
80x140x2	V	20	10	4,0x40	12,21	4,27	5,96	15,09	5,31	7,43	13,08	1,60	5,28	15,75	2,00	6,60
				4,0x50	14,52	5,55	7,82	16,47	6,83	9,67	14,52	1,60	5,28	16,47	2,00	6,60
				5,0x40	17,43	12,08	14,52	20,16	14,51	16,80	17,43	1,60	5,28	20,16	2,00	6,60
				5,0x50	18,98	14,28	15,82	22,10	17,10	18,42	18,98	1,60	5,28	22,10	2,00	6,60
	T	10	6	4,0x40	6,55	2,56	2,55	8,07	3,19	3,18	8,72	1,32	5,28	10,50	1,59	6,60
				4,0x50	8,10	3,33	3,36	9,68	4,10	4,17	9,68	1,47	5,28	10,98	1,67	6,60
				5,0x40	11,62	7,25	8,19	13,44	8,71	9,97	11,62	1,60	5,28	13,44	2,00	6,60
				5,0x50	12,65	8,57	9,49	14,74	10,26	11,05	12,65	1,60	5,28	14,74	2,00	6,60
80x150x2	V	22	12	4,0x40	14,21	5,11	7,59	17,53	6,36	9,46	15,26	1,43	5,28	18,38	1,79	6,60
				4,0x50	16,94	6,65	9,91	19,21	8,18	12,20	16,94	1,43	5,28	19,21	1,79	6,60
				5,0x40	20,33	14,40	17,43	23,52	17,28	20,16	20,33	1,43	5,28	23,52	1,79	6,60
				5,0x50	22,14	17,00	18,98	25,79	20,34	22,10	22,14	1,43	5,28	25,79	1,79	6,60
	T	12	6	4,0x40	7,85	2,56	4,31	9,68	3,18	5,37	8,72	1,18	5,28	10,50	1,42	6,60
				4,0x50	9,68	3,32	5,62	10,98	4,09	6,91	9,68	1,31	5,28	10,98	1,48	6,60
				5,0x40	11,62	7,20	8,71	13,44	8,64	10,08	11,62	1,43	5,28	13,44	1,79	6,60
				5,0x50	12,65	8,50	9,49	14,74	10,17	11,05	12,65	1,43	5,28	14,74	1,79	6,60
80x180x2	V	26	14	4,0x40	17,44	6,01	10,54	21,01	7,48	13,10	17,44	1,11	5,28	21,01	1,39	6,60
				4,0x50	19,36	7,84	13,64	21,96	9,66	16,72	19,36	1,11	5,28	21,96	1,39	6,60
				5,0x40	23,23	17,42	20,33	26,88	20,97	23,52	23,23	1,11	5,28	26,88	1,39	6,60
				5,0x50	25,31	20,70	22,14	29,47	24,33	25,79	25,31	1,11	5,28	29,47	1,39	6,60
	T	14	8	4,0x40	10,57	3,43	5,85	12,97	4,28	7,27	10,90	1,11	5,28	13,13	1,38	6,60
				4,0x50	12,10	4,48	7,56	13,72	5,52	9,25	12,10	1,11	5,28	13,72	1,39	6,60
				5,0x40	14,52	9,82	11,62	16,80	11,36	13,44	14,52	1,11	5,28	16,80	1,39	6,60
				5,0x50	15,82	10,70	12,65	18,42	12,46	14,74	15,82	1,11	5,28	18,42	1,39	6,60
80x210x2	V	30	16	4,0x40	19,62	6,84	13,58	23,63	8,51	16,86	19,62	0,93	5,28	23,63	1,16	6,60
				4,0x50	21,78	8,90	17,45	24,70	10,96	21,29	21,78	0,93	5,28	24,70	1,16	6,60
				5,0x40	26,14	18,91	23,23	30,24	21,87	26,88	26,14	0,93	5,28	30,24	1,16	6,60
				5,0x50	28,47	20,59	25,31	33,15	23,98	29,47	28,47	0,93	5,28	33,15	1,16	6,60
	T	16	8	4,0x40	10,90	3,42	7,44	13,13	4,25	9,24	10,90	0,93	5,28	13,13	1,15	6,60
				4,0x50	12,10	4,45	9,55	13,72	5,48	10,98	12,10	0,93	5,28	13,72	1,16	6,60
				5,0x40	14,52	9,60	11,62	16,80	11,10	13,44	14,52	0,93	5,28	16,80	1,16	6,60
				5,0x50	15,82	10,45	12,65	18,42	12,17	14,74	15,82	0,93	5,28	18,42	1,16	6,60
90x145x2	V	22	12	4,0x40	13,57	5,15	7,86	16,76	6,41	9,79	15,26	1,49	5,28	18,38	1,86	6,60
				4,0x50	16,93	6,72	10,24	19,21	8,27	12,60	16,94	1,49	5,28	19,21	1,86	6,60
				5,0x40	20,33	14,89	17,43	23,52	17,91	20,16	20,33	1,49	5,28	23,52	1,86	6,60
				5,0x50	22,14	17,68	18,98	25,79	21,10	22,10	22,14	1,49	5,28	25,79	1,86	6,60
	T	12	6	4,0x40	7,52	2,57	4,46	9,28	3,20	5,56	8,72	1,23	5,28	10,50	1,48	6,60
				4,0x50	9,36	3,36	5,80	10,98	4,14	7,13	9,68	1,36	5,28	10,98	1,55	6,60
				5,0x40	11,62	7,44	8,71	13,44	8,96	10,08	11,62	1,49	5,28	13,44	1,86	6,60
				5,0x50	12,65	8,84	9,49	14,74	10,60	11,05	12,65	1,49	5,28	14,74	1,86	6,60
98x141x2	V	22	12	4,0x40	13,03	5,17	8,09	16,10	6,43	10,07	15,26	1,54	5,28	18,38	1,93	6,60
				4,0x50	16,33	6,75	10,52	19,21	8,32	12,94	16,94	1,54	5,28	19,21	1,93	6,60
				5,0x40	20,33	15,14	17,43	23,52	18,24	20,16	20,33	1,54	5,28	23,52	1,93	6,60
				5,0x50	22,14	18,03	18,98	25,79	21,28	22,10	22,14	1,54	5,28	25,79	1,93	6,60
	T	12	6	4,0x40	7,23	2,58	4,58	8,94	3,22	5,69	8,72	1,27	5,28	10,50	1,53	6,60
				4,0x50	9,05	3,37	5,94	10,87	4,16	7,30	9,68	1,41	5,28	10,98	1,60	6,60
				5,0x40	11,62	7,57	8,71	13,44	9,12	10,08	11,62	1,54	5,28	13,44	1,93	6,60
				5,0x50	12,65	9,02	9,49	14,74	10,83	11,05	12,65	1,54	5,28	14,74	1,93	6,60

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		n_H	n_J		Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
					$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
100x140x2	V	22	12	4,0x40	12,89	5,23	8,13	15,94	6,53	10,12	15,26	1,56	5,28	18,38	1,94	6,60
				4,0x50	16,18	6,87	10,57	19,21	8,50	13,00	16,94	1,56	5,28	19,21	1,94	6,60
				5,0x40	20,33	16,20	17,43	23,52	19,64	20,16	20,33	1,56	5,28	23,52	1,94	6,60
				5,0x50	22,14	19,58	18,98	25,79	23,65	22,10	22,14	1,56	5,28	25,79	1,94	6,60
	T	12	6	4,0x40	7,16	2,62	4,61	8,84	3,26	5,74	8,72	1,28	5,28	10,50	1,55	6,60
				4,0x50	8,97	3,44	5,99	10,78	4,25	7,35	9,68	1,43	5,28	10,98	1,62	6,60
				5,0x40	11,62	8,10	8,71	13,44	9,82	10,08	11,62	1,56	5,28	13,44	1,94	6,60
				5,0x50	12,65	9,79	9,49	14,74	11,83	11,05	12,65	1,56	5,28	14,74	1,94	6,60
100x160x2	V	24	12	4,0x40	15,26	5,25	9,41	18,38	6,54	11,71	15,26	1,28	5,28	18,38	1,60	6,60
				4,0x50	16,94	6,89	12,20	19,21	8,53	14,97	16,94	1,28	5,28	19,21	1,60	6,60
				5,0x40	20,33	16,39	17,43	23,52	19,89	20,16	20,33	1,28	5,28	23,52	1,60	6,60
				5,0x50	22,14	19,86	18,98	25,79	24,01	22,10	22,14	1,28	5,28	25,79	1,60	6,60
	T	12	6	4,0x40	8,63	2,62	4,16	10,50	3,27	5,18	8,72	1,06	5,28	10,50	1,27	6,60
				4,0x50	9,68	3,45	5,43	10,98	4,27	6,68	9,68	1,17	5,28	10,98	1,33	6,60
				5,0x40	11,62	8,19	8,71	13,44	9,94	10,08	11,62	1,28	5,28	13,44	1,60	6,60
				5,0x50	12,65	9,93	9,49	14,74	12,01	11,05	12,65	1,28	5,28	14,74	1,60	6,60
100x170x2	V	26	14	4,0x40	17,44	6,10	11,11	21,01	7,60	13,81	17,44	1,19	5,28	21,01	1,49	6,60
				4,0x50	19,36	8,01	14,33	21,96	9,90	17,53	19,36	1,19	5,28	21,96	1,49	6,60
				5,0x40	23,23	18,79	20,33	26,88	22,58	23,52	23,23	1,19	5,28	26,88	1,49	6,60
				5,0x50	25,31	21,26	22,14	29,47	24,76	25,79	25,31	1,19	5,28	29,47	1,49	6,60
	T	14	8	4,0x40	9,95	3,49	6,20	12,24	4,35	7,70	10,90	1,19	5,28	13,13	1,48	6,60
				4,0x50	12,10	4,58	7,98	13,72	5,66	9,75	12,10	1,19	5,28	13,72	1,49	6,60
				5,0x40	14,52	10,06	11,62	16,80	11,63	13,44	14,52	1,19	5,28	16,80	1,49	6,60
				5,0x50	15,82	10,95	12,65	18,42	12,76	14,74	15,82	1,19	5,28	18,42	1,49	6,60
100x200x2	V	30	16	4,0x40	19,62	6,99	14,22	23,63	8,72	17,64	19,62	0,98	5,28	23,63	1,23	6,60
				4,0x50	21,78	9,19	18,21	24,70	11,38	21,96	21,78	0,98	5,28	24,70	1,23	6,60
				5,0x40	26,14	21,85	23,23	30,24	25,73	26,88	26,14	0,98	5,28	30,24	1,23	6,60
				5,0x50	28,47	24,23	25,31	33,15	28,21	29,47	28,47	0,98	5,28	33,15	1,23	6,60
	T	16	8	4,0x40	10,90	3,50	7,77	13,13	4,36	9,64	10,90	0,98	5,28	13,13	1,22	6,60
				4,0x50	12,10	4,60	9,68	13,72	5,69	10,98	12,10	0,98	5,28	13,72	1,23	6,60
				5,0x40	14,52	10,92	11,62	16,80	13,13	13,44	14,52	0,98	5,28	16,80	1,23	6,60
				5,0x50	15,82	12,37	12,65	18,42	14,40	14,74	15,82	0,98	5,28	18,42	1,23	6,60
114x163x2	V	26	14	4,0x40	17,30	6,12	11,56	21,01	7,63	14,36	17,44	1,25	5,28	21,01	1,56	6,60
				4,0x50	19,36	8,05	14,88	21,96	9,96	18,17	19,36	1,25	5,28	21,96	1,56	6,60
				5,0x40	23,23	19,16	20,33	26,88	22,87	23,52	23,23	1,25	5,28	26,88	1,56	6,60
				5,0x50	25,31	21,53	22,14	29,47	25,07	25,79	25,31	1,25	5,28	29,47	1,56	6,60
	T	14	8	4,0x40	9,45	3,50	6,44	11,64	4,36	7,99	10,90	1,25	5,28	13,13	1,56	6,60
				4,0x50	11,65	4,60	8,26	13,72	5,69	10,08	12,10	1,25	5,28	13,72	1,56	6,60
				5,0x40	14,52	10,23	11,62	16,80	11,83	13,44	14,52	1,25	5,28	16,80	1,56	6,60
				5,0x50	15,82	11,14	12,65	18,42	12,97	14,74	15,82	1,25	5,28	18,42	1,56	6,60
114x193x2	V	30	16	4,0x40	19,62	7,04	14,67	23,63	8,78	18,20	19,62	1,02	5,28	23,63	1,28	6,60
				4,0x50	21,78	9,28	18,75	24,70	11,50	21,96	21,78	1,02	5,28	24,70	1,28	6,60
				5,0x40	26,14	22,48	23,23	30,24	26,00	26,88	26,14	1,02	5,28	30,24	1,28	6,60
				5,0x50	28,47	24,48	25,31	33,15	28,51	29,47	28,47	1,02	5,28	33,15	1,28	6,60
	T	16	8	4,0x40	10,90	3,52	8,03	13,13	4,39	9,96	10,90	1,02	5,28	13,13	1,27	6,60
				4,0x50	12,10	4,64	9,68	13,72	5,75	10,98	12,10	1,02	5,28	13,72	1,28	6,60
				5,0x40	14,52	11,33	11,62	16,80	13,31	13,44	14,52	1,02	5,28	16,80	1,28	6,60
				5,0x50	15,82	12,54	12,65	18,42	14,60	14,74	15,82	1,02	5,28	18,42	1,28	6,60
120x120x2	V	18	10	4,0x40	9,32	4,40	5,15	11,54	5,49	6,42	13,08	1,95	5,28	15,75	2,44	6,60
				4,0x50	11,84	5,80	6,76	14,36	7,20	8,37	14,52	1,95	5,28	16,47	2,44	6,60
				5,0x40	17,43	14,22	14,52	20,16	17,34	16,80	17,43	1,95	5,28	20,16	2,44	6,60
				5,0x50	18,98	17,41	15,82	22,10	21,15	18,42	18,98	1,95	5,28	22,10	2,44	6,60
	T	10	6	4,0x40	5,30	2,64	3,01	6,56	3,30	3,75	8,72	1,61	5,28	10,50	1,94	6,60
				4,0x50	6,72	3,48	3,95	8,14	4,32	4,88	9,68	1,79	5,28	10,98	2,03	6,60
				5,0x40	11,62	8,53	8,71	13,44	10,40	10,08	11,62	1,95	5,28	13,44	2,44	6,60
				5,0x50	12,65	10,45	9,49	14,74	12,69	11,05	12,65	1,95	5,28	14,74	2,44	6,60

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		n_H	n_J		Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
					$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
120x140x2	V	22	12	4,0x40	13,16	5,30	8,35	16,26	6,61	10,39	15,26	1,51	5,28	18,38	1,89	6,60
				4,0x50	16,48	6,99	10,85	19,21	8,68	13,33	16,94	1,51	5,28	19,21	1,89	6,60
				5,0x40	20,33	17,37	17,43	23,52	21,22	20,16	20,33	1,51	5,28	23,52	1,89	6,60
				5,0x50	22,14	21,37	18,98	25,79	26,01	22,10	22,14	1,51	5,28	25,79	1,89	6,60
	T	12	6	4,0x40	8,01	2,65	4,43	9,87	3,31	5,51	8,72	1,25	5,28	10,50	1,50	6,60
				4,0x50	9,68	3,50	5,76	10,98	4,34	7,08	9,68	1,38	5,28	10,98	1,57	6,60
				5,0x40	11,62	8,69	8,71	13,44	10,61	10,08	11,62	1,51	5,28	13,44	1,89	6,60
				5,0x50	12,65	10,69	9,49	14,74	13,01	11,05	12,65	1,51	5,28	14,74	1,89	6,60
120x160x2	V	26	14	4,0x40	16,89	6,18	11,77	20,83	7,71	14,61	17,44	1,28	5,28	21,01	1,60	6,60
				4,0x50	19,36	8,16	15,12	21,96	10,13	18,45	19,36	1,28	5,28	21,96	1,60	6,60
				5,0x40	23,23	20,27	20,33	26,88	24,76	23,52	23,23	1,28	5,28	26,88	1,60	6,60
				5,0x50	25,31	24,67	22,14	29,47	28,73	25,79	25,31	1,28	5,28	29,47	1,60	6,60
	T	14	8	4,0x40	9,22	3,53	6,54	11,37	4,41	8,12	10,90	1,28	5,28	13,13	1,59	6,60
				4,0x50	11,41	4,66	8,38	13,62	5,79	10,22	12,10	1,28	5,28	13,72	1,60	6,60
				5,0x40	14,52	11,58	11,62	16,80	13,60	13,44	14,52	1,28	5,28	16,80	1,60	6,60
				5,0x50	15,82	12,80	12,65	18,42	14,91	14,74	15,82	1,28	5,28	18,42	1,60	6,60
120x180x2	V	28	14	4,0x40	17,44	6,18	12,94	21,01	7,71	16,07	17,44	1,11	5,28	21,01	1,39	6,60
				4,0x50	19,36	8,16	16,61	21,96	10,13	19,21	19,36	1,11	5,28	21,96	1,39	6,60
				5,0x40	23,23	20,27	20,33	26,88	24,76	23,52	23,23	1,11	5,28	26,88	1,39	6,60
				5,0x50	25,31	24,94	22,14	29,47	30,35	25,79	25,31	1,11	5,28	29,47	1,39	6,60
	T	14	8	4,0x40	10,57	3,53	5,85	12,97	4,41	7,27	10,90	1,11	5,28	13,13	1,38	6,60
				4,0x50	12,10	4,66	7,56	13,72	5,79	9,25	12,10	1,11	5,28	13,72	1,39	6,60
				5,0x40	14,52	11,58	11,62	16,80	13,60	13,44	14,52	1,11	5,28	16,80	1,39	6,60
				5,0x50	15,82	12,80	12,65	18,42	14,91	14,74	15,82	1,11	5,28	18,42	1,39	6,60
120x190x2	V	30	16	4,0x40	19,62	7,05	14,87	23,63	8,80	18,44	19,62	1,04	5,28	23,63	1,30	6,60
				4,0x50	21,78	9,30	18,97	24,70	11,53	21,96	21,78	1,04	5,28	24,70	1,30	6,60
				5,0x40	26,14	22,58	23,23	30,24	26,12	26,88	26,14	1,04	5,28	30,24	1,30	6,60
				5,0x50	28,47	24,60	25,31	33,15	28,64	29,47	28,47	1,04	5,28	33,15	1,30	6,60
	T	16	8	4,0x40	10,90	3,52	8,12	13,13	4,40	10,07	10,90	1,04	5,28	13,13	1,30	6,60
				4,0x50	12,10	4,65	9,68	13,72	5,77	10,98	12,10	1,04	5,28	13,72	1,30	6,60
				5,0x40	14,52	11,43	11,62	16,80	13,40	13,44	14,52	1,04	5,28	16,80	1,30	6,60
				5,0x50	15,82	12,61	12,65	18,42	14,69	14,74	15,82	1,04	5,28	18,42	1,30	6,60
126x187x2	V	30	16	4,0x40	19,62	7,06	15,06	23,63	8,80	18,67	19,62	1,06	5,28	23,63	1,33	6,60
				4,0x50	21,78	9,31	19,19	24,70	11,55	21,96	21,78	1,06	5,28	24,70	1,33	6,60
				5,0x40	26,14	22,69	23,23	30,24	26,24	26,88	26,14	1,06	5,28	30,24	1,33	6,60
				5,0x50	28,47	24,71	25,31	33,15	28,77	29,47	28,47	1,06	5,28	33,15	1,33	6,60
	T	16	8	4,0x40	10,90	3,53	8,25	13,13	4,40	10,22	10,90	1,06	5,28	13,13	1,32	6,60
				4,0x50	12,10	4,65	9,68	13,72	5,77	10,98	12,10	1,06	5,28	13,72	1,33	6,60
				5,0x40	14,52	11,49	11,62	16,80	13,48	13,44	14,52	1,06	5,28	16,80	1,33	6,60
				5,0x50	15,82	12,69	12,65	18,42	14,77	14,74	15,82	1,06	5,28	18,42	1,33	6,60
140x140x2	V	22	12	4,0x40	13,16	5,33	8,35	16,26	6,66	10,39	15,26	1,51	5,28	18,38	1,89	6,60
				4,0x50	16,48	7,06	10,85	19,21	8,77	13,33	16,94	1,51	5,28	19,21	1,89	6,60
				5,0x40	20,33	18,07	17,43	23,52	22,17	20,16	20,33	1,51	5,28	23,52	1,89	6,60
				5,0x50	22,14	22,48	18,98	25,79	27,49	22,10	22,14	1,51	5,28	25,79	1,89	6,60
	T	12	6	4,0x40	7,31	2,67	4,76	9,03	3,33	5,92	8,72	1,25	5,28	10,50	1,50	6,60
				4,0x50	9,14	3,53	6,17	10,97	4,39	7,57	9,68	1,38	5,28	10,98	1,57	6,60
				5,0x40	11,62	9,03	8,71	13,44	11,08	10,08	11,62	1,51	5,28	13,44	1,89	6,60
				5,0x50	12,65	11,24	9,49	14,74	13,74	11,05	12,65	1,51	5,28	14,74	1,89	6,60
140x160x2	V	26	14	4,0x40	16,89	6,22	11,77	20,83	7,77	14,61	17,44	1,28	5,28	21,01	1,60	6,60
				4,0x50	19,36	8,23	15,12	21,96	10,24	18,45	19,36	1,28	5,28	21,96	1,60	6,60
				5,0x40	23,23	21,08	20,33	26,88	25,86	23,52	23,23	1,28	5,28	26,88	1,60	6,60
				5,0x50	25,31	26,22	22,14	29,47	30,64	25,79	25,31	1,28	5,28	29,47	1,60	6,60
	T	14	8	4,0x40	9,22	3,56	6,54	11,37	4,44	8,12	10,90	1,28	5,28	13,13	1,59	6,60
				4,0x50	11,41	4,70	8,38	13,62	5,85	10,22	12,10	1,28	5,28	13,72	1,60	6,60
				5,0x40	14,52	12,04	11,62	16,80	14,59	13,44	14,52	1,28	5,28	16,80	1,60	6,60
				5,0x50	15,82	13,73	12,65	18,42	15,99	14,74	15,82	1,28	5,28	18,42	1,60	6,60

GH - Balkenschuhe Typ 04 Kombi

					Holz - Holz - Befestigung						Beton/Stahl - Stahl - Befestigung					
					KLED = "mittel"			Charakteristisch			KLED = "mittel"			Charakteristisch		
		n_H	n_J		$F_{z,Rd}$	$F_{y,Rd}$	$F_{z,Up,Rd}$	$F_{z,Rk}$	$F_{y,Rk}$	$F_{z,Up,Rk}$	$F_{z,NT,Rd}$	$F_{l,Bo,Ed}$	$F_{ax,Bo,Ed}$	$F_{z,NT,Rk}$	$F_{l,Bo,Ek}$	$F_{ax,Bo,Ek}$
140x180x2	V	30	16	4,0x40	19,62	7,11	15,59	23,63	8,88	19,32	19,62	1,11	5,28	23,63	1,39	6,60
				4,0x50	21,78	9,41	19,36	24,70	11,70	21,96	21,78	1,11	5,28	24,70	1,39	6,60
				5,0x40	26,14	24,09	23,23	30,24	29,56	26,88	26,14	1,11	5,28	30,24	1,39	6,60
				5,0x50	28,47	28,05	25,31	33,15	32,67	29,47	28,47	1,11	5,28	33,15	1,39	6,60
	T	16	8	4,0x40	10,90	3,56	8,52	13,13	4,44	10,50	10,90	1,11	5,28	13,13	1,38	6,60
				4,0x50	12,10	4,70	9,68	13,72	5,85	10,98	12,10	1,11	5,28	13,72	1,39	6,60
				5,0x40	14,52	12,04	11,62	16,80	14,78	13,44	14,52	1,11	5,28	16,80	1,39	6,60
				5,0x50	15,82	14,47	12,65	18,42	16,85	14,74	15,82	1,11	5,28	18,42	1,39	6,60

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Ermächtigt und notifiziert gemäß Artikel 10 der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte.

MITGLIED DER EOTA

Europäische Technische Zulassung ETA-12/0481

[Übersetzung aus dem Englischen]

Handelsbezeichnung:	RAMPA-Muffen Typ BL und SKL
Zulassungsinhaber:	Hans Brügmann GmbH & Co. Auf der Heide 8 DE-21514 Büchen Tel. +49 (0)4155 8141-0 Fax +49 (0)4155 8141-80 Internet www.rampa.de
Zulassungsgegenstand und Verwendungszweck:	Gewindemuffen mit Außenholzgewinde und metrischem Innengewinde als Verbindungsmittel in Holzbauwerken
Geltungsdauer bis zum:	2013-03-18 2018-03-18
Herstellwerk:	Hans Brügmann GmbH & Co. Auf der Heide 8 DE-21514 Büchen
Diese Europäische Technische Zulassung umfasst:	14 Seiten einschließlich 2 Anhänge, die Bestandteil dieses Dokuments sind.

I RECHTSGRUNDLAGEN UND ALLGEMEINE BEDINGUNGEN

1 Diese Europäische Technische Zulassung wird erteilt durch ETA-Danmark A/S in Übereinstimmung mit:

- der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedsstaaten über Bauprodukte[1)] in der durch Richtlinie 93/68/EWG des Rates vom 22. Juli 1993[2)] geänderten Fassung

- der Rechtsverordnung 559 vom 27. Juni 1994 (ersetzt Rechtsverordnung 480 vom 25. Juni 1991) über das Inkrafttreten der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedsstaaten über Bauprodukte

- den gemeinsamen Verfahrensregeln zur Beantragung, Vorbereitung und Erteilung von europäischen technischen Zulassungen gemäß Anhang zur Entscheidung 94/23/EG[3)] der Kommission

2 ETA-Danmark A/S ist berechtigt zu überprüfen, ob die Bestimmungen dieser europäischen technischen Zulassung eingehalten werden. Diese Überprüfung kann im Herstellwerk erfolgen. Gleichwohl bleibt der Inhaber der europäischen technischen Zulassung für die Konformität der Produkte mit der europäischen technischen Zulassung und deren Eignung für die bestimmungsgemäße Verwendung verantwortlich.

3 Diese europäische technische Zulassung ist nicht auf andere als die auf Seite 1 angegebenen Hersteller oder Vertreter des Herstellers bzw. andere Herstellwerke als die auf Seite 1 dieser europäischen technischen Zulassung genannten übertragbar.

4 Diese europäische technische Zulassung kann von ETA-Danmark A/S gemäß Artikel 5 (1) der Richtlinie 89/106/EWG des Rates widerrufen werden.

5 Diese europäische technische Zulassung darf – auch bei Übermittlung in elektronischer Form – nur ungekürzt wiedergegeben werden. Mit schriftlicher Zustimmung der ETA-Danmark A/S kann jedoch eine auszugsweise Wiedergabe erfolgen. In diesem Fall ist die auszugsweise Wiedergabe als solche zu kennzeichnen. Texte und Zeichnungen von Werbebroschüren dürfen weder im Widerspruch zur europäischen technischen Zulassung stehen noch diese missbräuchlich verwenden.

6 Diese europäische technische Zulassung wird durch ETA-Danmark A/S in englischer Sprache erteilt:
Diese Ausgabe entspricht vollständig der in der EOTA verteilten Fassung. Übersetzungen in andere Sprachen müssen als solche kenntlich gemacht werden.

1) Amtsblatt der Europäischen Gemeinschaften Nr. L40, 11. Feb. 1989, S. 12
2) Amtsblatt der Europäischen Gemeinschaften Nr. L220, 30. Aug. 1993, S. 1
3) Amtsblatt der Europäischen Gemeinschaften Nr. L17, 20. Jan. 1994, S. 34

II BESONDERE BEDINGUNGEN DER EUROPÄISCHEN TECHNISCHEN ZULASSUNG

1 Beschreibung des Produkts und des Verwendungszwecks

1.1 Beschreibung des Produkts

RAMPA-Muffen Typ BL und SKL sind Gewindemuffen, die außen mit einem Holzgewinde und innen mit einem metrischen Gewinde zur Aufnahme von metrischen Schrauben versehen sind. Das äußere Holzgewinde ist ein Vollgewinde. Die Muffen werden aus Kohlenstoffstahl Werkstoff-Nr. 1.0718 gemäß EN 10277-3 oder Edelstahl Werkstoff-Nr. 1.4104 gemäß 10088-3, Werkstoff-Nr. 1.4305 oder 1.4404 gemäß EN 10088-5 gefertigt. Ist ein Korrosionsschutz erforderlich, so müssen Material bzw. Beschichtung mit den relevanten in Anhang A der EN 14592 angeführten Spezifikationen übereinstimmen.

1.2 Maße und Material

Der Nenndurchmesser (Gewindeaußendurchmesser) d sollte nicht kleiner als 10,0 mm und nicht größer als 25,0 mm sein. Die Gesamtlänge L der Muffen darf nicht kürzer als 30 mm und nicht länger als 100 mm sein. Die sonstigen Maße sind in Anhang A angegeben.

Beim Holzgewinde reicht das Verhältnis des Kerndurchmessers zum Gewindeaußendurchmesser d_i/d von 0,75 bis 0,86.

Die Länge des Holzgewindes ℓ_g entspricht der Länge der Muffen L, wobei die Gewindelänge mindestens dem dreifachen Nenndurchmesser d entspricht ($\ell_g \geq 3 \cdot d$).

Beim Holzgewinde reicht die Gewindesteigung p (Abstand zwischen zwei nebeneinander liegenden Gewindeflanken) von $0{,}2 \cdot d$ bis $0{,}33 \cdot d$.

Bei einem Biegewinkel α von weniger als $(45/d^{0,7} + 20)$ Grad dürfen die Muffen keine Risse aufweisen.

Hinweis: Im Vergleich mit herkömmlichen selbstbohrenden Schrauben darf für RAMPA-Muffen mit einer Gewindelänge von $3 \cdot d$ eine effektive Mindestgewindelänge von $4 \cdot d$ angenommen werden. Der Hintergrund dafür ist, dass herkömmliche selbstbohrende Schrauben einschließlich der Schraubenspitze, die nur teilweise zur Ausziehtragfähigkeit beiträgt, eine Mindestgewindelänge von $4 \cdot d$ aufweisen.

1.3 Vorgesehener Verwendungszweck

Die Muffen sind in tragenden Holzkonstruktionen zur Verbindung von Bauteilen aus Vollholz (Nadelholz), Brettschichtholz, Brettsperrholz und Furnierschichtholz sowie ähnlich verleimten Holzbauteilen, Holzwerkstoffplatten und Stahlteilen bestimmt.

Stahlbleche und Holzwerkstoffplatten (ausgenommen Massivholzplatten, Furnierschichtholz und Brettsperrholz) dürfen nur auf der Seite der metrischen Schraube angebracht werden.

Nachstehende Holzwerkstoffplatten können verwendet werden:

- Sperrholz gemäß EN 636 oder europäischer technischer Zulassung
- Spanplatten gemäß EN 312 oder europäischer technischer Zulassung
- Platten aus langen, flachen, ausgerichteten Spänen (OSB) gemäß EN 300 oder europäischer technischer Zulassung
- Faserplatten gemäß EN 622-2 und 622-3 oder europäischer technischer Zulassung (Mindestrohdichte 650 kg/m³)
- Zementgebundene Spanplatten gemäß europäischer technischer Zulassung
- Massivholzplatten gemäß EN 13353 und Brettsperrholz gemäß europäischer technischer Zulassung
- Furnierschichtholz gemäß EN 14374 oder europäischer technischer Zulassung
- Weitere Holzwerkstoffprodukte gemäß europäischer technischer Zulassung, sofern die europäische technische Zulassung des betreffenden Produkts Bestimmungen über die Verwendung von selbstbohrenden Schrauben vorsieht, die eingehalten werden.

Die Muffen werden nach Vorbohren eingeschraubt. Der Durchmesser der Vorbohrung muss über die gesamte Gewindelänge dem Kerndurchmesser der Muffen entsprechen.

Die Muffen sind für Holzverbindungen vorgesehen, welche die Anforderungen an mechanische Beständigkeit, Stabilität und Gebrauchssicherheit im Sinne der grundlegenden Anforderungen 1 und 4 der Richtlinie 89/106/EWG erfüllen.

Die Bemessung der Verbindungen muss auf den charakteristischen Werten der Tragfähigkeit der Muffen beruhen. Die Bemessungswerte der Tragfähigkeiten sind von den charakteristischen Werten gemäß Eurocode 5 oder einer entsprechenden nationalen Norm abzuleiten.

Die Muffen sind zur Verwendung in Verbindungen mit ruhender oder vorwiegend ruhender Belastung vorgesehen.

Hinsichtlich der Korrosionsbeständigkeit ist der Anwendungsbereich der Muffen nach den am Einbauort geltenden nationalen Vorschriften unter Berücksichtigung der dort herrschenden Umweltbedingungen festzulegen. Abschnitt 2.7 dieser europäischen technischen Zulassung enthält Angaben zum Korrosionsschutz von RAMPA-Muffen Typ BL und SKL aus Kohlenstoffstahl

und entsprechende Werkstoffnummern für Muffen aus Edelstahl.

Angenommene Nutzungsdauer
Unter der Voraussetzung einer angemessenen Verwendung und Instandhaltung beträgt die angenommene Nutzungsdauer der Muffen 50 Jahre.

Die Angabe zur Nutzungsdauer ist nicht als eine Garantie des Herstellers oder der die europäische technische Zulassung ausstellenden Zulassungsstelle anzusehen. „Angenommene Nutzungsdauer“ bedeutet, dass bei normaler Nutzung nach Ablauf der angenommenen Nutzungsdauer die tatsächliche Nutzungsdauer weitaus länger sein kann, ohne dass dabei eine größere Schädigung eintritt, die sich auf die grundlegenden Anforderungen auswirkt.

2 Produktmerkmale und Beurteilung

Merkmal		Beurteilung des Merkmals
2.1 Mechanische Festigkeit und Stabilität*)		
2.1.1	Zugtragfähigkeit	Charakteristischer Wert $f_{tens,k}$: d = 10,0 mm: 8,8 kN d = 12,0 mm: 13 kN d = 16,0 mm: 23 kN d = 18,5 mm: 31 kN d = 22,0 mm: 41 kN d = 25,0 mm: 41 kN
2.1.2	Einschraubdrehmoment	Verhältnis des charakteristischen Werts des Bruchdrehmoments zum mittleren Einschraubdrehmoment: $f_{tor,k} / R_{tor,mean} \geq 1,5$
2.1.3	Bruchdrehmoment	Charakteristischer Wert $f_{tor,k}$: d = 10,0 mm: 9,0 Nm d = 12,0 mm: 25 Nm d = 16,0 mm: 40 Nm d = 18,5 mm: 80 Nm d = 22,0 mm: 130 Nm d = 25,0 mm: 180 Nm
2.2 Sicherheit im Brandfall		
2.2.1	Brandverhalten	Die Muffen bestehen aus Stahl der **Euroklasse A1** gemäß EN 1350-1 und EG-Beschluss 96/603/EG, geändert durch EG-Beschluss 2000/605/EG.
2.3 Hygiene, Gesundheit und Umwelt		
2.3.1	Beeinflussung der Luftqualität	Keine gefährlichen Stoffe **)
2.4 Gebrauchssicherheit		Nicht zutreffend
2.5 Lärmschutz		Nicht zutreffend
2.6 Energiewirtschaftlichkeit und Wärmespeicherung		Nicht zutreffend
2.7 Weitere Aspekte der Gebrauchstauglichkeit		
2.7.1	Haltbarkeit	Die Schrauben weisen bei der Verwendung in Holzkonstruktionen, bei denen Holzarten gemäß Eurocode 5 und den Vorgaben der Nutzungsklassen 1, 2 und 3 zum Einsatz kommen, eine zufriedenstellende Haltbarkeit und Gebrauchstauglichkeit auf.
2.7.2	Gebrauchstauglichkeit	
2.7.3	Identifikation	Siehe Anhang A

*) Siehe Seite 7 dieser ETA

**) Entsprechend http://europa.eu.int-/comm/enterprise/construction/internal/dangsub/dangmain.htm Zusätzlich zu den spezifischen Klauseln in dieser Europäischen Technischen Zulassung, die sich auf gefährliche Stoffe beziehen, können weitere Anforderungen an die Produkte, die in diesen Bereich fallen, bestehen (z. B. umgesetzte europäische Gesetzgebung und einzelstaatliche Gesetze, Bestimmungen und Verwaltungsvorschriften). Zur Einhaltung der Regelungen der EU-Bauproduktrichtlinie muss diesen Anforderungen, sofern zutreffend, entsprochen werden.

2.1 Mechanische Festigkeit und Stabilität

Die Tragfähigkeiten der RAMPA-Muffen gelten für die in Ziffer 1 genannten Holzwerkstoffe, auch wenn nachstehend nur der Begriff Holz verwendet wird.

Für eine Bemessung gemäß Eurocode 5 oder einer entsprechenden nationalen Norm sind der charakteristische Wert der Tragfähigkeit rechtwinklig zur Muffenachse und der charakteristische Wert des Ausziehwiderstands der RAMPA-Muffen anzuwenden.

Die Eindringtiefe muss $\ell_{ef} \geq 3 \cdot d$ betragen, wobei d der Gewindeaußendurchmesser der Muffe ist.

Die für die jeweiligen Bauteile bzw. Holzwerkstoffplatten gegebenenfalls vorhandenen europäischen technischen Zulassungen sind zu berücksichtigen.

Tragfähigkeit bei Beanspruchung rechtwinklig zur Muffenachse (Abscheren)
Der charakteristische Wert der Tragfähigkeit rechtwinklig zur Achse der RAMPA-Muffen ist nach EN 1995-1-1:2008 (Eurocode 5) mit dem Gewindeaußendurchmesser d als Nenndurchmesser der Muffen zu berechnen. Der Seileffekt darf dabei berücksichtigt werden.

Der charakteristische Wert des Fließmoments ist wie folgt zu berechnen:

Muffe d = 10,0 mm:	$M_{y,k}$ = 17 Nm
Muffe d = 12,0 mm:	$M_{y,k}$ = 29 Nm
Muffe d = 16,0 mm:	$M_{y,k}$ = 65 Nm
Muffe d = 18,5 mm:	$M_{y,k}$ = 104 Nm
Muffe d = 22,0 mm:	$M_{y,k}$ = 156 Nm
Muffe d = 25,0 mm:	$M_{y,k}$ = 182 Nm

Der charakteristische Wert der Lochleibungsfestigkeit $f_{h,k}$ der Muffen in vorgebohrten Löchern beträgt bei einem Winkel zwischen Muffenachse und Faserrichtung von $0° \leq \alpha \leq 90°$:

$$f_{h,k} = \frac{0{,}082 \cdot \rho_k \cdot (1 - 0{,}01 \cdot d)}{2{,}5 \cdot \cos^2 \alpha + \sin^2 \alpha} \quad [N/mm^2]$$

Darin sind

ρ_k Charakteristischer Wert der Rohdichte [kg/m³]
d Gewindeaußendurchmesser [mm]
α Winkel zwischen Muffenachse und Faserrichtung

Der charakteristische Wert der Lochleibungsfestigkeit von in den Schmalflächen von Brettsperrholz (in der Regel die Schnittflächen) eingedrehten Muffen ergibt sich unabhängig vom Winkel zwischen Muffenachse und Faserrichtung von $0° \leq \alpha \leq 90°$:

$$f_{h,k} = 20 \cdot d^{-0,5} \quad [N/mm^2]$$

Darin ist
d Gewindeaußendurchmesser [mm]

Der charakteristische Wert der Lochleibungsfestigkeit von in den Seitenflächen von Brettsperrholz (Oberflächen der beiden äußeren Brettlagen) eingedrehten Muffen sollte wie bei Bauteilen aus Vollholz auf Grundlage des charakteristischen Wertes der Rohdichte der äußeren Brettlagen berechnet werden. Sofern relevant sollte der Winkel zwischen der Belastungsrichtung und der entsprechenden Faserrichtung berücksichtigt werden. Die Querkraft soll dabei rechtwinklig zur Muffenachse und parallel zur Seitenfläche des Brettsperrholzes wirken.

Tragfähigkeit bei Beanspruchung in Richtung der Muffenachse (Herausziehen)
Der charakteristische Wert des Ausziehwiderstands $F_{ax,\alpha,Rk}$ von RAMPA-Muffen in Bauteilen aus Vollholz (Nadelholz), Brettschichtholz, Brettsperrholz oder Furnierschichtholz, die unter einem Winkel von $30° \leq \alpha \leq 90°$ zur Faserrichtung eingedreht sind, ist gemäß EN 1995-1-1:2008 nach folgender Gleichung zu berechnen:

$$F_{ax,\alpha,Rk} = \frac{n_{ef} \cdot 9 \cdot d \cdot \ell_{ef}}{1{,}2 \cdot \cos^2 \alpha + \sin^2 \alpha} \cdot \left(\frac{\rho_k}{350} \right)^{0,8} \quad [N]$$

Darin sind

n_{ef}	Wirksame Anzahl der Muffen gemäß EN 1995-1-1:2008
d	Gewindeaußendurchmesser [mm]
ℓ_{ef}	Eindringtiefe des Gewindeteils gemäß EN 1995-1-1:2008 [mm]
α	Winkel zwischen Muffenachse und Faserrichtung ($\alpha \geq 30°$)
ρ_k	Charakteristischer Wert der Rohdichte [kg/m³]

Bei langen Muffen, die in Brettsperrholz mehr als eine Brettlage durchdringen, dürfen die verschieden Brettlagen anteilig berücksichtigt werden.

Der Ausziehwiderstand von in den Schmalflächen von Furnierschichtholz unter einem Winkel von $30° \leq \alpha \leq 90°$ zur Faserrichtung eingedrehten Muffen ist um 20 % zu verringern.

Der Ausziehwiderstand wird gegebenenfalls durch den Kopfdurchziehwiderstand der metrischen Schraube bzw. der Unterlegscheibe oder durch die Zugtragfähigkeit der Muffe bzw. der metrischen Schraube begrenzt.

Der Verschiebungsmodul K_{ser} des Gewindeteils einer Muffe beträgt für den Grenzzustand der Gebrauchstauglichkeit unabhängig vom Winkel α zwischen Muffenachse und Faserrichtung:

$$K_{ser} = 780 \cdot d^{0,2} \cdot \ell_{ef}^{0,4} \quad [N/mm],$$

Darin sind

d	Gewindeaußendurchmesser [mm]
ℓ_{ef}	Eindringtiefe des Gewindes [mm]

Zugtragfähigkeit

Die charakteristische Wert der Zugtragfähigkeit $f_{tens,k}$ von RAMPA-Muffen beträgt:

d = 10,0 mm:	$f_{tens,k}$ = 8,8 kN
d = 12,0 mm:	$f_{tens,k}$ = 13 kN
d = 16,0 mm:	$f_{tens,k}$ = 23 kN
d = 18,5 mm:	$f_{tens,k}$ = 31 kN
d = 22,0 mm:	$f_{tens,k}$ = 41 kN
d = 25,0 mm:	$f_{tens,k}$ = 41 kN

Die charakteristische Zugtragfähigkeit $F_{tens,RK}$ von RAMPA-Muffen ist gemäß EN 1995-1-1:2008 wie folgt zu ermitteln:

$$F_{tens,Rk} = n_{ef} \cdot \min\left\{f_{tens,k}\,;\,0{,}9 \cdot f_{ub} \cdot A_s\right\} \quad [N]$$

Darin sind

n_{ef}	Wirksame Anzahl der Muffen gemäß EN 1995-1-1:2008
$f_{tens,k}$	Charakteristischer Wert der Zugfestigkeit einer RAMPA-Muffe [N]
f_{ub}	Charakteristischer Wert der Zugfestigkeit der in die RAMPA-Muffe eingeschraubten metrischen Schraube [N/mm²]
A_s	Spannungsquerschnitt der metrischen Schraube [mm²]

Hinweis: Die Werte für die charakteristische Zugfestigkeit und den Spannungsquerschnitt der metrischen Schraube hängen von der jeweils verwendeten Schraube ab. Daher ist der charakteristische Wert der Zugtragfähigkeit von RAMPA-Muffen, in die metrische Schrauben eingedreht sind, in Abhängigkeit dieser Schrauben zu berechnen.

Muffen mit kombinierter Beanspruchung rechtwinklig zur Muffenachse und in Richtung der Muffenachse

Bei Muffen, die sowohl rechtwinklig zur Muffenachse als auch in Richtung der Muffenachse beansprucht werden, muss die folgende Bedingung erfüllt sein:

$$\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{v,Ed}}{F_{v,Rd}}\right)^2 \le 1$$

Darin sind

$F_{ax,Ed}$	Bemessungswert der Beanspruchung in Achsrichtung
$F_{v,Ed}$	Bemessungswert der Beanspruchung rechtwinklig zur Achsrichtung
$F_{ax,Rd}$	Bemessungswert der Tragfähigkeit auf Herausziehen
$F_{v,Rd}$	Bemessungswert der Tragfähigkeit auf Abscheren

2.7 Weitere Aspekte der Gebrauchstauglichkeit

2.7.1 Korrosionsschutz der Nutzungsklasse 1, 2 und 3.

RAMPA-Muffen werden aus Kohlenstoff-Stahldraht mit der Werkstoff-Nr. 1.0718 gemäß EN 10277-3 hergestellt und sind vermessingt, vernickelt, bronziert oder galvanisch verzinkt und gelb oder blau chromatiert. Die mittlere Dicke der Zinkschicht beträgt 5μm.

Edelstahl-Muffen sind aus Stahl mit der Werkstoff-Nr. 1.4104 gemäß EN 10088-3, bzw. 1.4305 oder 1.4404 gemäß EN 10088-5 hergestellt.

3 Konformitätsnachweis und CE-Kennzeichnung

3.1 System des Konformitätsnachweises

Das System des Konformitätsnachweises ist 2+, beschrieben in der Richtlinie 89/106/EWG des Rates (Bauproduktenrichtlinie) Anhang III.

a) Aufgaben des Herstellers:

(1) Werkseigene Produktionskontrolle,
(2) Erstprüfung des Produkts,

b) Aufgaben der benannten Stelle:

(1) Erstinspektion des Werks und der werkseigenen Produktionskontrolle,
(2) Fortlaufende Überwachung

3.2 Zuständigkeiten

3.2.1 Aufgaben des Herstellers

3.2.1.1 Werkseigene Produktionskontrolle

Der Hersteller verfügt über ein werkseigenes Produktionskontrollsystem und führt permanent innerbetriebliche Produktionskontrollen durch. Alle vom Hersteller berücksichtigten Grundlagen, Anforderungen und Vorschriften sind systematisch in Form von schriftlichen Richtlinien und Verfahrensanweisungen zusammenzustellen. Dieses Produktionskontrollsystem gewährleistet, dass das Produkt der europäischen technischen Zulassung entspricht.

Der Hersteller verwendet ausschließlich Rohmaterial, das mit einschlägigen Kontrolldokumenten wie im Kontrollplan [4] dargelegt geliefert wird. Vor der Annahme ist angeliefertes Rohmaterial Kontrollen und Tests durch den Hersteller zu unterziehen. Die Prüfung von Material umfasst die Kontrolle der von dem Lieferanten vorgelegten Inspektionsdokumente (Vergleich mit Nennwerten) durch Überprüfung der Maße und Bestimmung der Materialeigenschaften, z. B. chemische Zusammensetzung, mechanische Eigenschaften und Dicke der Zinkbeschichtung.

Die hergestellten Muffen werden folgenden Prüfungen unterzogen:

- Spezifikation des Rohmaterials
- Maße der Muffen
- Charakteristischer Wert der Zugtragfähigkeit $f_{tens,k}$
- Charakteristischer Wert des Bruchdrehmoments $f_{tor,k}$
- Charakteristischer Wert des Einschraubdrehmoment $R_{tor,k}$
- Dauerhaftigkeit
- Kennzeichnung

Der Kontrollplan, der Bestandteil der technischen Dokumentation dieser europäischen technischen Zulassung ist, enthält Angaben zum Umfang, zur Art und Weise und zur Anzahl der Prüfungen sowie zu den Kontrollen, die im Rahmen der werkseigenen Produktionskontrolle durchzuführen sind. Der Kontrollplan wurde zwischen dem Zulassungsinhaber und ETA-Danmark vereinbart.

Die Ergebnisse der werkseigenen Produktionskontrolle werden aufgezeichnet und ausgewertet. Die Aufzeichnungen enthalten mindestens folgende Informationen:

- Bezeichnung des Produkts, des Ausgangsmaterials und der Komponenten
- Art der Kontrolle bzw. Prüfung
- Herstellungsdatum des Produkts und Datum der Prüfung des Produkts bzw. des Ausgangsmaterials und/oder der Komponenten
- Kontroll- und Prüfergebnisse sowie gegebenenfalls Vergleich mit den Anforderungen
- Unterschrift der für die werkseigene Produktionskontrolle zuständigen Person

Die Unterschriften sind der ETA-Danmark auf Anfrage vorzulegen.

-3.2.1.2 Erstprüfung des Produkts

Für die Erstprüfung dürfen die Ergebnisse derjenigen Versuche herangezogen werden, die im Rahmen der Begutachtung für die europäische technische Zulassung durchgeführt wurden, es sei denn, es haben sich bei der Produktionsanlage oder im Herstellwerk Änderungen ergeben. In solchen Fällen muss die erforderliche Erstprüfung zwischen der die europäische technische Zulassung ausstellenden Behörde und der benannten Stelle abgestimmt werden.

Die Erstprüfung erstreckt sich auf folgende Prüfungen:

- Spezifikation des Rohmaterials
- Maße der Muffen

4 Der Kontrollplan ist bei ETA-Danmark hinterlegt und wird nur den zugelassenen Stellen, die am Prozess der Erstellung des Konformitätsnachweises beteiligt sind, zur Verfügung gestellt.

- Charakteristischer Wert des Ausziehparameters $f_{ax,k}$
- Charakteristischer Wert des Kopfdurchziehparameters $f_{head,k}$
- Charakteristischer Wert der Zugtragfähigkeit $f_{tens,k}$
- Charakteristischer Wert der Streckgrenze, soweit relevant
- Charakteristischer Wert des Bruchdrehmoments $f_{tor,k}$
- Charakteristischer Wert des Einschraubdrehmoments $R_{tor,k}$
- Dauerhaftigkeit

3.2.2. Aufgaben der benannten Stellen

3.2.2.1 Erstinspektion des Werks und der werkseigenen Produktionskontrolle

Die zugelassene Stelle sollte sicherstellen, dass entsprechend dem Kontrollplan das Herstellwerk, insbesondere die Mitarbeiter und die Ausrüstung sowie die werkseigene Produktionskontrolle geeignet sind, eine fortlaufende und ordnungsgemäße Herstellung der Muffen gemäß den Spezifikationen in Teil 2 zu gewährleisten.

3.2.2.2 Fortlaufende Überwachung

Die zugelassene Stelle soll das Herstellwerk zwecks Durchführung von Routinekontrollen mindestens zweimal jährlich besuchen. Es ist zu überprüfen, dass das System der werkseigenen Produktionskontrolle und die vorgegebenen Fertigungsprozesse unter Berücksichtigung des Kontrollplanes eingehalten werden.

Die Ergebnisse der Produktzertifizierung und der fortlaufenden Überwachung sind ETA-Danmark von der Zertifizierungsstelle auf Anfrage zur Verfügung zu stellen. Werden Bestimmungen der europäischen technischen Zulassung und des Kontrollplanes nicht mehr erfüllt, so wird das Konformitätszertifikat von der zugelassenen Stelle entzogen.

3.3 CE-Kennzeichnung

Die CE-Kennzeichnung ist an jeder Packung Muffen anzubringen. Dem Kürzel „CE“ folgt die Identifikationsnummer der benannten Stelle, ergänzt durch folgende Informationen:

- Name bzw. Erkennungszeichen des Herstellers
- Die letzten beiden Ziffern des Jahres in dem die CE-Kennzeichnung angebracht wurde
- Nummer der Europäischen Technischen Zulassung
- Bezeichnung des Produkts
- Gewindeaußendurchmesser und Länge der Muffen
- Art und mittlere Dicke des Korrosionsschutzes
- Edelstahl, einschließlich Werkstoff-Nr.
- Brandverhalten
- Nummer des EU-Konformitätszertifikats

4 Annahmen, die zu einer positiven Bewertung der Brauchbarkeit des Produkts für den vorgesehenen Verwendungszweck führten

4.1 Fertigung

Die Muffen werden gemäß den Bestimmungen dieser europäischen technischen Zulassung unter Anwendung des automatisierten Herstellverfahrens gefertigt, das die benannte Stelle bei der Inspektion der Fertigungsanlage ermittelt und in der technischen Dokumentation festgehalten hat.

4.2 Einbau

4.2.1 Der Einbau hat gemäß Eurocode 5 oder einer entsprechenden nationalen Norm zu erfolgen, es sei denn, nachstehend werden andere Festlegungen getroffen. Die Einbauanleitungen der Firma Hans Brügmann GmbH & Co. KG sollten berücksichtigt werden.

4.2.2 Die Muffen sind in tragenden Holzkonstruktionen zur Verbindung von Teilen aus Vollholz (Nadelholz), Brettschichtholz, Brettsperrholz und Furnierschichtholz sowie vergleichbar verklebten Holzbauteilen, Holzwerkstoffplatten und Stahlteilen bestimmt.

Die Muffen dürfen in tragenden Holzkonstruktionen zur Verbindung von Bauteilen, für die eine europäische technische Zulassung besteht, verwendet werden, sofern in dieser europäischen technischen Zulassung die Verwendung von Schrauben, für die ebenfalls eine europäische technische Zulassung besteht, für tragende Holzverbindungen zulässig ist.

In tragenden Holzkonstruktionen sind bei einer Verbindung mindestens zwei Muffen zu verwenden.

Die Mindesteindringtiefe in Bauteile aus Vollholz, Brettschichtholz oder Brettsperrholz beträgt 3·d.

Holzwerkstoffplatten und Stahlbleche dürfen nur auf der Seite der metrischen Schraube angeordnet werden. Die Holzwerkstoffplatten sollten eine Dicke von mindestens 1,2·d aufweisen.

Für Bauteile nach europäischer technischer Zulassung sind die Bedingungen von europäischen technischen Zulassungen zu berücksichtigen.

Der Winkel zwischen Muffenachse und Faserrichtung muss mindestens $\alpha = 30°$ betragen.

4.2.3 Die Muffen sind in vorgebohrte Löcher einzudrehen. Der Durchmesser des vorgebohrten Loches muss dem Kerndurchmesser des Holzgewindes der Muffe entsprechen. In Stahlteilen sind die Löcher mit einem entsprechenden Durchmesser vorzubohren.

Für das Eindrehen der Muffen ist ausschließlich das von der Hans Brügmann GmbH & Co. KG vorgesehene Werkzeug zu verwenden.

4.2.4 In Holzbauteilen sind für Muffen die in EN 1995-1-1:2008 (Eurocode 5) in Absatz 8.3.1.2 und Tabelle 8.2 angegebenen Mindestrand- und Mindestachsabstände wie bei Nägeln in vorgebohrten Nagellöchern einzuhalten. Dabei ist der Gewindeaußendurchmesser d zu Grunde zu legen.

Mindestachs- und Mindestrandabstände von Muffen, die in den Seitenflächen von Brettsperrholz mit einer Mindestdicke von t = 10·d eingeschraubt sind, können wie folgt ermittelt werden (siehe Anhang B):

Achsabstand a_1 parallel zur Faserrichtung $a_1 = 4 \cdot d$
Achsabstand a_2 rechtwinklig zur Faserrichtung $a_2 = 2{,}5 \cdot d$
Randabstand $a_{1,c}$ vom Schwerpunkt der Muffe bis zum unbeanspruchten Hirnholzende $a_{1,c} = 6 \cdot d$
Randabstand $a_{1,t}$ vom Schwerpunkt der Muffe bis zum beanspruchten Hirnholzende $a_{1,t} = 6 \cdot d$
Randabstand $a_{2,c}$ vom Schwerpunkt der Muffe bis zum unbeanspruchten Rand $a_{2,c} = 2{,}5 \cdot d$
Randabstand $a_{2,t}$ vom Schwerpunkt der Muffe bis zum beanspruchten Rand $a_{2,t} = 6 \cdot d$

Mindestachs- und Mindestrandabstände von Muffen, die in den Schmalflächen von Brettsperrholz mit einer Mindestdicke von t = 10·d und mit der Mindesteindringtiefe eingeschraubt sind, sind wie folgt zu ermitteln (siehe Anhang B):

Achsabstand a_1 parallel zur Seitenfläche $a_1 = 10 \cdot d$
Achsabstand a_2 rechtwinklig zur Seitenfläche $a_2 = 4 \cdot d$
Randabstand $a_{1,c}$ vom Schwerpunkt der Muffe bis zum unbeanspruchten Hirnholz $a_{1,c} = 7 \cdot d$
Randabstand $a_{1,t}$ vom Schwerpunkt der Muffe bis zum beanspruchten Hirnholz $a_{1,t} = 12 \cdot d$
Randabstand $a_{2,c}$ vom Schwerpunkt der Muffe bis zum unbeanspruchten Rand $a_{2,c} = 3 \cdot d$
Randabstand $a_{2,t}$ vom Schwerpunkt der Muffe bis zum beanspruchten Rand $a_{2,t} = 6 \cdot d$

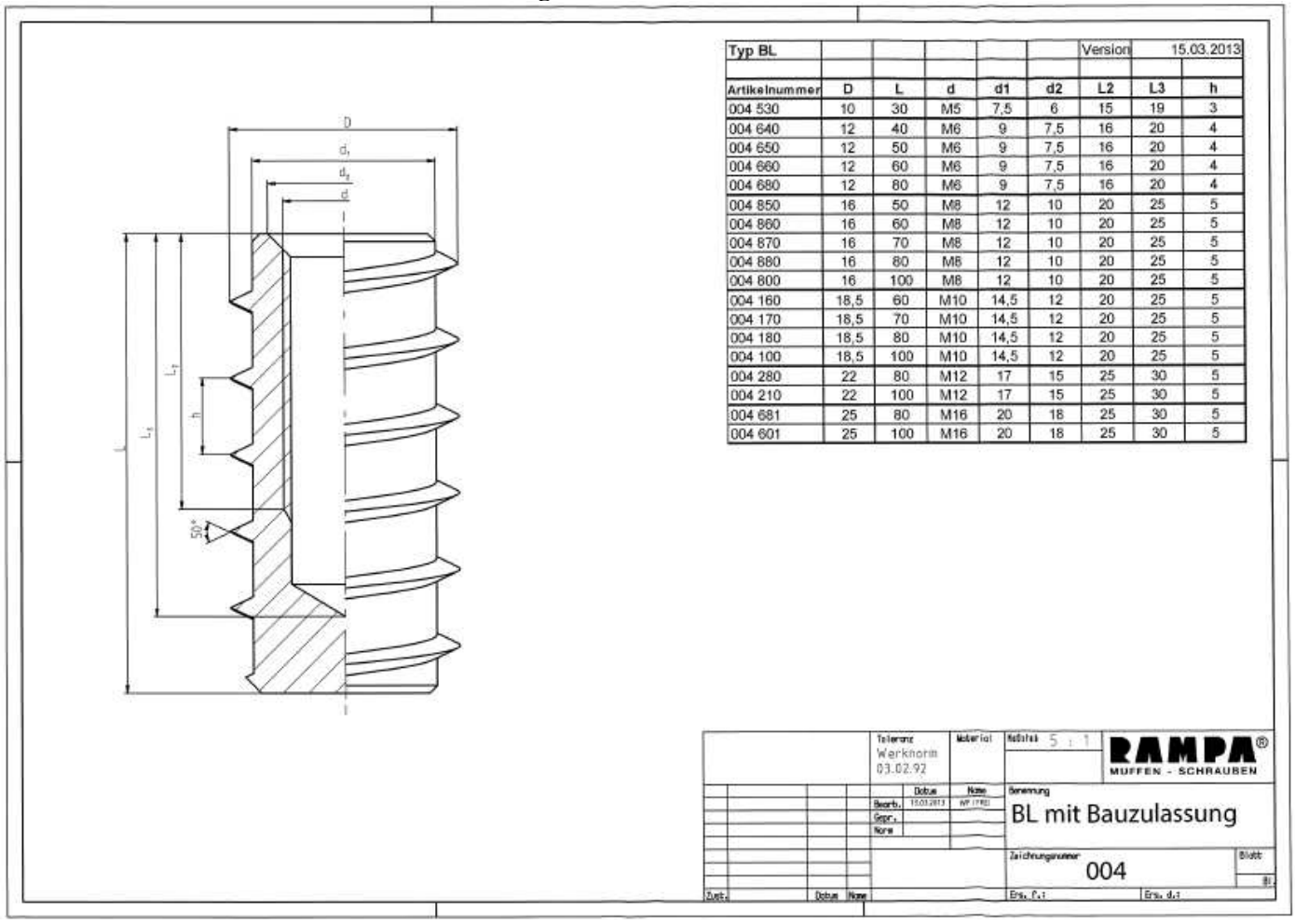
Mindestachs- und Mindestrandabstände für RAMPA-Muffen in Brettsperrholz sind in Anhang B angegeben.

4.3 Instandhaltung und Reparatur

Während der angenommenen Nutzungsdauer ist keine Instandhaltung erforderlich. Sollte eine Reparatur nötig werden, wird eine Muffe in der Regel ausgetauscht.

Thomas Bruun
Manager, ETA-Danmark

Anhang A
Zeichnungen von RAMPA-Muffen



Typ BL						Version		15.03.2013
Artikelnummer	D	L	d	d1	d2	L2	L3	h
004 530	10	30	M5	7,5	6	15	19	3
004 640	12	40	M6	9	7,5	16	20	4
004 650	12	50	M6	9	7,5	16	20	4
004 660	12	60	M6	9	7,5	16	20	4
004 680	12	80	M6	9	7,5	16	20	4
004 850	16	50	M8	12	10	20	25	5
004 860	16	60	M8	12	10	20	25	5
004 870	16	70	M8	12	10	20	25	5
004 880	16	80	M8	12	10	20	25	5
004 800	16	100	M8	12	10	20	25	5
004 160	18,5	60	M10	14,5	12	20	25	5
004 170	18,5	70	M10	14,5	12	20	25	5
004 180	18,5	80	M10	14,5	12	20	25	5
004 100	18,5	100	M10	14,5	12	20	25	5
004 280	22	80	M12	17	15	25	30	5
004 210	22	100	M12	17	15	25	30	5
004 681	25	80	M16	20	18	25	30	5
004 601	25	100	M16	20	18	25	30	5

Toleranz Werknorm 03.02.92 | Material | Maßstab 5 : 1 | RAMPA® MUFFEN - SCHRAUBEN
Bearb. 15.03.2013 | Benennung: BL mit Bauzulassung
Zeichnungsnummer: 004 | Blatt

Tabelle A.1: Einbauparameter

Muffengröße			M4	M5	M6	M8	M10	M12	M16
Bohrlochdurchmesser im Holz	d_1 =	[mm]	6	8	10	13	15	18	21
Mindesteinschraubtiefe in die Muffe	L_{min} =	[mm]	4	5	6	8	10	12	16

Zusätzliche Einbauparameter:

Mindesttiefe des Bohrloches im Holz = L
Verfügbare Gewindelänge in der Muffe = L_2

Anforderungen an Befestigungsschraube, Gewindestange und Mutter gemäß technischer Dokumentation:

Stahl, verzinkt

- Festigkeitsklasse 4.6 / 5.6 / 5.8 oder 8.8 gemäß EN ISO 898-1 oder EN 20898-2

Edelstahl, A2 oder A4

- Edelstahl 1.4301; 1.4401; 1.4404; 1.4578; 1.4439; 1.4362 gemäß EN 10088
- Festigkeitsklasse 50, 70 oder 80 nach EN ISO 3506

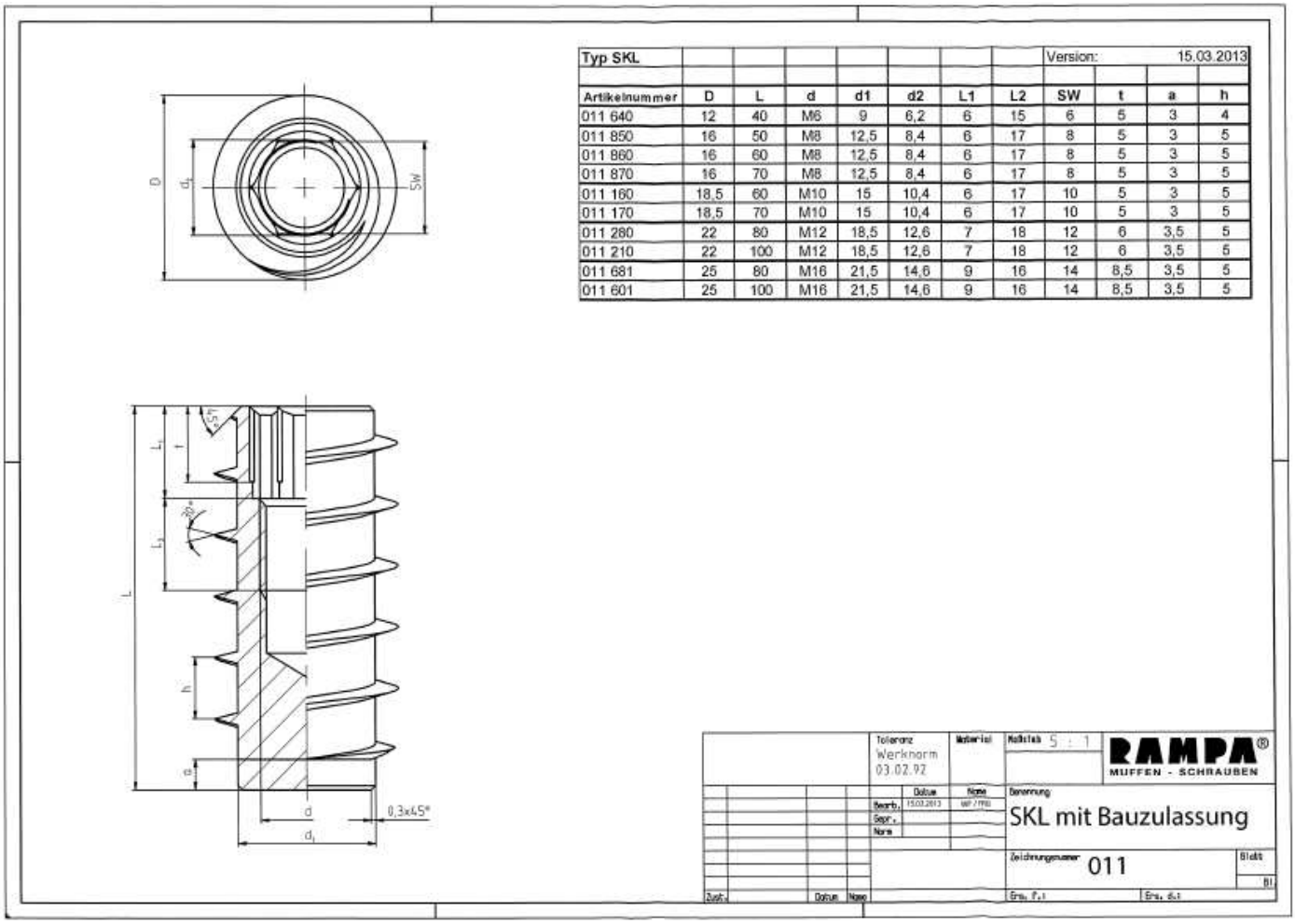


Tabelle A.2: Einbauparameter

Muffengröße			M6	M8	M10	M12	M16
Bohrlochdurchmesser im Holz	d_1	[mm]	10	13	15	18	21
Mindesteinschraubtiefe in die Muffe	L_{min}	[mm]	6	8	10	12	16

Zusätzliche Einbauparameter:

Mindesttiefe des Bohrloches im Holz = L
Verfügbare Gewindelänge in der Muffe = L_2

Anforderungen an Befestigungsschraube, Gewindestange und Mutter gemäß technischer Dokumentation:

Stahl, verzinkt

- Festigkeitsklasse 4.6 / 5.6 / 5.8 oder 8.8 gemäß EN ISO 898-1 oder EN 20898-2

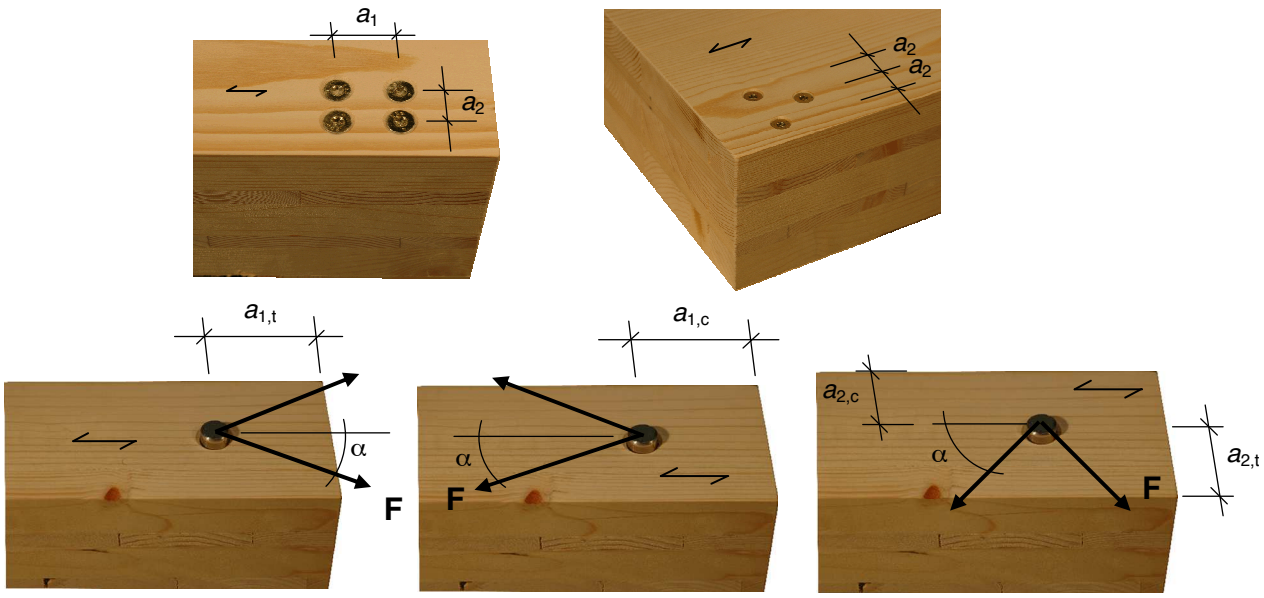
Edelstahl, A2 oder A4

- Edelstahl 1.4301; 1.4401; 1.4404; 1.4578; 1.4439; 1.4362 gemäß EN 10088
- Festigkeitsklasse 50, 70 oder 80 nach EN ISO 3506

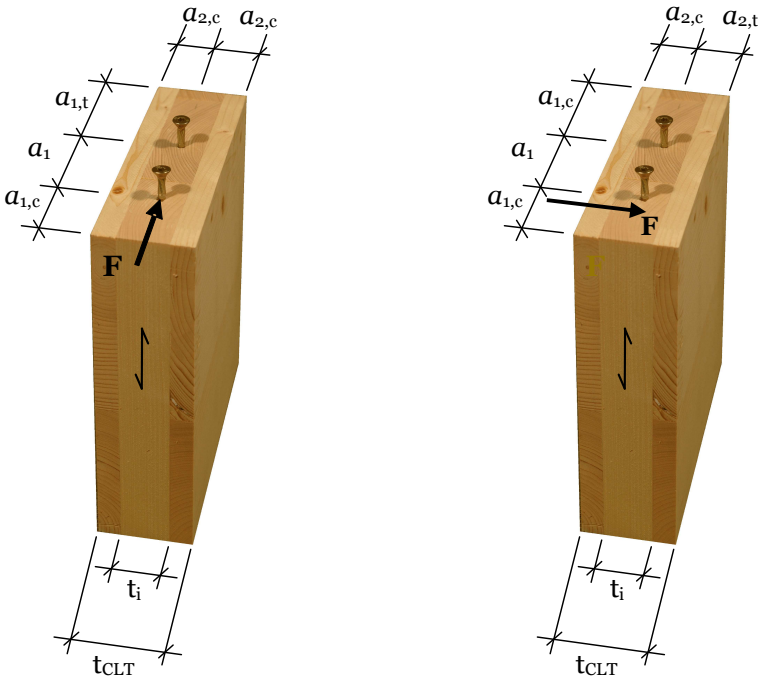
Anhang B
Mindestachs- und Mindestrandabstände

Rechtwinklig zur Muffenachse oder in Richtung der Muffenachse beanspruchte Muffen in der Seiten- oder Schmalfläche von Brettsperrholz

Definition von Achs- und Randabstand bei Anordnung in der Seitenfläche:



Definition von Achs- und Randabstand bei Anordnung in der Schmalfläche:



Mindestachs- und Mindestrandabstände von in der Seiten- oder Schmalfläche in Brettsperrholz angeordneten Muffen.

	a_1	$a_{1,t}$	$a_{1,c}$	a_2	$a_{2,t}$	$a_{2,c}$
Seitenfläche	**4 · d**	**6 · d**	**6 · d**	**2,5 · d**	**6 · d**	**2,5 · d**
Schmalfläche	**10 · d**	**12 · d**	**7 · d**	**4 · d**	**6 · d**	**3 · d**

Deutsches Institut für Bautechnik

DIBt

Allgemeine bauaufsichtliche Zulassung

Zulassungsstelle für Bauprodukte und Bauarten

Bautechnisches Prüfamt

Eine vom Bund und den Ländern gemeinsam getragene Anstalt des öffentlichen Rechts

Mitglied der EOTA, der UEAtc und der WFTAO

Datum: 08.10.2012

Geschäftszeichen: I 52-1.9.1-649/12

Zulassungsnummer:
Z-9.1-649

Geltungsdauer
vom: **8. Oktober 2012**
bis: **8. Oktober 2017**

Antragsteller:
VERBAND HIGH-TECH-ABBUND im Zimmererhandwerk e.V.
Hellmuth-Hirth-Straße 7
73760 Ostfildern

Zulassungsgegenstand:
Schwalbenschwanz-Verbindung in Bauteilen



Der oben genannte Zulassungsgegenstand wird hiermit allgemein bauaufsichtlich zugelassen.
Diese allgemeine bauaufsichtliche Zulassung umfasst sieben Seiten und zwei Anlagen.
Diese allgemeine bauaufsichtliche Zulassung ersetzt die allgemeine bauaufsichtliche Zulassung Nr. Z-9.1-649 vom 15. August 2012. Der Gegenstand ist erstmals am 15. Oktober 2007 allgemein bauaufsichtlich zugelassen worden.

I ALLGEMEINE BESTIMMUNGEN

1 Mit der allgemeinen bauaufsichtlichen Zulassung ist die Verwendbarkeit bzw. Anwendbarkeit des Zulassungsgegenstandes im Sinne der Landesbauordnungen nachgewiesen.

2 Sofern in der allgemeinen bauaufsichtlichen Zulassung Anforderungen an die besondere Sachkunde und Erfahrung der mit der Herstellung von Bauprodukten und Bauarten betrauten Personen nach den § 17 Abs. 5 Musterbauordnung entsprechenden Länderregelungen gestellt werden, ist zu beachten, dass diese Sachkunde und Erfahrung auch durch gleichwertige Nachweise anderer Mitgliedstaaten der Europäischen Union belegt werden kann. Dies gilt ggf. auch für im Rahmen des Abkommens über den Europäischen Wirtschaftsraum (EWR) oder anderer bilateraler Abkommen vorgelegte gleichwertige Nachweise.

3 Die allgemeine bauaufsichtliche Zulassung ersetzt nicht die für die Durchführung von Bauvorhaben gesetzlich vorgeschriebenen Genehmigungen, Zustimmungen und Bescheinigungen.

4 Die allgemeine bauaufsichtliche Zulassung wird unbeschadet der Rechte Dritter, insbesondere privater Schutzrechte, erteilt.

5 Hersteller und Vertreiber des Zulassungsgegenstandes haben, unbeschadet weiter gehender Regelungen in den "Besonderen Bestimmungen", dem Verwender bzw. Anwender des Zulassungsgegenstandes Kopien der allgemeinen bauaufsichtlichen Zulassung zur Verfügung zu stellen und darauf hinzuweisen, dass die allgemeine bauaufsichtliche Zulassung an der Verwendungsstelle vorliegen muss. Auf Anforderung sind den beteiligten Behörden Kopien der allgemeinen bauaufsichtlichen Zulassung zur Verfügung zu stellen.

6 Die allgemeine bauaufsichtliche Zulassung darf nur vollständig vervielfältigt werden. Eine auszugsweise Veröffentlichung bedarf der Zustimmung des Deutschen Instituts für Bautechnik. Texte und Zeichnungen von Werbeschriften dürfen der allgemeinen bauaufsichtlichen Zulassung nicht widersprechen. Übersetzungen der allgemeinen bauaufsichtlichen Zulassung müssen den Hinweis "Vom Deutschen Institut für Bautechnik nicht geprüfte Übersetzung der deutschen Originalfassung" enthalten.

7 Die allgemeine bauaufsichtliche Zulassung wird widerruflich erteilt. Die Bestimmungen der allgemeinen bauaufsichtlichen Zulassung können nachträglich ergänzt und geändert werden, insbesondere, wenn neue technische Erkenntnisse dies erfordern.

Deutsches Institut für Bautechnik
33

II BESONDERE BESTIMMUNGEN

1 Zulassungsgegenstand und Anwendungsbereich

1.1 Zulassungsgegenstand

Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. werden mit CNC-gesteuerten Abbundmaschinen als Teil der zu verbindenden Bauteile mit den in den Anlagen dargestellten Formen und Maßen hergestellt. Sie werden ohne zusätzliche mechanische Verbindungsmittel verwendet. Zur Herstellung der Verbindung wird der Schwalbenschwanzzapfen am Hirnholzende des Nebenträgers in eine entsprechende Vertiefung in der Seitenholzfläche des Hauptträgers eingetrieben.

1.2 Anwendungsbereich

Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. dürfen als Holzverbindung für tragende Holzkonstruktionen verwendet werden, die nach DIN 1052[1] oder DIN EN 1995-1-1[2] in Verbindung mit DIN EN 1995-1-1/NA[3] zu bemessen und auszuführen sind, soweit in dieser allgemeinen bauaufsichtlichen Zulassung nichts anderes bestimmt ist.

Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. dürfen zur Verbindung von Holzbauteilen (Hauptträger und Nebenträger) aus

- Brettschichtholz nach DIN 1052,
- Balkenschichtholz aus Nadelholz nach allgemeiner bauaufsichtlicher Zulassung,
- Vollholz aus Nadelholz mindestens der Sortierklasse S 10 nach DIN 4074-1[4] oder DIN EN 14081-1[5] in Verbindung mit DIN 20000-5[6] verwendet werden.

Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. dürfen nur in Einschubrichtung belastet werden.

Es dürfen entweder schräge oder geneigte Anschlüsse ausgeführt werden. Schräge Anschlüsse sind in den Grenzen $45° \leq \phi \leq 135°$ zulässig. Geneigte Anschlüsse dürfen in den Grenzen $-45° \leq \delta \leq +45°$ ausgeführt werden (siehe Anlage 1).

Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. dürfen nur für Auflageranschlüsse bei Tragwerken verwendet werden, die vorwiegend ruhend (siehe DIN 1055-3) bzw. statisch oder quasi-statisch (siehe DIN EN 1990[7] und DIN EN 1991-1-1[8] in Verbindung mit DIN EN 1991-1-1/NA [9]) belastet sind. Sie dürfen nur für Anschlüsse an verdrehungssteife oder gegen Verdrehen ausreichend gesicherte Hauptträger verwendet werden.

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1	DIN 1052: 2008-12	Entwurf, Berechnung und Bemessung von Holzbauwerken; Allgemeine Bemessungsregeln und Bemessungsregeln für den Hochbau
2	DIN EN 1995-1-1:2010-12	Eurocode 5: Bemessung und Konstruktion von Holzbauten - Teil 1-1: Allgemeines - Allgemeine Regeln und Regeln für den Hochbau
3	DIN EN 1995-1-1/NA:2010-12	Nationaler Anhang - National festgelegte Parameter - Eurocode 5: Bemessung und Konstruktion von Holzbauten - Teil 1-1: Allgemeines - Allgemeine Regeln und Regeln für den Hochbau
4	DIN 4074-1:2003-06	Sortierung von Holz nach der Tragfähigkeit - Teil 1: Nadelschnittholz
5	DIN EN 14081-1:2011-05	Holzbauwerke - Nach Festigkeit sortiertes Bauholz für tragende Zwecke mit rechteckigem Querschnitt - Teil 1: Allgemeine Anforderungen
6	DIN 20000-5:2012-03	Anwendung von Bauprodukten in Bauwerken - Teil 5: Nach Festigkeit sortiertes Bauholz für tragende Zwecke mit rechteckigem Querschnitt
7	DIN EN 1990:2010-12	Eurocode: Grundlagen der Tragwerksplanung
8	DIN EN 1991-1-1:2010-12	Eurocode 1: Einwirkungen auf Tragwerke - Teil 1-1: Allgemeine Einwirkungen auf Tragwerke - Wichten, Eigengewicht und Nutzlasten im Hochbau
9	DIN EN 1991-1-1/NA:2010-12	Nationaler Anhang – National festgelegte Parameter - Eurocode 1: Einwirkungen auf Tragwerke - Teil 1-1: Allgemeine Einwirkungen auf Tragwerke - Wichten, Eigengewicht und Nutzlasten im Hochbau

Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. dürfen nur in Bauwerken verwendet werden, in denen eine relative Luftfeuchte von 85 % nur für einige Wochen pro Jahr überschritten wird (Nutzungsklassen 1 und 2 nach DIN 1052 oder DIN EN 1995-1-1).

2 Bestimmungen für die Schwalbenschwanz-Verbindungen in Bauteilen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V.

2.1 Eigenschaften

2.1.1 Bauteile mit Schwalbenschwanz-Verbindungen müssen bezüglich der Form und der Maße der Anlage 2 entsprechen.

2.1.2 Die Breite der Neben- und Hauptträger b_N und b_H muss mindestens 60 mm, und die Querschnittshöhe h_N bzw. h_H mindestens 140 mm betragen. Die Querschnittshöhe h_N darf höchstens 280 mm betragen.

Die am Nebenträger auszufräsenden Schwalbenschwanzzapfen sind am Nebenträger mittig anzuordnen (siehe Anlage 1).

Das Ausklinkungsverhältnis α muss mindestens den Wert 0,4 haben, der Radius der Zapfenausrundung r muss zwischen 15 mm und 60 mm, der Konuswinkel des Zapfens γ zwischen 4° und 12°, der Schwalbenschwanzfräswinkel β zwischen 10° und 18° und die Zapfenlänge ℓ_Z zwischen 25 mm und 30 mm betragen.

Das Ausklinkungsverhältnis α wird wie folgt ermittelt: $\alpha = \cos\delta \cdot (h_Z - r)/h_N$.

Hierin bedeuten:

δ Neigung des Nebenträgers in °

h_Z Zapfenhöhe in mm (siehe Anlage 2),

r Zapfenlochradius in mm (siehe Anlage 2),

h_N Höhe des Nebenträgers in mm.

Die Breite des Zapfens b_Z gemäß Anlage 2 muss mindestens 80% der Nebenträgerbreite b_N betragen.

Die Holzfeuchte der Bauteile mit Schwalbenschwanz-Verbindungen darf bei der Herstellung maximal 15 % betragen.

2.2 Herstellung und Kennzeichnung

2.2.1 Herstellung

Die Herstellung der Schwalbenschwanz-Zapfen und -Vertiefungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. darf nur im Werk erfolgen.

Nach dem Fräsen der Schwalbenschwanz-Zapfen und -Vertiefungen ist der Anschlussbereich hinsichtlich vorhandener Fehlstellen zu kontrollieren. Sind Fehlstellen, wie zum Beispiel lose Äste, im Anschlussbereich vorhanden, sind die Bauteile auszusortieren.

2.2.2 Kennzeichnung

Die Bauteile mit Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. (Nebenträger mit Schwalbenschwanzzapfen und Hauptträger mit entsprechender Vertiefung) und der Lieferschein müssen vom Hersteller mit dem Übereinstimmungszeichen (Ü-Zeichen) nach den Übereinstimmungszeichen-Verordnungen der Länder gekennzeichnet werden. Die Kennzeichnung darf nur erfolgen, wenn die Voraussetzungen nach Abschnitt 2.3 erfüllt sind.

Darüber hinaus muss der Lieferschein folgende Angaben enthalten:

- Bezeichnung des Zulassungsgegenstandes
- Herstellwerk

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2.3 Übereinstimmungsnachweis

2.3.1 Allgemeines

Die Bestätigung der Übereinstimmung der Bauteile mit Schwalbenschwanz-Verbindungen mit den Bestimmungen dieser allgemeinen bauaufsichtlichen Zulassung muss für jedes Herstellwerk mit einem Übereinstimmungszertifikat auf der Grundlage einer werkseigenen Produktionskontrolle und einer regelmäßigen Fremdüberwachung einschließlich einer Erstprüfung der Bauteile mit Schwalbenschwanz-Verbindungen nach Maßgabe der folgenden Bestimmungen erfolgen.

Für die Erteilung des Übereinstimmungszertifikates und die Fremdüberwachung einschließlich der dabei durchzuführenden Produktprüfungen hat der Hersteller der Bauteile mit Schwalbenschwanz-Verbindungen eine hierfür anerkannte Zertifizierungsstelle sowie eine hierfür anerkannte Überwachungsstelle einzuschalten.

Die Erklärung, dass ein Übereinstimmungszertifikat erteilt ist, hat der Hersteller durch Kennzeichnung der Bauprodukte mit dem Übereinstimmungszeichen (Ü-Zeichen) unter Hinweis auf den Verwendungszweck abzugeben.

Dem Deutschen Institut für Bautechnik ist von der Zertifizierungsstelle eine Kopie des von ihr erteilten Übereinstimmungszertifikats zur Kenntnis zu geben.

2.3.2 Werkseigene Produktionskontrolle

Es gelten die beim Deutschen Institut für Bautechnik hinterlegten Regelungen des Prüf- und Überwachungsplanes, die Bestandteil dieser allgemeinen bauaufsichtlichen Zulassung sind.

2.3.3 Fremdüberwachung

In jedem Herstellwerk ist die werkseigene Produktionskontrolle durch eine Fremdüberwachung regelmäßig zu überprüfen, mindestens jedoch einmal jährlich.

Im Rahmen der Fremdüberwachung ist eine Erstprüfung der Bauteile mit Schwalbenschwanz-Verbindungen durchzuführen und können auch Proben für Stichprobenprüfungen entnommen werden. Die Probenahme und Prüfungen obliegen jeweils der anerkannten Überwachungsstelle.

Die Ergebnisse der Zertifizierung und Fremdüberwachung sind mindestens fünf Jahre aufzubewahren. Sie sind von der Zertifizierungsstelle bzw. der Überwachungsstelle dem Deutschen Institut für Bautechnik und der zuständigen obersten Bauaufsichtsbehörde auf Verlangen vorzulegen.

3 Bestimmungen für Entwurf und Bemessung

3.1 Allgemeines

3.1.1 Für die Bemessung von Holzkonstruktionen unter Verwendung von Schwalbenschwanz-Verbindungen gilt DIN 1052 oder DIN EN 1995-1-1 in Verbindung mit DIN EN 1995-1-1/NA, soweit in dieser allgemeinen bauaufsichtlichen Zulassung nichts anderes bestimmt ist.

3.1.2 Die Tragfähigkeit nebeneinander liegender Schwalbenschwanz-Verbindungen ist in Anlehnung an DIN 1052:2008-12, 11.1.5 (5), (7) und (8) zu ermitteln.

3.1.3 Die Schwächung des Hauptträgers durch die eingefräste Vertiefung in der Seitenholzfläche ist bei der Bemessung des Hauptträgers zu berücksichtigen.

3.1.4 Der Rechenwert des Verschiebungsmoduls einer Schwalbenschwanz-Verbindung darf zu $K_{ser} = 7$ kN/mm angenommen werden.

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3.2 Bemessung von Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. nach DIN 1052:2008-12 oder nach DIN EN 1995-1-1 in Verbindung mit DIN EN 1995-1-1/NA

Der Bemessungswert der Tragfähigkeit $R_{90,d}$ einer auf Querkraft in Einschubrichtung beanspruchten Schwalbenschwanz-Verbindung beträgt je Anschluss:

$$R_{90,d} = \min \begin{cases} k_{ab} \cdot \frac{h_z}{h_z - r} \left(6{,}5 + \frac{18 \cdot (h_H - h_z + r)^2}{h_H^2} \right) \cdot (t_{ef} \cdot h_H)^{0,8} \cdot f_{t,90,d} \\ \frac{k_v \cdot b_N \cdot (h_z - r)}{1{,}5} \cdot f_{v,d} \end{cases} \quad \text{(in N)} \qquad (1)$$

Hierin bedeuten:

h_H Höhe des Hauptträgers in mm,

b_H Breite des Hauptträgers in mm,

h_Z Zapfenhöhe parallel zur Seitenfläche der Hauptträger in mm (siehe Anlage 2),

r Zapfenlochradius parallel zur Seitenfläche der Hauptträger in mm (siehe Anlage 2),

t_{ef} wirksame Anschlusstiefe in mm, t_{ef} = min (b_H, 100 mm) für ein- und beidseitige Anschlüsse,

$f_{t,90,d}$ Bemessungswert der Querzugfestigkeit, $f_{t,90,d} = f_{t,90,k} \cdot k_{mod} / \gamma_M$,

$f_{t,90,k}$ = 0,5 N/mm²,

k_{mod} Beiwert zur Berücksichtigung der Lasteinwirkungsdauer und der Holzfeuchte

γ_M Teilsicherheitsbeiwert für die Festigkeitseigenschaften

γ_M = 1,3

k_{ab} Beiwert zur Berücksichtigung ein- oder beidseitiger Anschlüsse

$k_{ab} = 1$ bei einseitigen Anschlüssen

$k_{ab} = \min \begin{cases} 1 \\ b_H/200 \end{cases}$ bei beidseitigen Anschlüssen

$$k_v = \min \left\{ 1 ; \frac{k_n}{\sqrt{h_N} \cdot \left(\sqrt{\alpha \cdot (1-\alpha)} + 0{,}4 \cdot \frac{\ell_Z}{h_N} \cdot \sqrt{\frac{1}{\alpha} - \alpha^2} \right)} \right\} \qquad (2)$$

h_N Höhe des Nebenträgers in mm,

b_N Breite des Nebenträgers in mm,

ℓ_Z Zapfenlänge in mm,

α = cos $\delta \cdot (h_Z - r)/h_N$, Ausklinkungsverhältnis,

δ Neigung des Nebenträgers in °

k_n = 5 für Vollholz und Balkenschichtholz aus Nadelholz,

k_n = 6,5 für Brettschichtholz,

$f_{v,d}$ Bemessungswert der Schubfestigkeit, $f_{v,d} = f_{v,k} \cdot k_{mod} / \gamma_M$,

$f_{v,k}$ = 2,5 N/mm².

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3.3 Brandschutz

Werden Anforderungen an den Feuerwiderstand der Holzkonstruktion gestellt, ist für diese Verbindungen die Feuerwiderstandsklasse nach DIN 4102-2 oder DIN EN 13501-2[10] nachzuweisen.

4 Bestimmungen für die Ausführung

4.1 Für die Ausführung von Holzkonstruktionen unter Verwendung von Schwalbenschwanz-Verbindungen gilt DIN 1052 oder DIN EN 1995-1-1 in Verbindung mit DIN EN 1995-1-1/NA, soweit im Folgenden nichts anderes bestimmt ist.

4.2 Die Fuge zwischen dem Stirnende des Nebenträgers und dem Hauptträger darf maximal 1 mm breit sein. Zwischenhölzer dürfen nicht verwendet werden. Die Schwalbenschwanz-Verbindungen des Verbandes HIGH-TECH-ABBUND im Zimmererhandwerk e.V. sind entsprechend der Anlage 1 anzuordnen und auszuführen.

Die Haupt- und Nebenträger sind oberkantenbündig einzubauen.

Um das Hineindrücken der Schwalbenschwanz-Zapfen bei geneigten Trägern zu erleichtern, ist ein Keil mit entsprechender Neigung auf dem Nebenträger als Montagehilfe aufzubringen. Zur Lagesicherung des Keils während des Einbringens des Schwalbenschwanz-Zapfens ist eine ausreichend dimensionierte Schraube oder ein Nagel zu verwenden.

4.3 Die Holzfeuchte der Bauteile mit Schwalbenschwanz-Verbindungen darf bei der Herstellung und dem Einbau maximal 15 % betragen.

Reiner Schäpel
Referatsleiter

Beglaubigt
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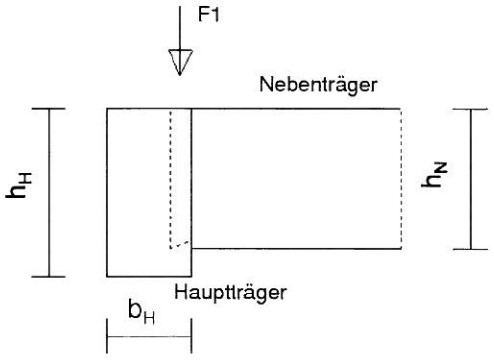
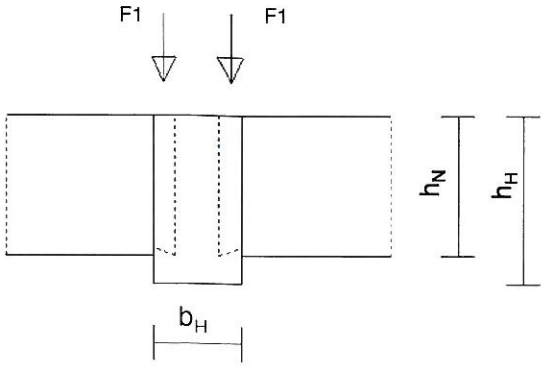
[10] DIN EN 13501-2:2008-01 Klassifizierung von Bauprodukten und Bauarten zu ihrem Brandverhalten - Teil 2: Klassifizierung mit den Ergebnissen aus den Feuerwiderstandsprüfungen, mit Ausnahme von Lüftungsanlagen;

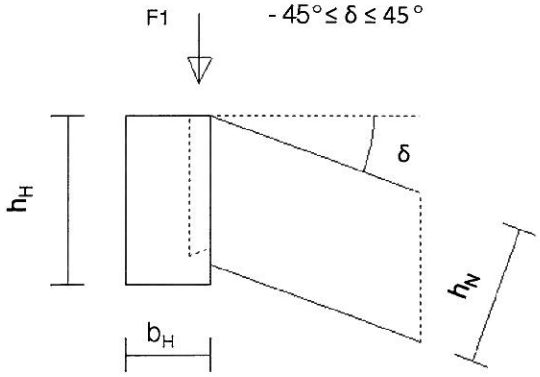
Einseitiger Anschluss



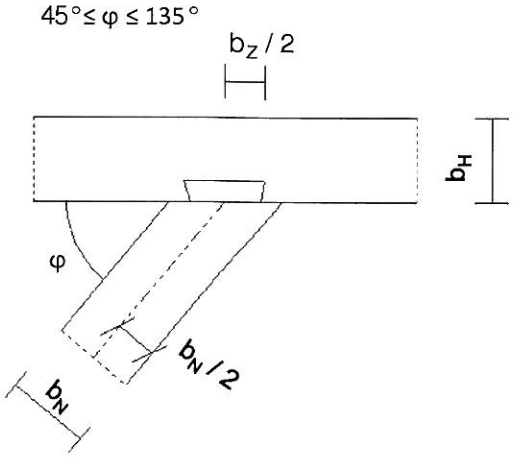
Beidseitiger Anschluss



Geneigter Anschluss



Schräger Anschluss



Nebenträgerhöhe	140	≤ h_N	≤	280
Nebenträgerbreite		b_N	≥	60
Hauptträgerhöhe		h_H	≥	140
Hauptträgerbreite		b_H	≥	60

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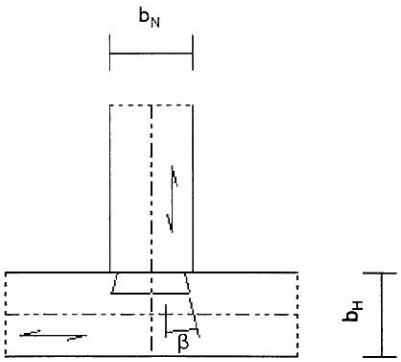
Schwalbenschwanz-Verbindung in Bauteilen

Prinzipdarstellung

Anlage 1

Draufsicht



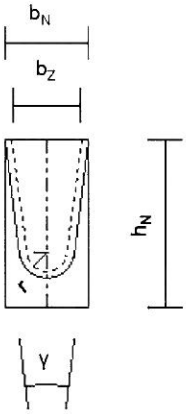
Legende

Zapfenradius in Fuge	$15 \leq r \leq 60$
Zapfenhöhe	h_z
Zapfenbreite (kleiner Wert)	b_z
Zapfenlänge	$25 \leq l_z \leq 30$
Zapfenkonuswinkel	$4° \leq \gamma \leq 12°$
Fräswinkel	$10° \leq \beta \leq 18°$
Zapfenlochtiefe	t_z
Zapfenlochradius in Fuge	$15 \leq r \leq 60$

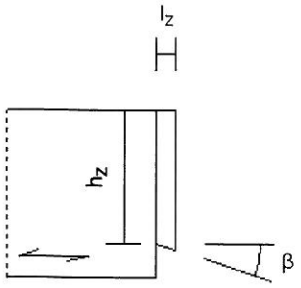
Maßtoleranzen + / - 0,2 mm

Nebenträger

Vorderansicht

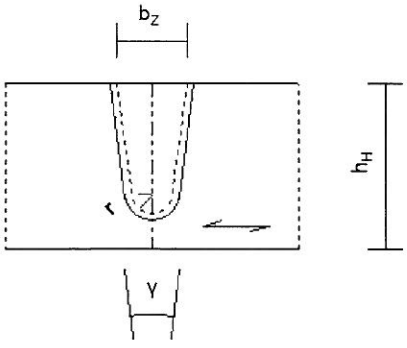


Seitenansicht

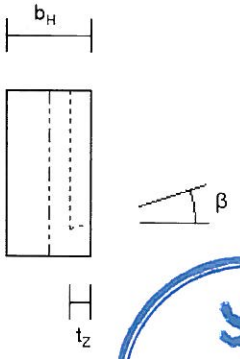


Hauptträger

Vorderansicht



Seitenansicht



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Schwalbenschwanz-Verbindung in Bauteilen

Form und Abmessungen

Anlage 2

GH Zuganker Top Vario 240 / 280



Zulassung ETA-10/0010

Anschlussarten

Holz/ Holz[1]	Holz/ Beton[2]	Holz/ Mauerwerk[2]	Holz/ Stahl
✓	✓	✓	✓

[1] mit Bauschrauben [2]Nachweis im Untergrund gesondert zu führen

Der Wandanschluß ist auch über eine Zwischenschicht (z.B. OSB) möglich

Verbindungsmittel in Holz

GH Rillennägel TFK III; CE nach EN 14592:2008

4,0x40	4,0x50	4,0x60	4,0x75	4,0x100
✓	✓	✓	✓	✓

GH Schraube Z-9.1-375 CE nach EN 14592

5,0x25	5,0x35	5,0x40	5,0x50	5,0x60	5,0x70
✓	✓	✓	✓	✓	✓

Verbindungsmittel in Beton

Betonsch	Bolzenanker	Schrauben DIN 601
✓	✓	✓

Lastrichtungen/Bezeichnungen

F_{Rk} / F_{Rd} Zuglast Verbinder

$F_{B,t,Ek}$ Zuglast Dübel ist gleich F_{Rk} / F_{Rd}

n_{NA} Anzahl Nägel

Berechnungsgrundlagen

Berechnung der Designwerte der Tragfähigkeiten der Verbindungsmittel nach DIN
Charakteristische Rohdichte der Bauteile ρ_k=350 kg/m³.
Maximale Anzahl an Verbindungsmittel bei Anordnung einer 60mm starken Schwelle und unter der Berücksichtigung der Abstände zum beanspruchten Hirnholzrand (15*d) nach EC 5

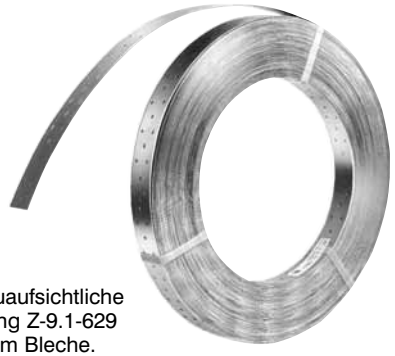
Statische Werte GH Zuganker

Tragfähigkeiten gem. ETA-10/0010

				4x40 /5x40		4x50 / 5x40		4x60 / 5x50	
Art. Nr.	**Typ**	**n_{Na}**	**KLED**	**$F_{Rd\ up}$**	**$F_{B,t,Ed}$**	**$F_{Rd\ up}$**	**$F_{B,t,Ed}$**	**$F_{Rd\ up}$**	**$F_{B,t,Ed}$**
110850	Top Vario 240	12	kurz	13,0	19,4	14,5	21,5	14,5	21,5
			mittel	11,6	17,3	13,8	20,6	14,3	21,2
			ständig	8,7	13,0	10,4	15,4	10,7	15,9
110867	Top Vario 280	17	kurz	14,5	21,5	14,5	21,5	14,5	21,5
			mittel	14,5	21,5	14,5	21,5	14,5	21,5
			ständig	12,3	18,4	14,5	21,5	14,5	21,5

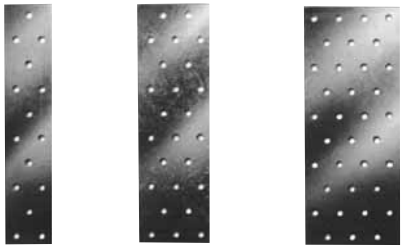
Alle Berechnungen und Werte sind ausschließlich für GH Produkte
Die Tragfähigkeiten wurden auf Grundlage europäischen GH Zulassungen und deren Spezifikationen berechnet.
Das übertragen der Werte auf Fremdfabrikate ist nicht möglich

Haftungsausschluss
Angaben keine Haftung übernommen.
Technische Änderungen vorbehalten.



Allg. bauaufsichtliche Zulassung Z-9.1-629 für 1,5mm Bleche.

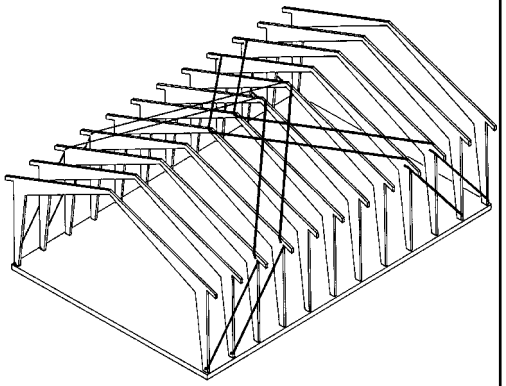
Die 2,0mm Bleche sind in der DIN geregelt.



40 × 1,5
40 × 2,0

60 × 1,5
60 × 2,0

80 × 1,5
80 × 2,0



Windrispenbänder

werden aus feuerverzinktem Stahlblech hergestellt.

Bei einer größeren Bestellmenge können auch Sonderabmessungen gefertigt werden - Preis und Lieferzeit auf Anfrage.

Windrispenbänder 40 × 2,0 sind auch in Edelstahl (Werkstoff-Nr. 1.4401) lieferbar.

Anwendung

Windrispenbänder können vielseitig für Baukonstruktionen verwendet werden, dienen aber hauptsächlich zur Aussteifung von Dachkonstruktionen.

Montage

Das Windrispenband wird mit CNA4,0×l Kammnägeln oder CSA5,0×l Schrauben auf die Sparren genagelt und am Fußpunkt gesondert verankert.

Für den Fall, dass größere Zugkräfte aufgenommen werden müssen, können mehrere nebeneinanderliegende Bänder eingebaut werden.

Für die Befestigung der Windrispenbänder an die First- und Fußpfetten wird das **Windaussteifungssystem 40/ 60** ohne Verwendung von Beihölzern empfohlen - siehe Seite 4.15 ff.

Stahlqualität:

2,0 mm: S 250 GD + Z 275 gemäß DIN EN 10326:2004
1,5 mm: S 320 GD + Z 275 gemäß DIN EN 10326:2004[1)]
[1)] Re_H = 335 N/mm² nach Werkszertifikat

Korrosionsschutz:

275 g/m² beidseitig - entsprechend einer Zinkschichtdicke von ca. 20 μm.

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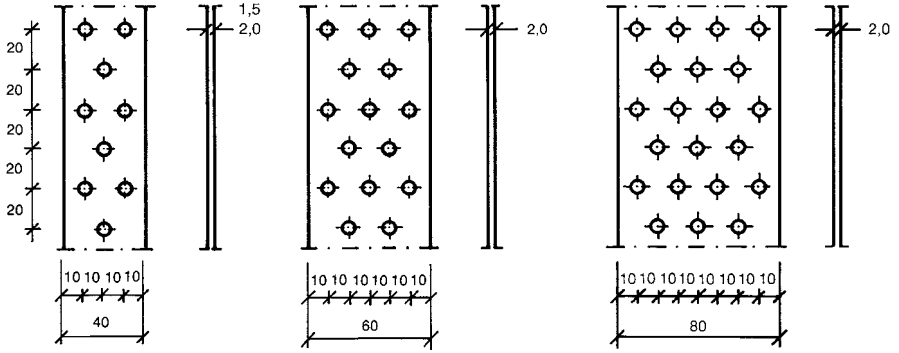
Windrispenbänder

40 × 1,5
40 × 2,0

60 × 1,5
60 × 2,0

80 × 1,5
80 × 2,0



Art. No.	Typ mm × mm × m	Breite [mm]	Dicke [mm]	Länge [m]	Löcher ∅[mm]
27414	**40 × 1,5 × 25**	40	1,5	25	5
27415	**40 × 1,5 × 50**	40	1,5	50	5
27419	**40 × 2,0 × 25**	40	2,0	25	5
27420	**40 × 2,0 × 50**	40	2,0	50	5
27615	**60 × 1,5 × 50**	60	1,5	50	5
27620	**60 × 2,0 × 50**	60	2,0	50	5
27815	**80 × 1,5 × 25**	80	1,5	25	5
27820	**80 × 2,0 × 25**	80	2,0	25	5

Statische Werte

Bemessungswerte der Tragfähigkeit auf Zug, $R_{1,d}$ des Windrispenbandes in kN in allen Klassen der Lasteinwirkungsdauer (KLED).
Die erforderliche Anzahl CNA4,0×40 Kammnägel, entsprechend $R_{1,d}$ des Windrispenbandes, ist in der Tabelle, abhängig von KLED, angegeben.

Typ			Erforderliche Nagelanzahl, wenn $F_{1,d} = R_{1,d}$ und CNA4,0x40 Kammnägel [1)]				
B x t		$R_{1,d}$	**Klasse der Lasteinwirkungsdauer (KLED) und k_{mod}**				
			ständig	lang	mittel	kurz	sehr kurz
[mm]	[mm]	[kN]	0,6	0,7	0,8	0,9	1,1
40 x	1,5	13,6	18	15	13	12	10
40 x	2,0	13,6	18	15	13	12	10
60 x	1,5	20,5	26	22	20	18	14
60 x	2,0	20,5	26	22	20	18	14
80 x	1,5	27,3	35	30	26	23	19
80 x	2,0	27,3	35	30	26	23	19

[1)] Bei der Verwendung von Bandanschlüssen (siehe Windaussteifungssystem) in Zusammenhang mit Windrispenband wird in der Regel das Problem fehlender Anschlußflächen gelöst.

BMF® Windaussteifungssystem 40/ 60

K 40/60
27946



40/60
27949



B 40/60 Ø20
27050

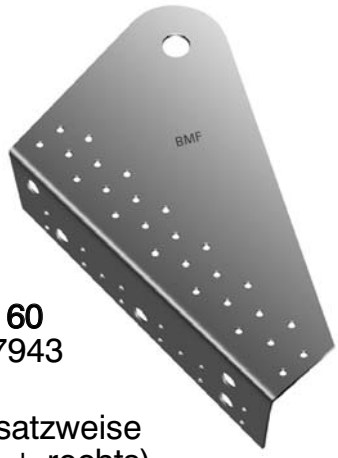


F 40
27940



F 40 werden satzweise verkauft (links + rechts).

G 60
27943



G 40 werden satzweise verkauft (links + rechts).

Siehe auch BMF Spanngerät 40 und Spanngerät 60 Seite 4.11.1.

BMF® Windaussteifungssystem 40/ 60

für die Windaussteifung von Dachkonstruktionen.

Die Anwendung dieses Systems gewährleistet eine optimale Ausnagelung (unter Einhaltung der Nagelabstände nach DIN 1052-2) bei Befestigung des Windrispenbandes an den Endpunkten (First- und Fußpunkt), ohne Verwendung von Beiholz.

Das Windaussteifungssystem besteht aus 3 verschiedenen Bandanschlüssen, einem Kopplungsverbinder und einem Spanngerät B 40/ 60 ∅ 20. Die Bandanschlüsse am First- und Fußpunkt werden mittels Kopplungsverbinder oder Spanngerät B 40/ 60 ∅ 20 an das Windrispenband 40 × 2,0 - 40 × 3,0 oder 60 × 2,0 angeschlossen.

Siehe auch Illustrationen und Beschreibung des Windaussteifungssystems Seite 4.20.3 bis 4.20.5.

Bezeichnung:

- **BMF Bandanschlüsse F40**
  werden satzweise verkauft
- **BMF Bandanschlüsse G60**
  werden satzweise verkauft
- **BMF Bandanschlüsse K40/60**
- **BMF Kopplungsverbinder 40/60**
  komplett mit Schrauben, Dorn und Splint
- **BMF Spanngeräte B40/60 ∅ 20**
  komplett mit Schrauben, Dorn und Splint

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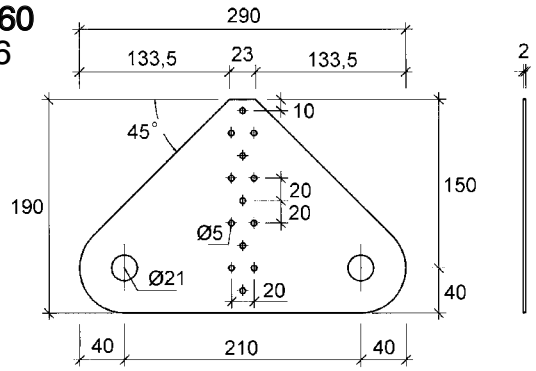
BMF® Windaussteifungssystem 40/ 60

SIMPSON Strong-Tie®

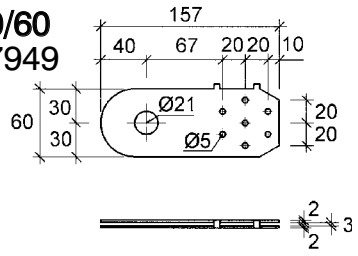
K 40/60
27946



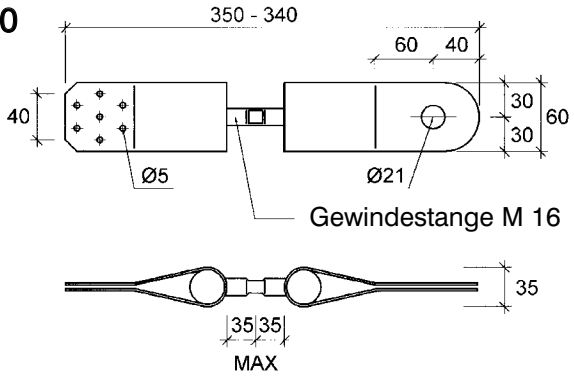
Stahlqualität
Verbinder: S 250 GD + Z 275 gemäß EN 10326: 2004.
Schrauben: Güte 8.8
Dorn: S 235 JR gemäß EN 10025.

Korrosionsschutz
Verbinder: 275 g/m² beidseitig - entsprechend einer Zinkschichtdicke von ca. 20 µm.
Schrauben, Dorn, Kammnägel: verzinkt mit einer Zinkschichtdicke von ca. 15 µm.

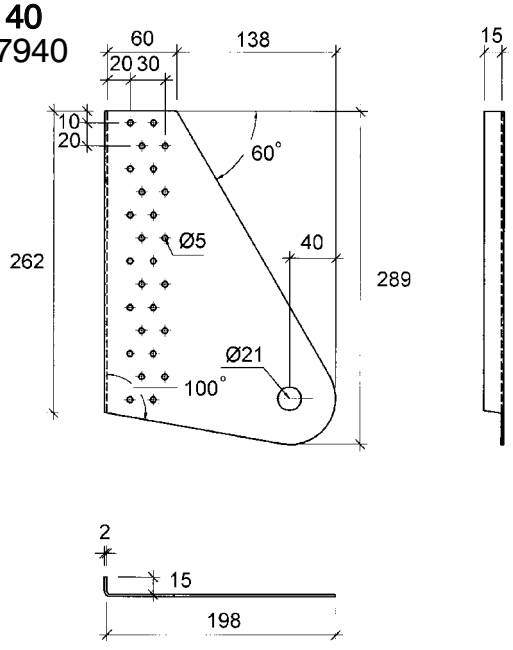
40/60
27949



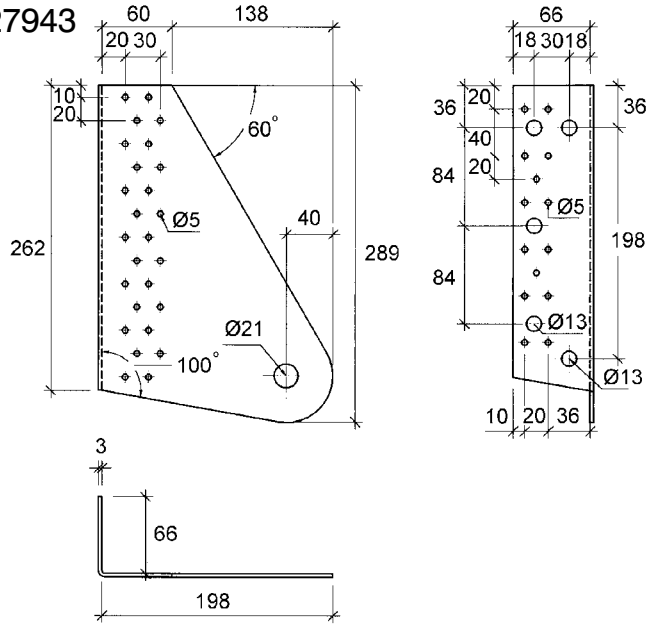
B 40/60 ∅ 20
27050



F 40
27940



G 60
27943



Art. No.	Typ	Löcher	
		∅ mm	Anzahl/ St.
27940	**1 Satz Bandanschlüsse F 40**	5 21	26+0 1+0
27943	**1 Satz Bandanschlüsse G 60**	5 13 21	26+14 0+5 1+0
27946	**Bandanschlüsse K 40/60**	5 21	13 2
27949	**Kopplungsverbinder 40/60**	5 21	7 1
27050	**Spanngeräte B 40/60 Ø20**	5 21	7 1

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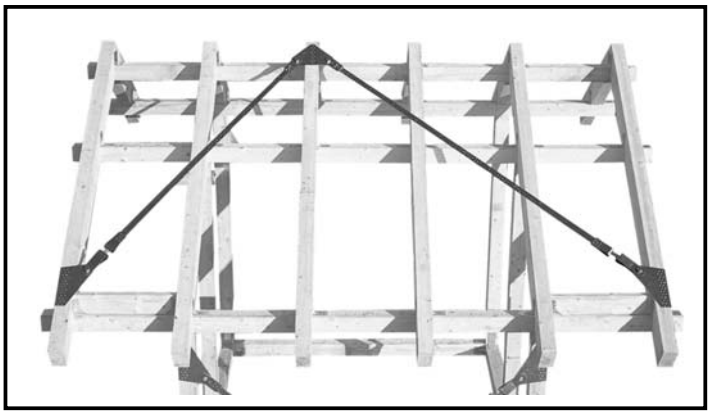
BMF® Windaussteifungssystem 40/60

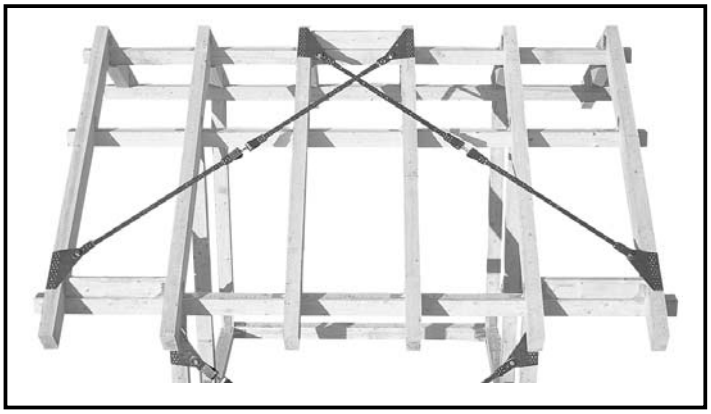
Dachaussteifung



BMF® Windaussteifungssystem

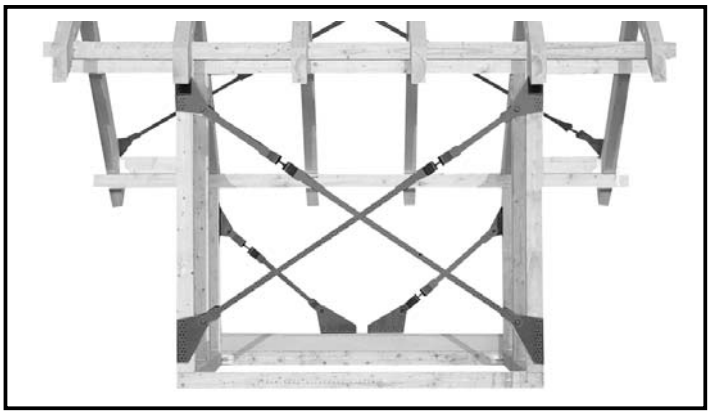
Das System ist flexibel und ist für Windrispenbandneigungen vom Binder zum Verband zwischen 30° und 60° wählbar. Der Einbau von Spanngeräten gestattet ein sicheres Spannen der Windrispenbänder und gibt die Möglichkeit zum Nachspannen.

Dachaussteifung



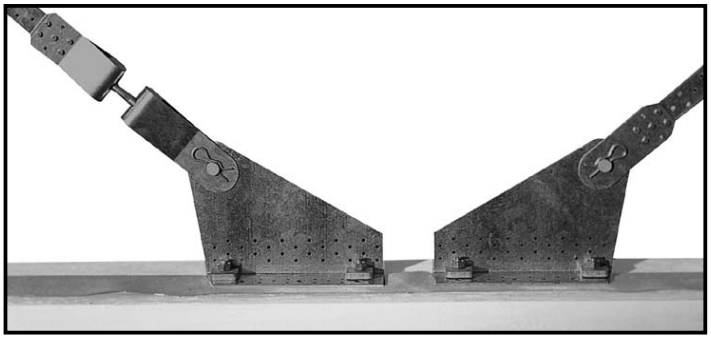
Das System ist vorteilhaft bei Renovierungsarbeiten, wo die Platzverhältnisse sehr eng sind. Der Bandanschluß kann hier seitlich am Sparren befestigt werden.

Wandaussteifung



Darüber hinaus kann das System bei Kreuzaussteifungen von Wänden verwendet werden.

Detail am Fundament



Die Bandanschlüsse werden im Fundament befestigt.
Zur Verstärkung der Stahlplatte im Bereich des Fundamentes soll eine BMF U-Scheibe verwendet werden.

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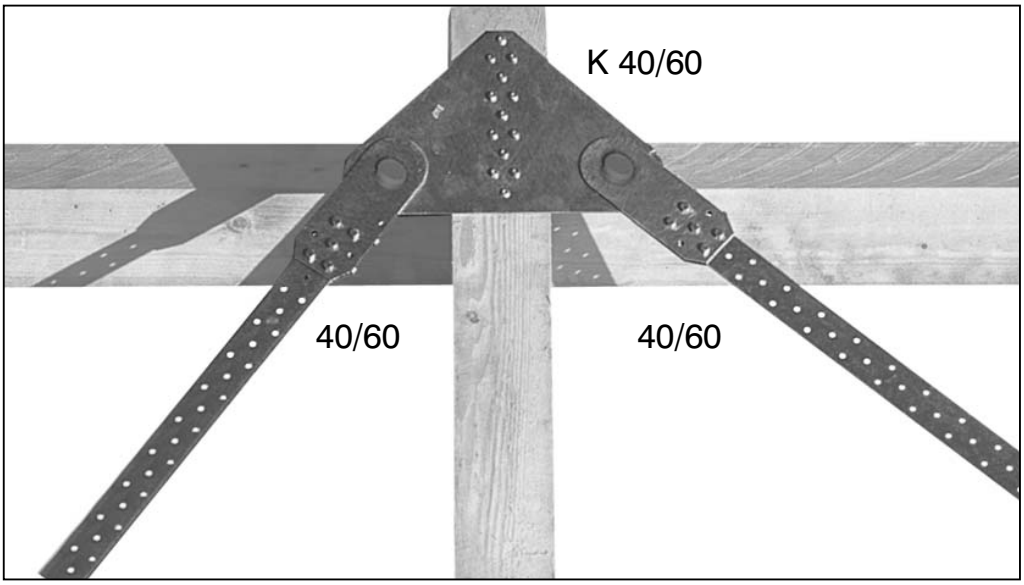
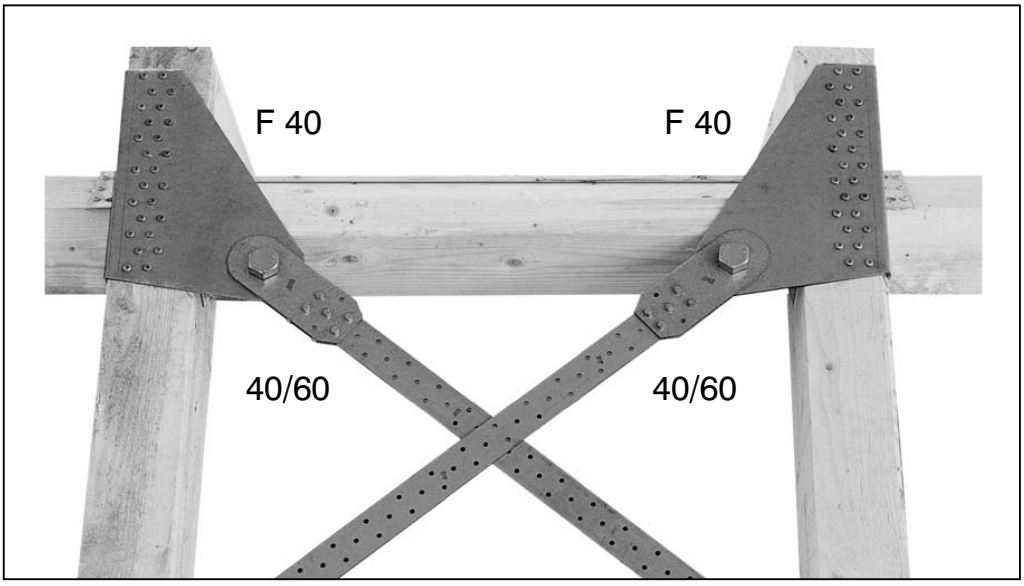
Detail am Firstpunkt, Anschluss eines Sparrens



Der Bandanschluss K 40/60 ist hier mit 2 St. Kopplungsverbindern 40/60, zur Aufnahme des Windrispenbandes 40 × 2,0, im Firstbereich eingebaut. Er wird auf der Oberseite des Sparrens mit BMF Kammnägeln 4,0 × 40 oder BMF Schrauben 5,0 × 35 montiert. Der Sparren wird separat auf der Firstpfette befestigt.

Detail am Firstpunkt, Anschluss zweier Sparren



Die Bandanschlüsse F 40 sind hier mit Kopplungsverbindern 40/60, zur Aufnahme des Windrispenbands 40 × 2,0, im Firstbereich eingebaut. Sie werden auf der Oberseite der Sparren mit BMF Kammnägeln 4,0 × 40 oder BMF Schrauben 5,0 × 35 befestigt. Zwischen den Sparren ist ein Füllholz oberhalb der Firstpfette mit Balkenschuhen eingebaut. Die Sparren werden separat auf der Firstpfette befestigt.

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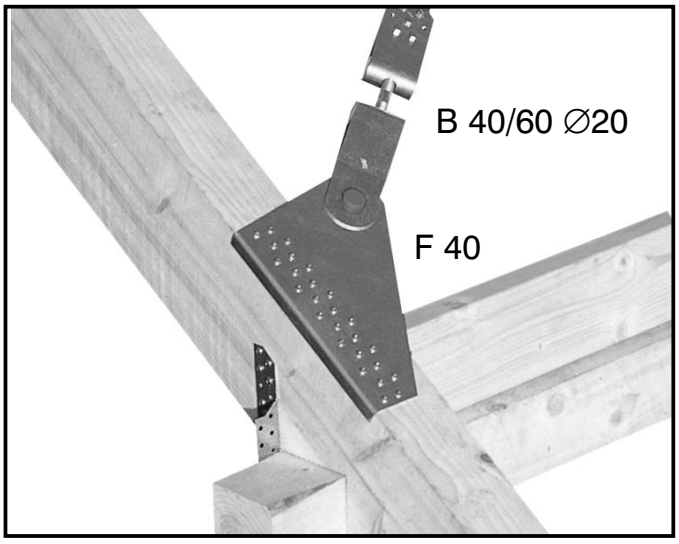
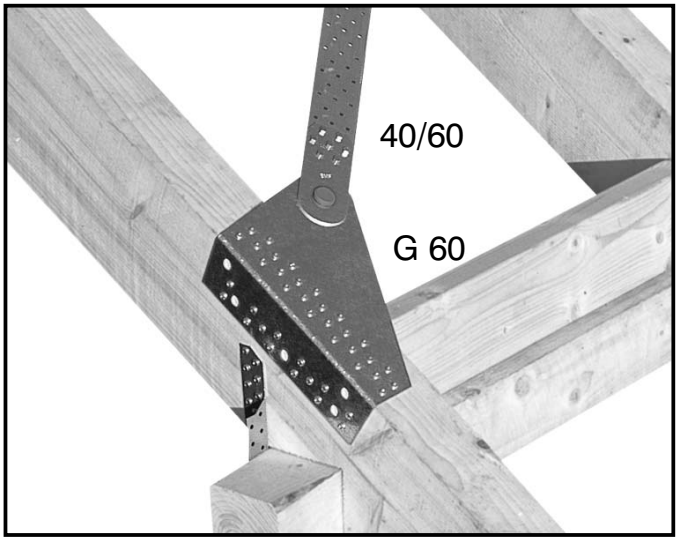
Detail am Fußpunkt, Ausnagelung oben



Der Anschluss an der Fußpfette ist hier mit dem Bandanschluss F 40, dem Spanngerät B 40/60 ∅20 und dem Windrispenband 40 × 2,0 gezeigt.

Der Bandanschluss F 40 wird auf der Oberseite des Sparrens mit BMF Kammnägeln 4,0 × 40 oder BMF Schrauben 5,0 × 35 befestigt. Zwischen den Sparren ist ein Füllholz oberhalb der Fußpfette mit Balkenschuhen eingebaut. Die Sparren werden separat auf der Fußpfette befestigt.

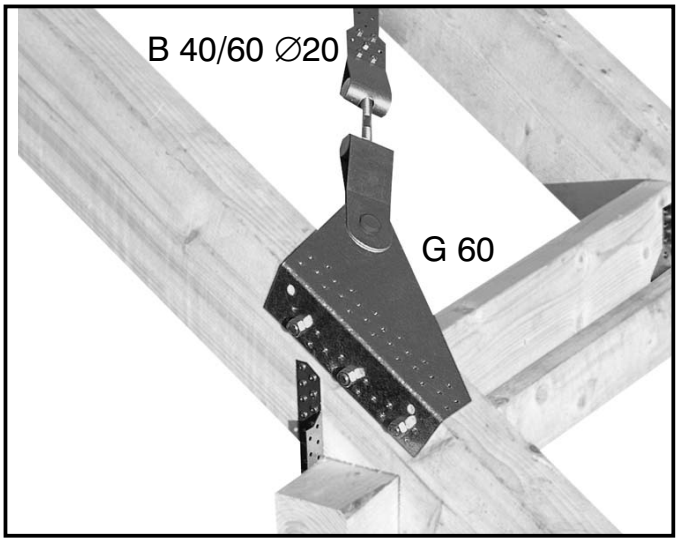
Detail am Fußpunkt, Ausnagelung oben/ seitlich



Der Anschluss an der Fußpfette ist hier mit dem Bandanschluss G 60, dem Kopplungsverbinder 40/60 und dem Windrispenband 60 × 2,0 gezeigt.

Der Bandanschluss G 60 wird oberhalb und seitlich des Sparrens mit BMF Kammnägeln 4,0 × 40 oder BMF Schrauben 5,0 × 35 befestigt. Zwischen den Sparren ist ein Füllholz oberhalb der Firstpfette mit Balkenschuhen eingebaut. Die Sparren werden separat auf der Fußpfette befestigt.

Detail am Fußpunkt, mit Bolzen



Der Anschluss an der Fußpfette ist hier mit dem Bandanschluss G 60, dem Spanngerät B 40/60 und dem Windrispenband 40 × 2,0 gezeigt.

Der Bandanschluss G 60 wird mit 3 Bolzen ∅12 seitlich am Sparren befestigt.

Zwischen den Sparren ist ein Füllholz oberhalb der Firstpfette mit Balkenschuhen eingebaut. Die Sparren werden separat auf der Fußpfette befestigt.

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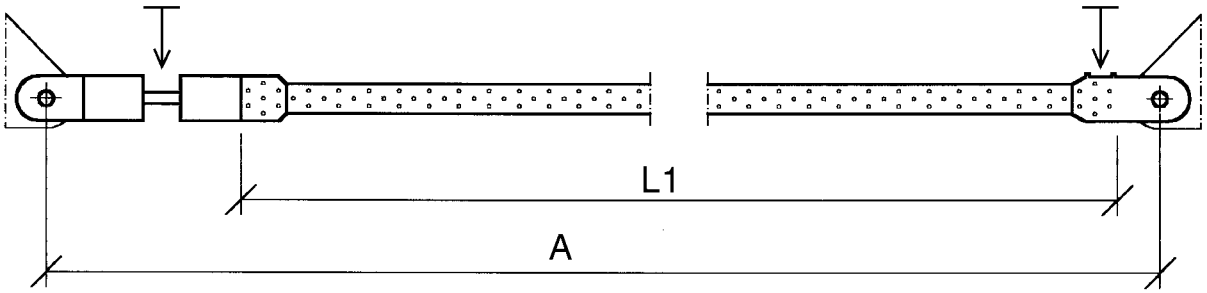
BMF® Windaussteifungssystem 40/60

Kürzen der Windrispenbänder 40 × 2,0 und 60 × 2,0 für das Windaussteifungssystem:

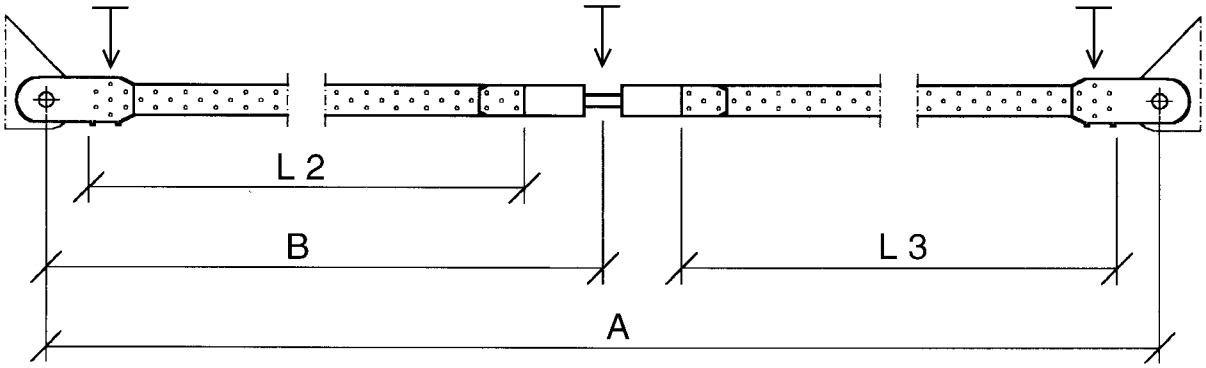
Beispiel 1

Spanngeräte B 40/60 **∅20 Windrispenband** **Kopplungsverbinder 40/60**



Beispiel 2

Kopplungsverbinder 40/60 **Spanngeräte 40** **Kopplungsverbinder 40/60**

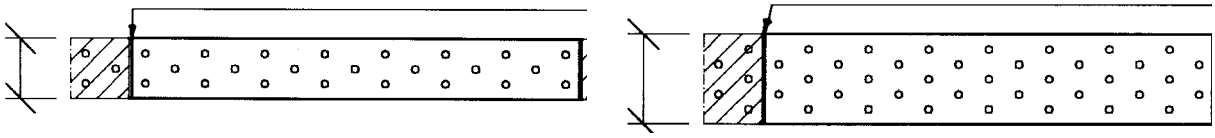


Wichtig beim Kürzen der Windrispenbänder

Windrispenband 40 × 2,0: **Windrispenband 60 × 2,0:**

Die Windrispenbänder werden mittig zwischen den Löchern gekürzt. Ein zugeschnittenes Windrispenband sollte am Anfang und am Ende je 2 Löcher aufweisen (siehe folgende Beispiele).

hier schneiden hier schneiden



Die Schnittlänge des Windrispenbandes (mm) muß durch 20 teilbar sein.

Beispiel 1
Ein A-Maß 4245 mm ist abgelesen
L1 = A - 360 mm,
L1 = 4245 - 360 mm = 3885 mm
Die fertige Bandlänge muß durch 20 teilbar sein.
L1 = 3885 auf 3900 mm aufrunden.

Beispiel 2
A-Maß = 4245 mm
L2 durch 20 teilbar wählen, L2 = 2700 mm wird gewählt
B-Maß = Mitte des Spanngerätes = 2700 + 172 mm = 2872 mm
L3 wird wie folgt ermittelt:
L3 = A - L2 - 344 mm
L3 = 4245 - 2700 - 344 = 1201 auf L3 = 1220 mm aufrunden
d.h. L2 = 2700 mm und L3 = 1220 mm.

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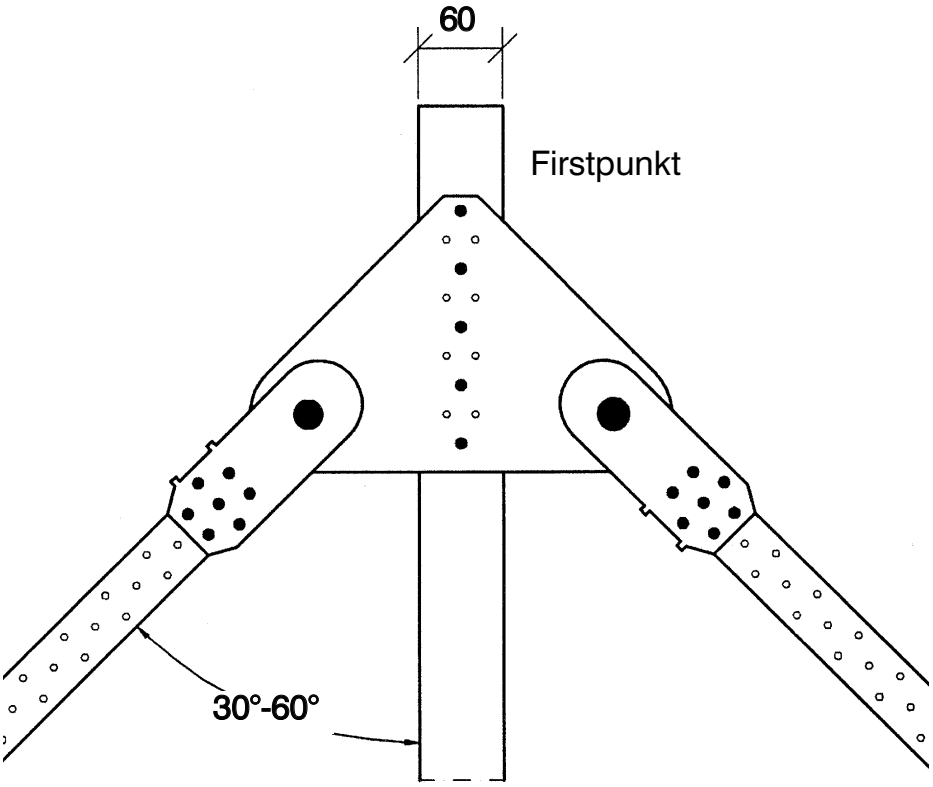
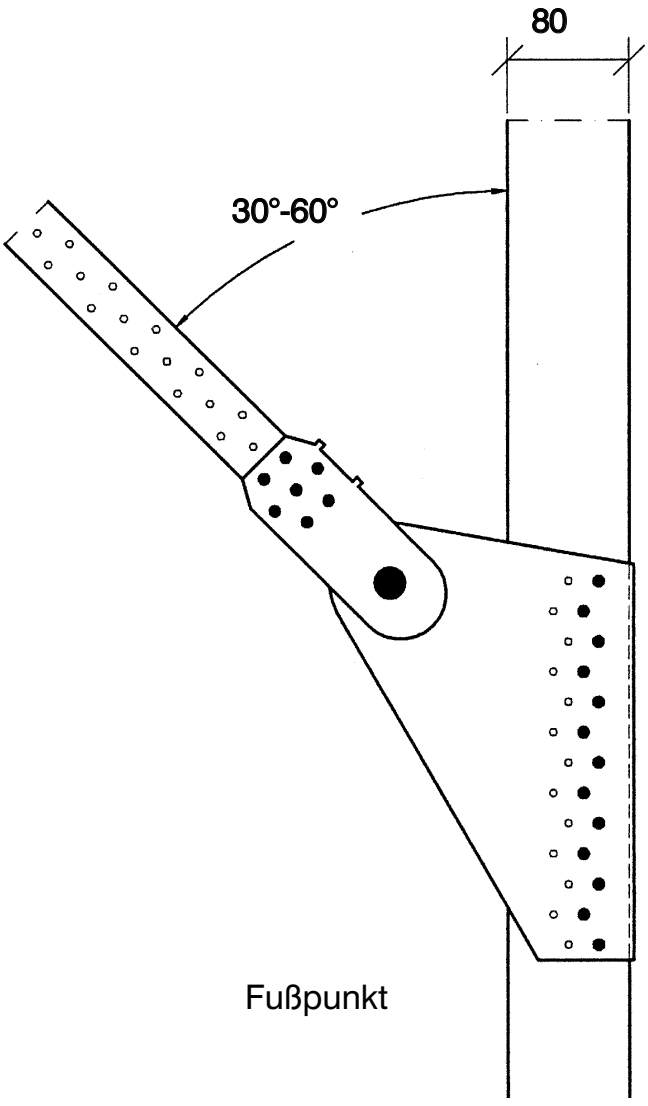
BMF® Windaussteifungssystem 40/ 60

Statische Werte: Anschlusswinkel



Maße in mm



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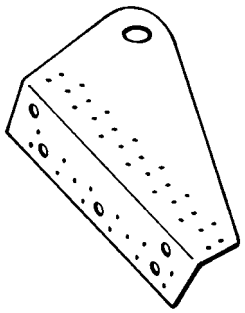
Statische Werte

Zulässige Belastungen für BMF Windaussteifungssystem [kN] - Lastfall H.

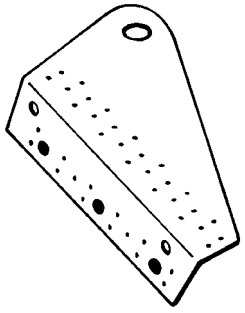


1. BMF Bandanschlüsse G60, Nagelbefestigung

Die Ergebnisse der einzelnen Varianten werden zusammengestellt:

Anschlusswinkel		30°	35°	40°	45°	50°	55°	60°
Variante 1	60 mm ≤ b < 80 mm	5,1	5,8	6,8	8,3	8,1	6,4	5,2
Variante 1	≥ 80 mm	11,0	12,6	15,0	17,3	14,7	11,8	9,8
Variante 2	40 × 40, b ≥ 40 mm	3,8	5,8	7,9	8,3	8,9	9,6	10,6
Variante 2	40 × 50, b ≥ 50 mm	4,8	6,8	7,9	8,3	8,9	9,6	10,6
Variante 2	40 × 60, b ≥ 60 mm	5,5	7,5	7,9	8,3	8,9	9,6	10,6
Variante 3	40 × 40	10,8	16,3	17,3	17,3	17,3	17,3	15,4
Variante 3	40 × 50	13,4	17,3	17,3	17,3	17,3	17,3	15,4
Variante 3	40 × 60	15,5	17,3	17,3	17,3	17,3	17,3	15,4

Variante 1: Ausnagelung oben: ≤ b < 80 (13 St. 4,0 × 40 mm Nägel), b ≥ 80 mm (26 St. 4,0 × 40 mm Nägel)
Variante 2: Ausnagelung seitlich (14 Nägel)
Variante 3: Kombination: b ≥ 80 mm, Nagelanzahl oben/seitlich = 26/ 14



2. BMF Bandanschlüsse G60, mit 3 × M12 Bolzen mit Unterlegscheibe, D = 58 mm, seitlich befestigt (t = 3 mm)

Breite ≥ 60 mm

Anschlusswinkel	30°	35°	40°	45°	50°	55°	60°
zul F (kN)	7,1	7,3	7,6	8,1	8,7	9,5	10,0

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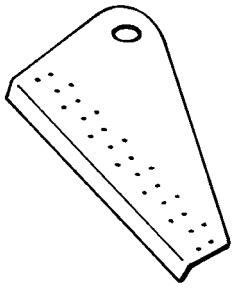
Statische Werte



3. BMF Bandanschlüsse F 40, Nagelbefestigung

60 ≤ Breite < 80 mm

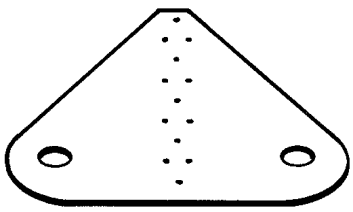
Anschlusswinkel	30°	35°	40°	45°	50°	55°	60°
zul F (kN)	5,1	5,8	6,8	8,3	8,1	6,4	5,2

(13 Nägel 4,0 × 40)

Breite ≥ 80 mm

Anschlusswinkel	30°	35°	40°	45°	50°	55°	60°
zul F (kN)	11,0	12,1	12,1	12,1	12,1	11,8	9,9

(26 Nägel 4,0 × 40)



4. BMF Bandanschlüsse K40/ 60

60 ≤ Breite < 80 mm

Anschlusswinkel	30°	35°	40°	45°	50°	55°	60°
zul F (kN)	1,6	1,7	1,9	2,1	2,4	2,8	3,5

(5 Nägel 4,0 × 40)

Breite ≥ 80 mm

Anschlusswinkel	30°	35°	40°	45°	50°	55°	60°
zul F (kN)	3,6	3,9	4,4	5,0	5,8	7,1	9,1

(13 Nägel 4,0 × 40)

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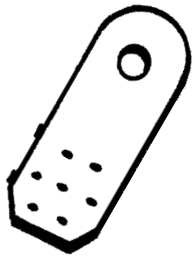
Statische Werte



5. BMF Kopplungsverbinder 40/ 60

Anschlusswinkel	30°	35°	40°	45°	50°	55°	60°
zul F (kN)	13,7	13,7	13,7	13,7	13,7	13,7	13,7

(1 Dorn 20 mm + 7 Schrauben 5 mm)

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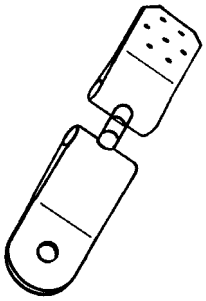

6. BMF Spanngeräte B40/ 60 ∅20 für 40 × 2,0, 40 × 3,0 und 60 × 2,0 Windrispenband

Spanngerät 40/ 60 ∅20	
Windrispen-band	Erf. Bolzenanzahl und -abmessung
40 × 2,0	5 × M5
40 × 3,0	5 × M5
60 × 2,0	5 × M5

BMF Windrispenband	
Typ	zul. Belastung (Zug) [kN]
40 × 2,0	9,1
40 × 3,0	13,7
60 × 2,0	13,7

Tragfähigkeit des Spanngerätes entspricht der des Windrispenbandes, wenn die oben angegebene Bolzenanzahl vorhanden ist.

Structural Calculations

Deliverable #5

Façade

Promoter: Solar Decathlon 2014

Building project: rooftop house

Editor: Team rooftop

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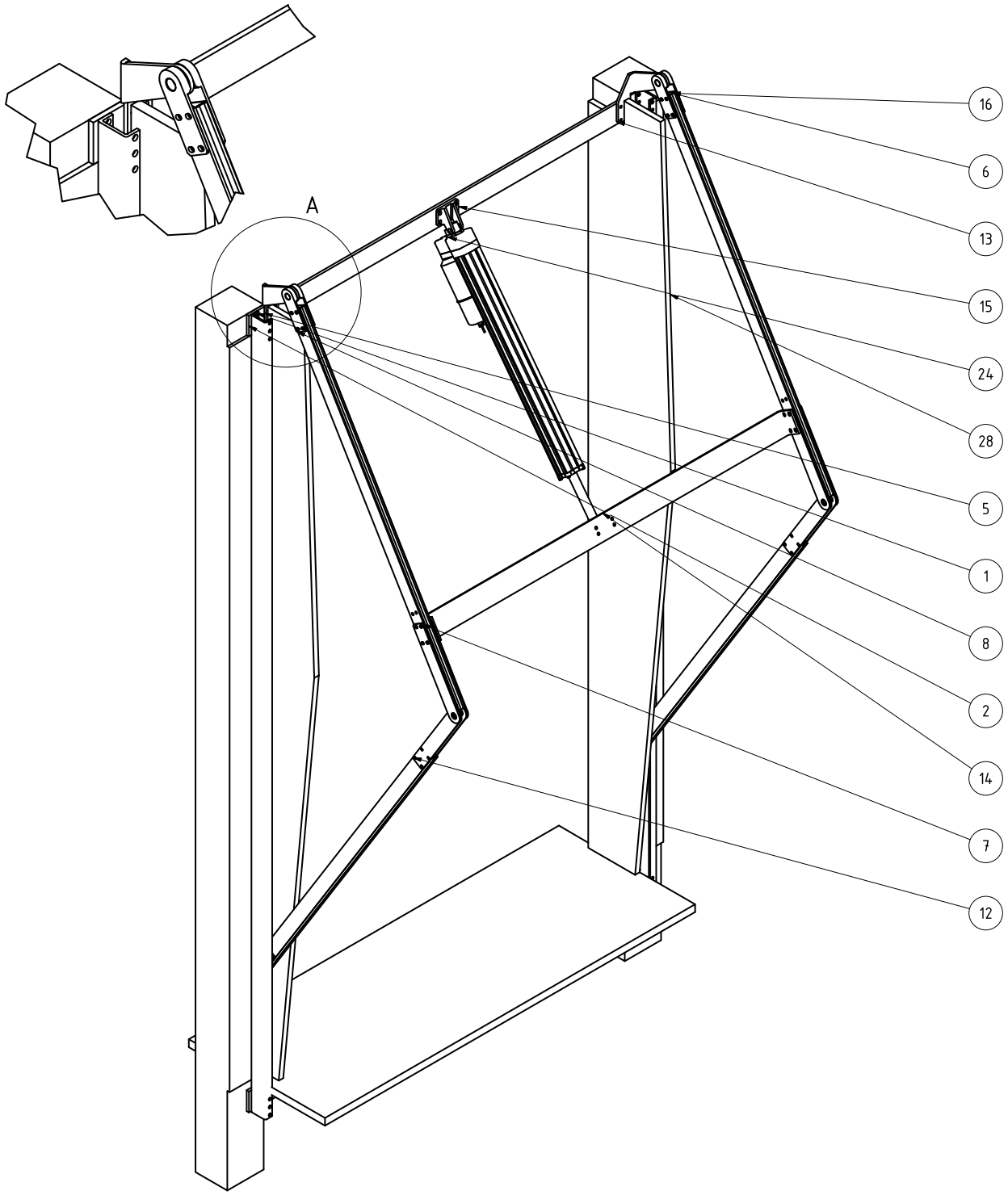
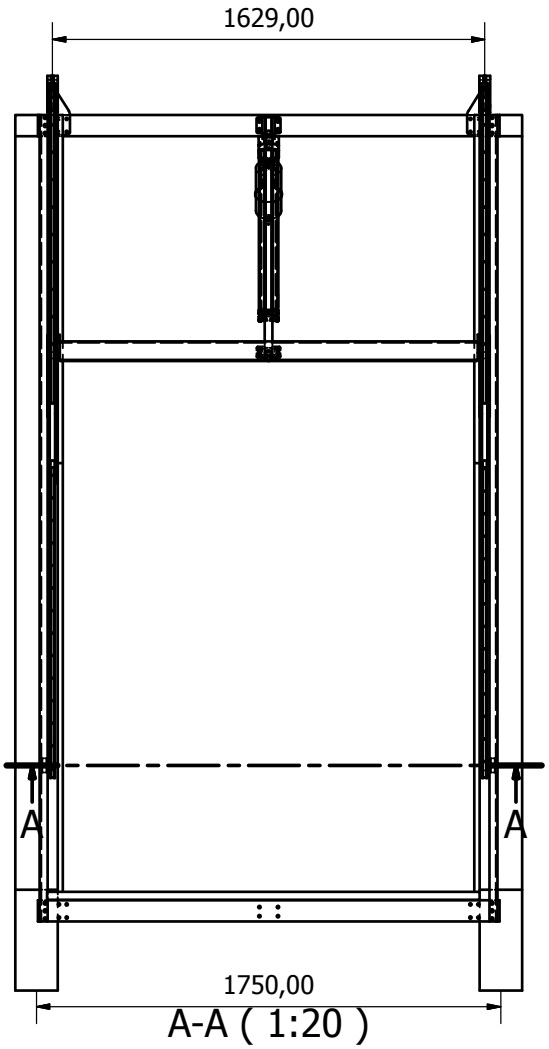
1.1.3 Pillars 10
1.2 Façade and pillars - dimensioning 11

1.1 Façade and pillars – load assumptions

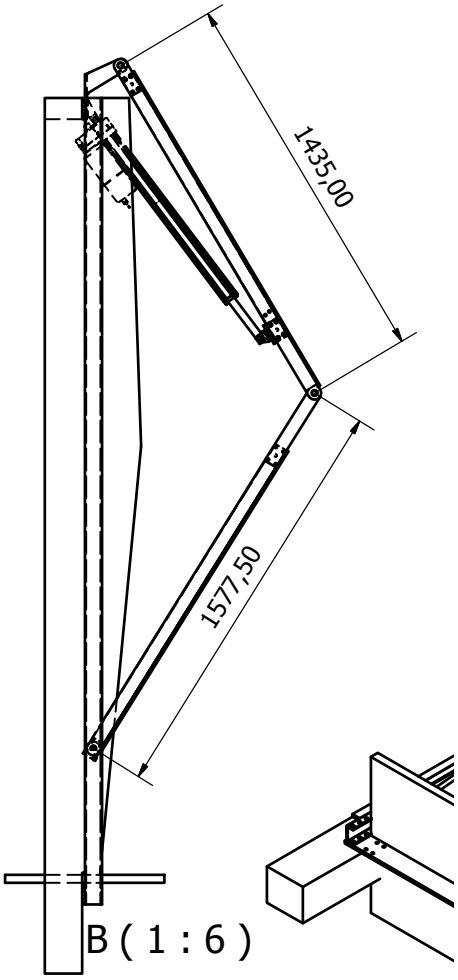
1.1.1 Façade



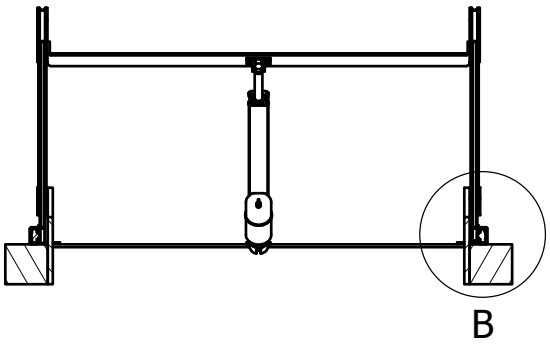
PARTS LIST			
ITEM	QTY	PART NUMBER	MATERIAL
1	2	WINKEL-PA5250AP-U_BAR	Mild Steel
2	2	CONNECTOR-PLATE	Mild Steel
3	2	WOOD_BEAM_160X100	Default
4	1	FLOOR-BOARD	Default
5	1	HINGE-MAIN-TYPE2	Mild Steel
6	2	ALU-DIN-6060-RECT-TUBE-50X30X2	Alu-6060
7	4	HINGE-CONNECT-PLATE-MIDDLE1	Mild Steel
8	4	HINGE-CONNECT-PLATE-TOP	Mild Steel
9	2	ALU-DIN-6060-RECT-TUBE-50X20X2	Alu-6060
10	2	WINKEL-FLANGEPLATE-PA5250AP	Default
11	2	WINKEL-WHEEL-PA5250AP	Poliamyde
12	4	HINGE-CONNECT-PLATE-MIDDLE2	Mild Steel
13	1	HINGE-MAIN-TYPE2-MIRROR-NEW	Mild Steel
14	1	MID-PLATE-SUPPORT	Mild Steel
15	1	CLEVIS-MOUNT-1	Mild Steel
16	2	RUBBER-FLAT-SHEET-1	Synthetic rubber
17	1	TOP-PLYWOOD-FRAME-1	Wood
18	2	RUBBER-FLAT-SHEET-2	Synthetic rubber
19	1	TOP-PLYWOOD-FRAME-2	Wood
20	1	CLEVIS-MOUNT-2	Mild Steel
22	1	ELECTRAK-LA24-TUBE-AA22-21B65M-	Default
23	1	ELECTRAK-LA24-MOTOR-AA22-21B65M	Default
24	1	ELECTRAK-LA24-REAR-AA22-21B65M-	Default
25	1	ELECTRAK-LA24-PLATE-AA22-21B65M	Default
26	1	SCREW-MFX-H-M5_SCREW-MFX-H-M5X2	Default
27	1	ELECTRAK-LA24-ROD-AA22-21B65M-6	Default

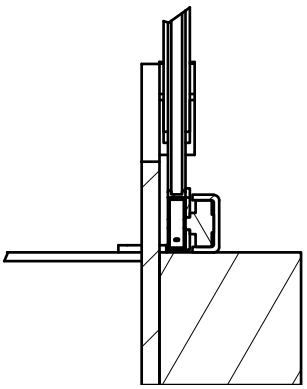


A-A (1:20)



B (1 : 6)





Dead loads:

So far the RStab model has been designed as a steel frame construction. Therefore the own weight of the system is assumed to be higher than the actual weight. On top of each frame construction is a covering. On the upper frame is an aluminum plate on which the thin film solar cells will be placed and on the lower part a ply wood plate will be installed.

DIMENSIONS OF ONE PANEL			
upper part		lower part	
length [m]	1,65	length [m]	1,6
width [m]	1,75	width [m]	1,75
area [qm]	2,8875	area [qm]	2,8
height of building [m]	3,5		

LOADS	force of gravit 10	positive direction of forces is direction of gravity	
own weight of panels			
solar cells[kg/qm]*	17,31		
wooden panel, t=24mm [kg/qm]	12	wooden panel, t=24mm [kg/qm]	12
connections, 10% of weight	2,931	connections, 10% percent of w	1,2
assumed weight of upper part: solar cells and construction [kg/qm]*	32,241	weight of lower part: wooden panel, construction [kg/qm]*	13,2
upper part weight [kg]	93,10	lower part weight [kg]	36,96
load [kN]	0,93	load [kN]	0,37
distributed area load [kN/qm]	0,32241	distributed area load [kN/qm]	0,132
load with [m]	0,875	load with [m]	0,875
load due to pannel on weight [kN/m]	0,28	load due to pannel on weight [kN/m]	0,12

own weight of the frame construction
will be taken into consideration by the program according to the chosen cross sections

Live loads:

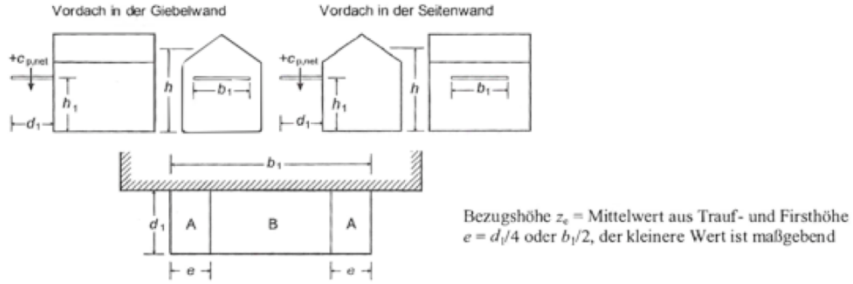
DIMENSIONS OF ONE PANEL					
upper part			**lower part**		
length [m]	1,65		length [m]	1,50	
width [m]	1,75		width [m]	1,75	
area [qm]	2,89		area [qm]	2,63	
height of building [m]	3,50				
wind					
according to EC 3					
Berlin, wind zone 2 inland, on top of the roof (ca. 20 m) – we are aware that structural calculations have to made for the actual construction in Versailles. However we think it preferable to prove our concept is feasible and thus assume the worse conditions of Berlin.					
peak velocity pressure q(p) [kN/qm]	0,9				
As the panels are not be open constantly, we assume their's is a "transitional state". Thus, according to DIN EN 1991-1-4/NA, NA-BB, the peak velocity pressure can be reduced by a factor of 0.5 as the state will not last more than 3 days (they will be closed in case of extraordinary storms) and as we have no additional security.					
factor of reduction	0,5				

reduced peak velocity pressure q(p) [kN/qm]	0,45				
There is one normative state for the wind calculation: the panel is 90° open and the doors are closed – a projecting roof / canopy / Vordach. The case that the panel is 90° open and the doors are open – free-standing roof / freistehendes Dach – doesn't apply as windows and doors don't count as open parts of a wall unless they have to be opened in storm situations, which ours don't have to be.					
projecting roof / canopy / Vordach					
according to Schneider Bautabellen (20. Auflage) page 3.33, DIN EN 1991-1-4 does not yet include precise guidelines for projecting roofs, we use the proposed guideline DIBt-Projekt ZP 52-5-3.94-1141/05 developed by Niemann & Partner GbR in 2006					

Dead loads:

Tafel 3.34 Aerodynamische Beiwerte $c_{p,net}$ für den resultierenden Druck an Vordächern

Höhenverhältnis h_1/h	Bereich A			Bereich B		
	Abwärtslast	Aufwärtslast $h_1/d_1 \le 1{,}0$	Aufwärtslast $h_1/d_1 \ge 3{,}5$	Abwärtslast	Aufwärtslast $h_1/d_1 \le 1{,}0$	Aufwärtslast $h_1/d_1 \ge 3{,}5$
≤ 0,1	1,1	-0,9	-1,4	0,9	-0,2	-0,5
0,2	0,8	-0,9	-1,4	0,5	-0,2	-0,5
0,3	0,7	-0,9	-1,4	0,4	-0,2	-0,5
0,4	0,7	-1,0	-1,5	0,3	-0,2	-0,5
0,5	0,7	-1,0	-1,5	0,3	-0,2	-0,5
0,6	0,7	-1,1	-1,6	0,3	-0,4	-0,7
0,7	0,7	-1,2	-1,7	0,3	-0,7	-1,0
0,8	0,7	-1,4	-1,9	0,3	-1,0	-1,3
0,9	0,7	-1,7	-2,2	0,3	-1,3	-1,6
1,0	0,7	-2,0	-2,5	0,3	-1,6	-1,9
Für Zwischenwerte $1{,}0 < h_1/d_1 < 3{,}5$ ist linear zu interpolieren; Zwischenwerte h_1/h dürfen linear interpoliert werden.						



Bezugshöhe z_e = Mittelwert aus Trauf- und Firsthöhe
$e = d_1/4$ oder $b_1/2$, der kleinere Wert ist maßgebend

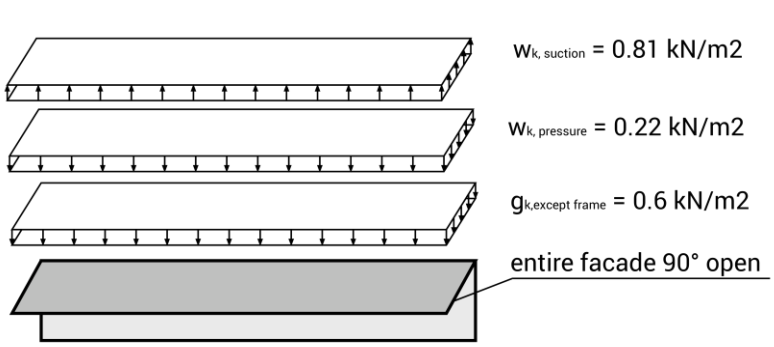
Abb. 3.34a Abmessungen und Einteilung der Flächen für Vordächer

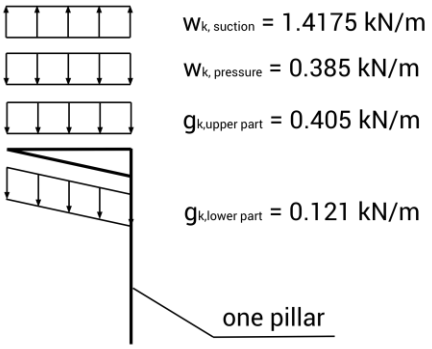
source: Alfons Goris (ed.): Schneider Bautabellen, 20. Auflage, Werner Verlag, Köln, 2012 (page 3.34)

h1/d1[]	1.000	panel as long as h1, in closed state down to floor
h1/h []	1.000	panel in 90° on horizontal line with roof
e	0.413	smaller ratio: length/4 or breadth/2
area A	1.361	
area B	1.526	
total area check	2.888	OK
A: aerodynamic factor c(p,net) downwards	0.700	see table on right side
A: aerodynamic factor c(p,net) upwards	-2.000	
B: aerodynamic factor c(p,net) downwards	0.300	
B: aerodynamic factor c(p,net) upwards	-1.600	
wind loads w(e)=q(p) * c(p,net)		
A: pressure [kN/qm]	0.315	
A: suction [kN/qm]	-0.900	
B: pressure [kN/qm]	0.135	
B: suction [kN/qm]	-0.720	
total area: pressure [kN/qm]	0.220	
total area: suction [kN/qm]	-0.805	

This is the normative case for the dynamic mechanism and the pillar deformations. As the panels will be closed when it snows, we need not consider the snow load. For all loads: see calculation sheet above.

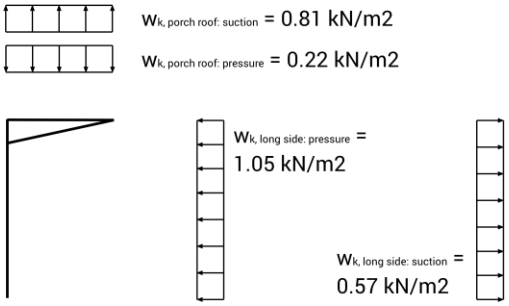
Facade is open 90°:



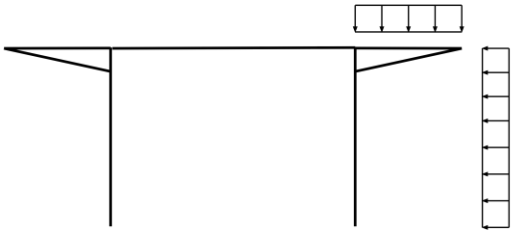


1.1.2 Possible combination of both wind loadings: wind on long walls and wind on porch roof

wind load case 1a) is decisive.

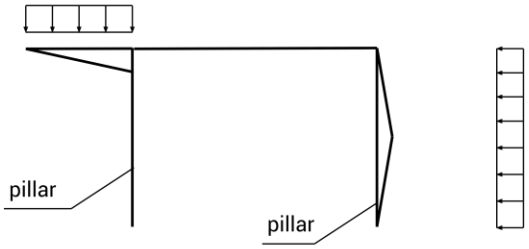


combination 2:

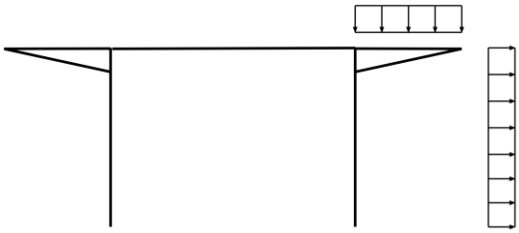


wind pressure on long side + pressure on same porch roof: not possible

combination 1a:

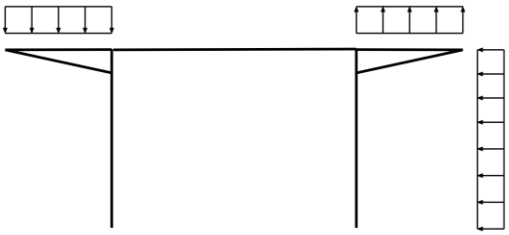


combination 3:



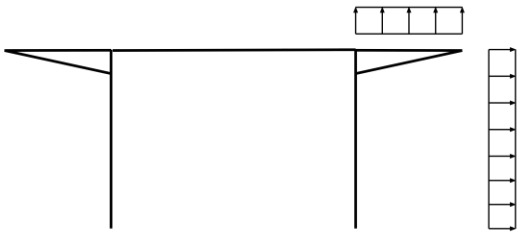
wind suction on long side + pressure on same porch roof

combination 1b:



wind pressure on long side + suction on porch roof on same side + pressure on other porch roof: since the own weight of the facade is higher than wind suction, case 1a is decisive for modeling.

combination 4:

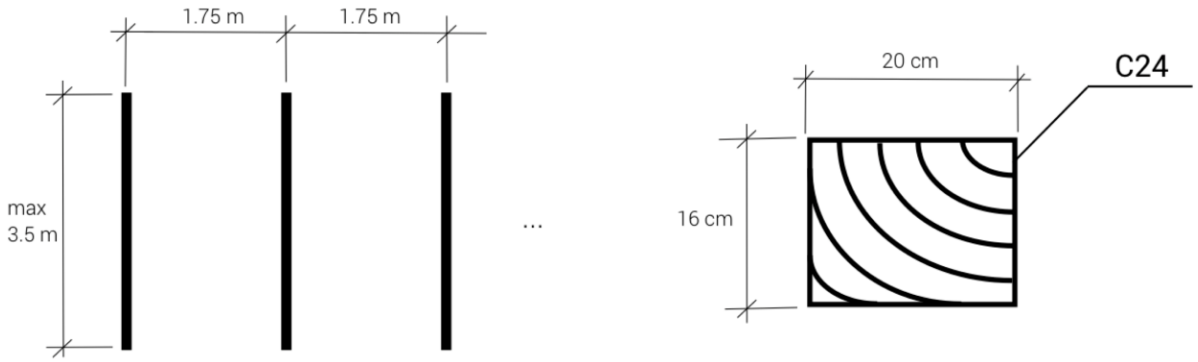


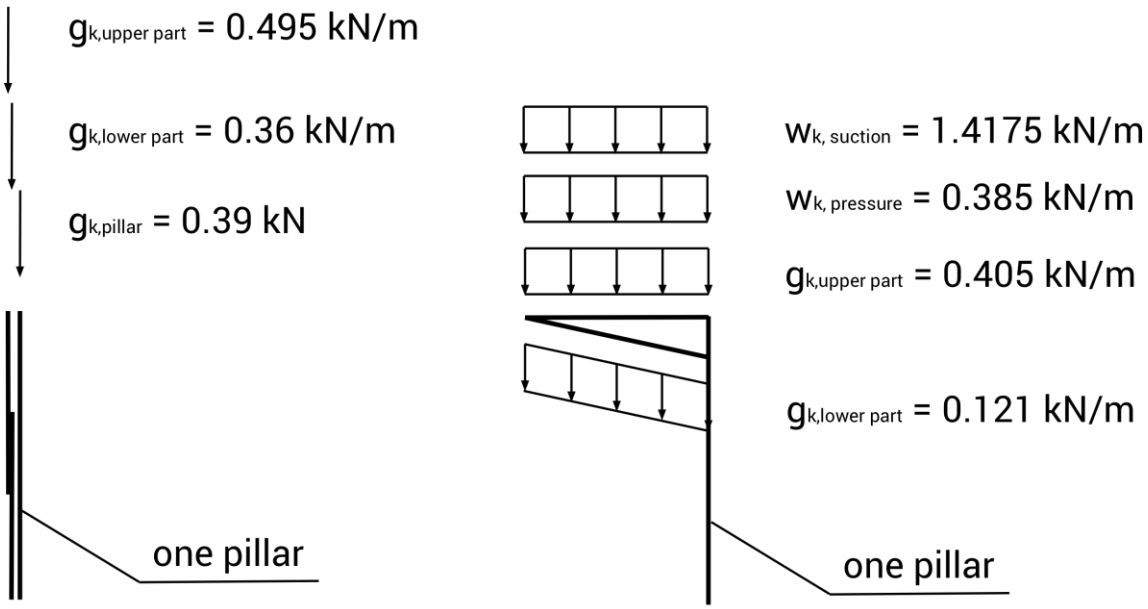
wind suction on long side + suction on same porch roof

1.1.3 Pillars

Dead load of a pillar:

material	width [m]	depth [m]	height [m]	area [m²]	specific weight [kN/m³]	load [kN]
construction wood C24 16x20cm	0.20	0.16	3.50	0.03	3.50	0.39
Σ						**0.39**





1.2 Façade and pillars - dimensioning

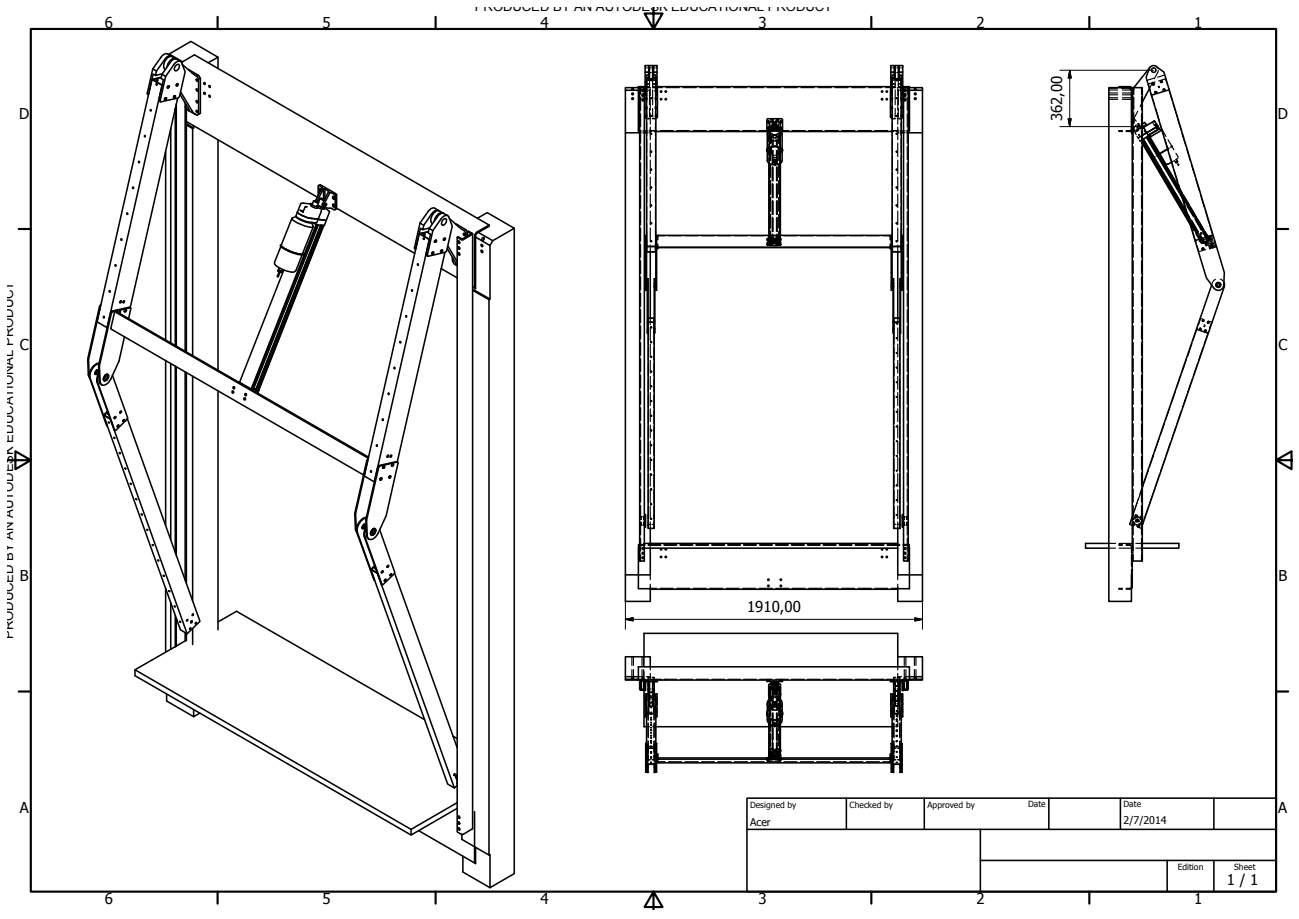
1) Dimensioning of one opening panel, according to the figure below.

One façade module consists of a top and a bottom part. Each part is a rectangular framework construction of four beams and on top of the framework. On top of the upper framework is an wooden plate and solar cells and on the lower one a wooden panel. The upper part of one façade modules is pin hinged connected to the top of each column and the bottom one is connected to the upper part and a shaft in the pillar. The opening mechanism is an actuator that increases in length to make the façade move.

The opening and closing mechanism will be very slow, no additional dynamical influences will be taken into account. In every position the drive shaft holds the façade in its position, therefore the connection to the upper frame will be fixed bearing.

Different wind load simulations are applied on diverse opening positions of the façade to design the panels, the connections and the mechanics. The most critical support loads of the façade will be considered to design the pillar and are also taken into account for the horizontal load transmission of the roof and the bracing walls W1 and W2.

Only small deflection will be tolerated by the mechanism, what needs to be considered for the design of the framework.



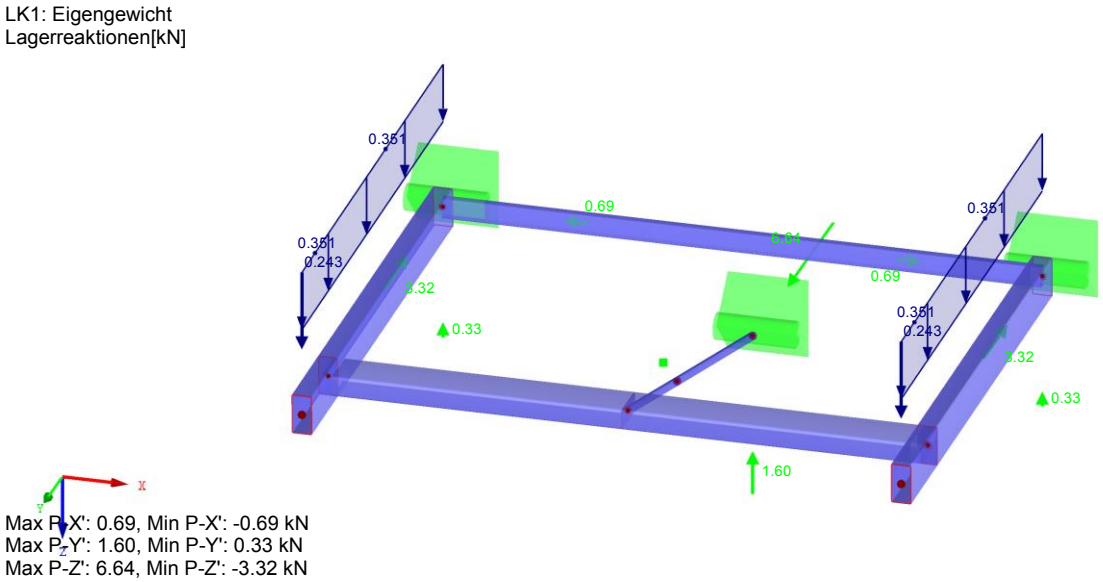
Three opening positions of the façade are considered to survey the effect of the façade strained by wind loads on the whole structure.

1) 90° opened façade → considered as a porch roof (Vordach) – see Appendix A-modulation 1
2) closed façade respectively almost closed/about to open façade → normal wind loads will be applied – see Appendix A modulation 2
3) middle position of the façade → considered as a porch roof, smaller area than 90° opened facade

The program RStab has been used to modulate the façade and identify reaction forces and stress resultants. On the following page there is an abstract of the results:

The most critical load case for the façade is the opened position, when the façade is exposed to self weight and wind pressure on the porch roof.

Load case self weight:



self-weight:

a) frame construction taken into account by program acc. to chosen cross sections

b) $g_{d,\text{ upper plate}}$ =(solar cells + wooden plate)*1.35*0.875m
=(0.17+12.5)kN/m^2*1.35*0.875m=0.361 kN/m
; 1.35 security factor self weight, 0.875m = load with

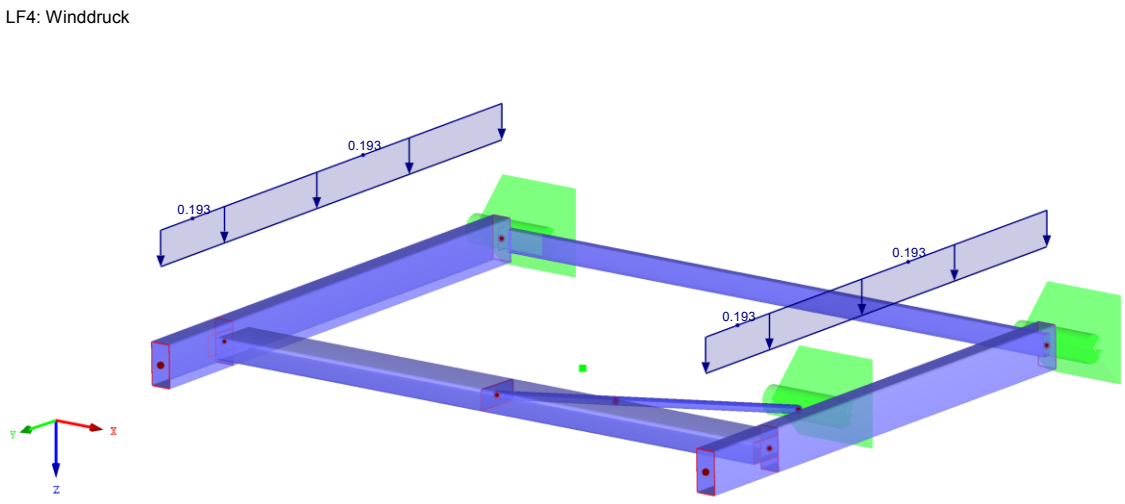
c) $G_{d,\text{ upper plate}}$= 0.12kN/m * 1.57m(length)*1.35=0.25 kN
Point load acting on the very edge of upper frame

Wind forces:

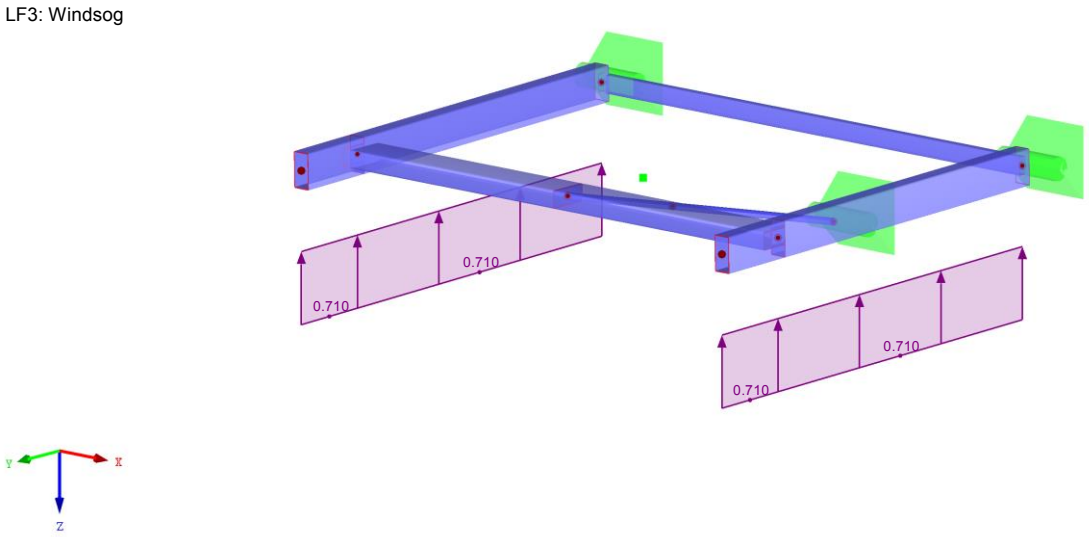
Wind forces are completely applied to the upper panel.

1) Wind pressure: $W_{k,\text{ pressure}}$= 0.22 kN/m^2
2) Wind suction: $W_{k,\text{ Suction}}$= -0.81 kN/m^2

1) Wind pressure, characteristically load:



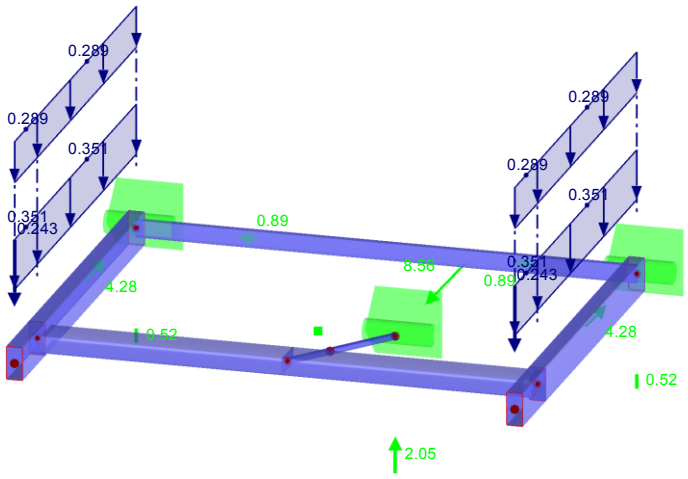
2) wind suction, characteristically load:



RESULTS:

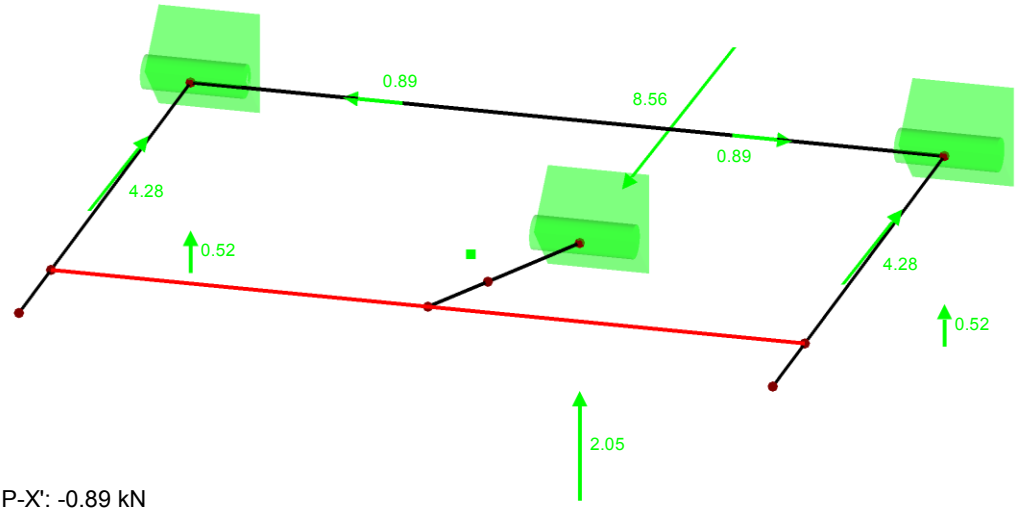
Most critical load case: selfweight + wind pressure

LK2: (GzT)d - Winddruck
Lagerreaktionen[kN]



Max P-X': 0.89, Min P-X': -0.89 kN
Max P-Y': 2.05, Min P-Y': 0.52 kN
Max P-Z': 8.56, Min P-Z': -4.28 kN

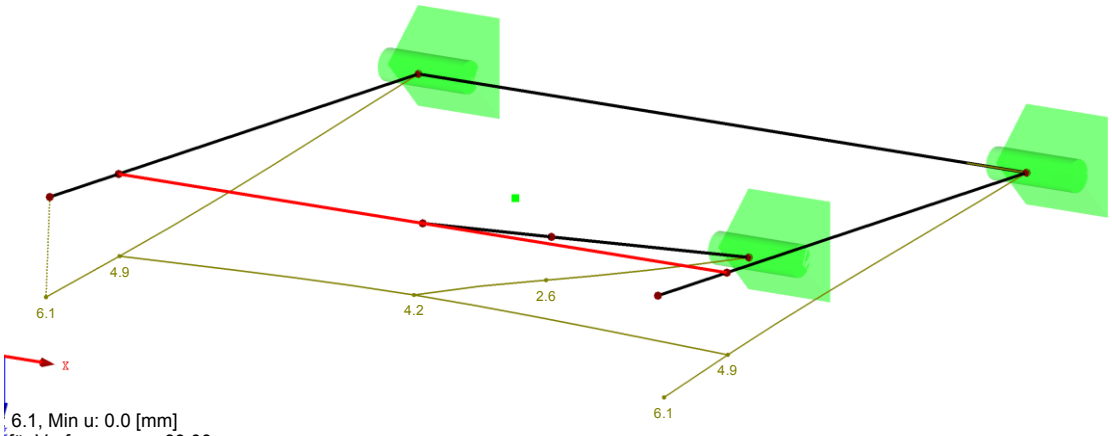
ıddruck
:N]



in P-X': -0.89 kN
in P-Y': 0.52 kN
in P-Z': -4.28 kN

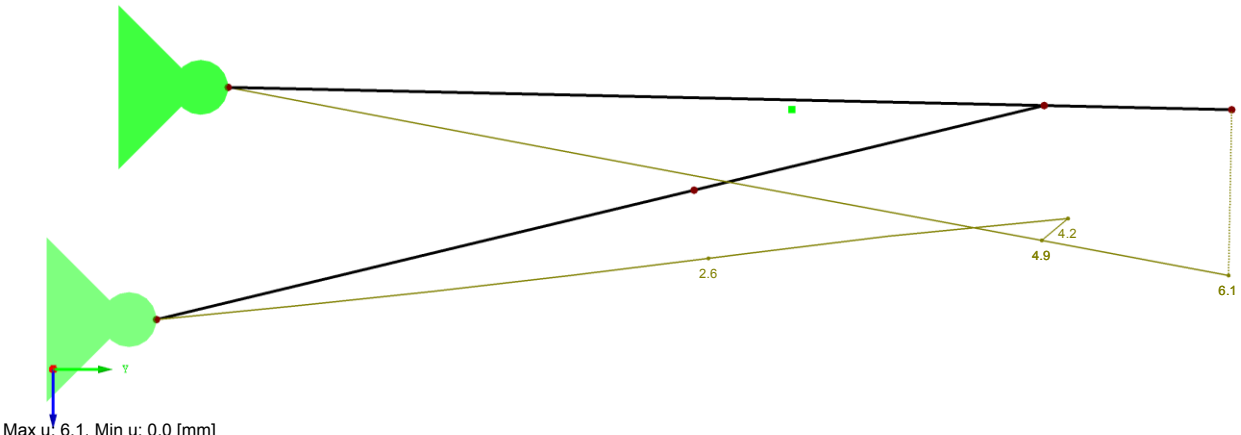
Deflections due to most critical wind load case:

ɜzT)d - Winddruck



6.1, Min u: 0.0 [mm]
für Verformungen: 39.00

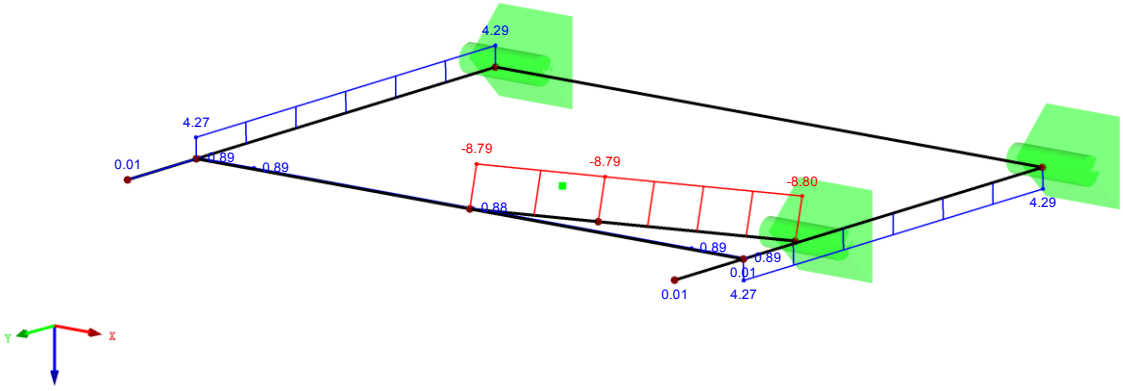
LK2: (GzT)d - Winddruck
u



Max u: 6.1, Min u: 0.0 [mm]
Faktor für Verformungen: 39.00

- Stress resultants due to most critical load case:
- normal forces:

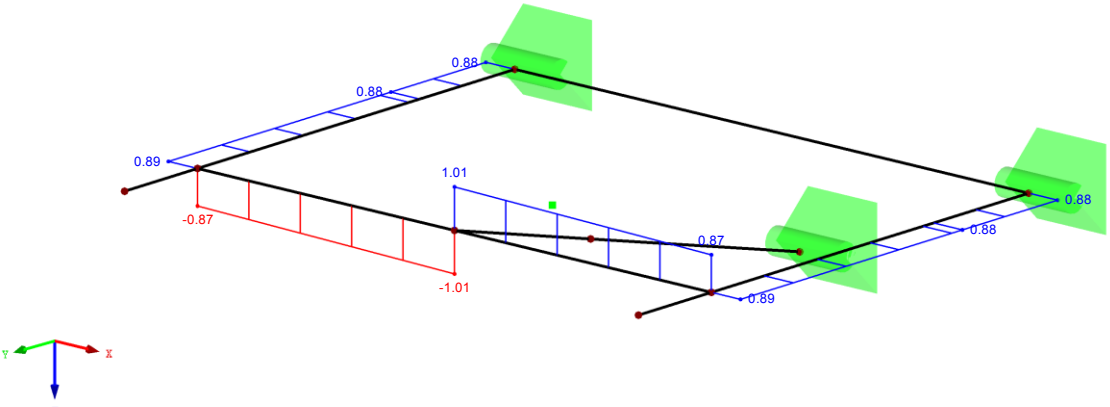
LK2: (GzT)d - Winddruck
N



Max N: 4.29, Min N: -8.80 [kN]

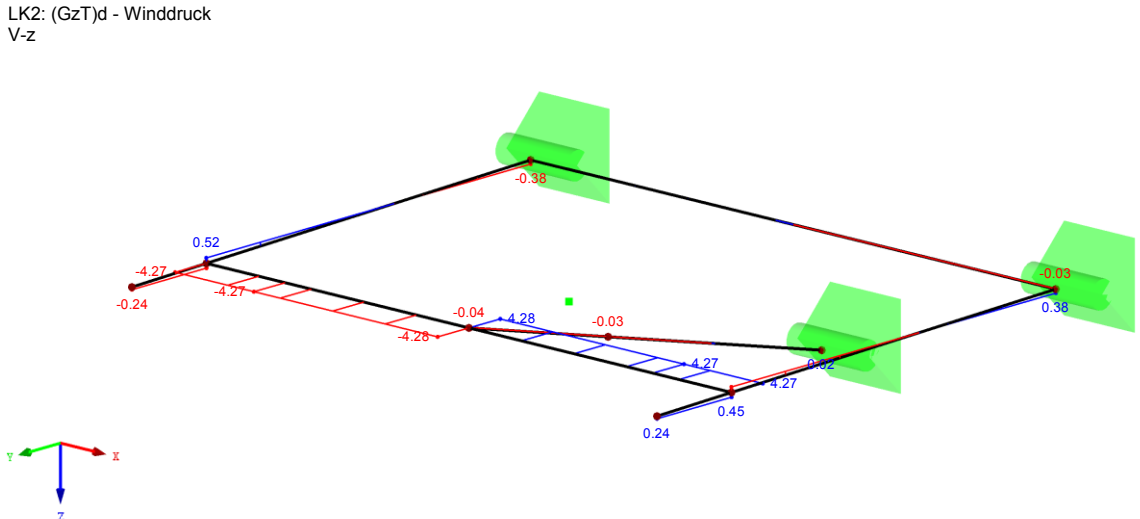
- local V_y:

LK2: (GzT)d - Winddruck
V-y



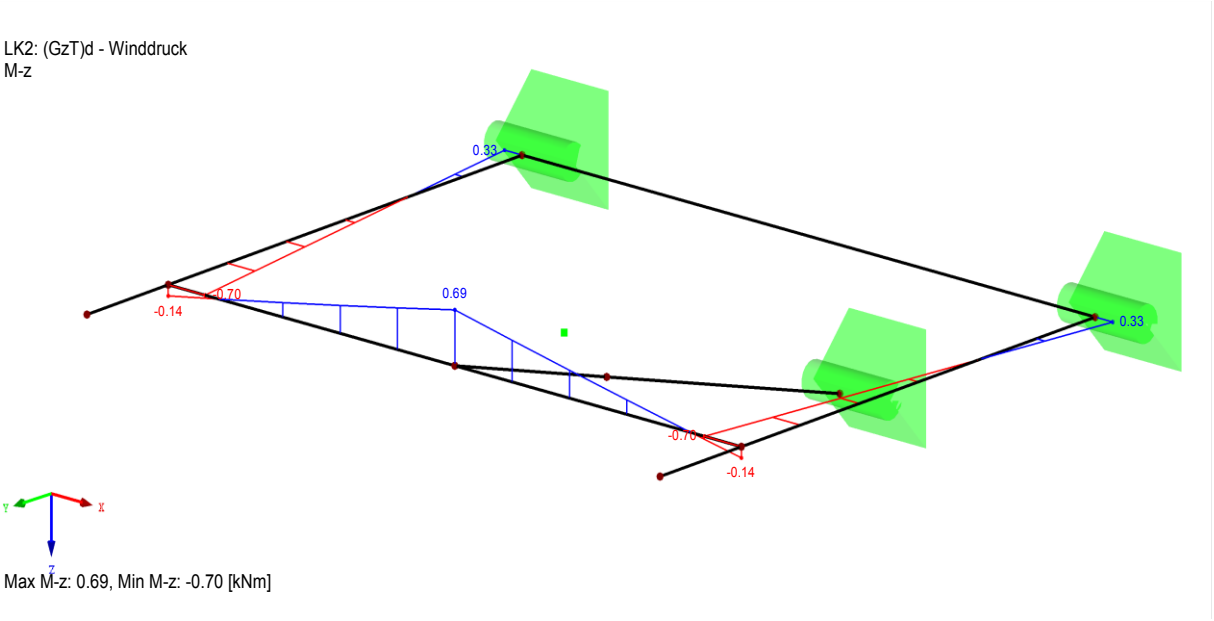
Max V-y: 1.01, Min V-y: -1.01 [kN]

- local V_z:



Max V-z: 4.28, Min V-z: -4.28 [kN]

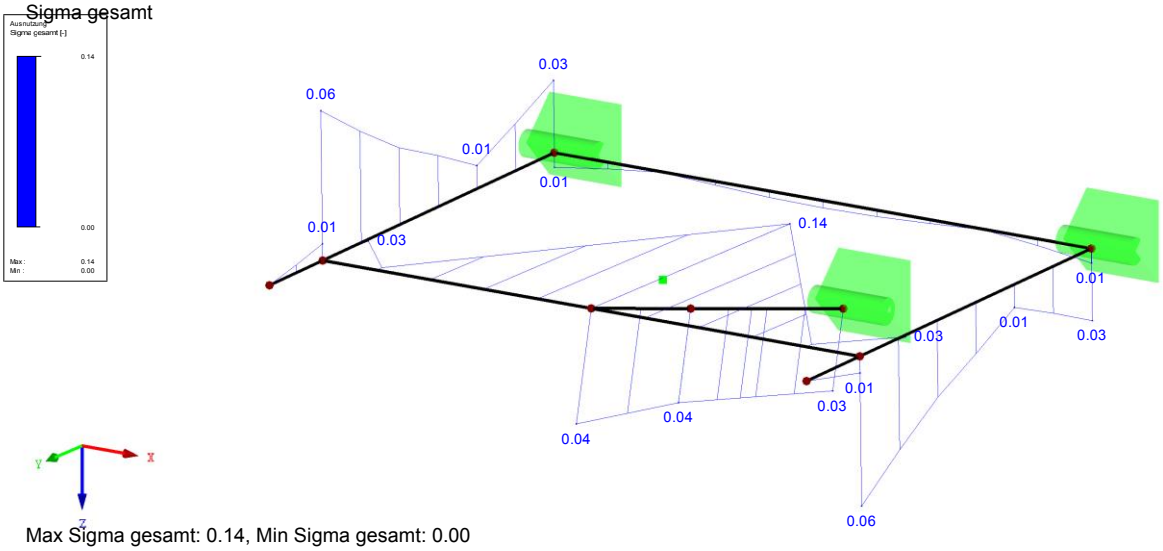
- local M_y



Max M-z: 0.69, Min M-z: -0.70 [kNm]

- Degree of capacity utilisation of each member in percent's:

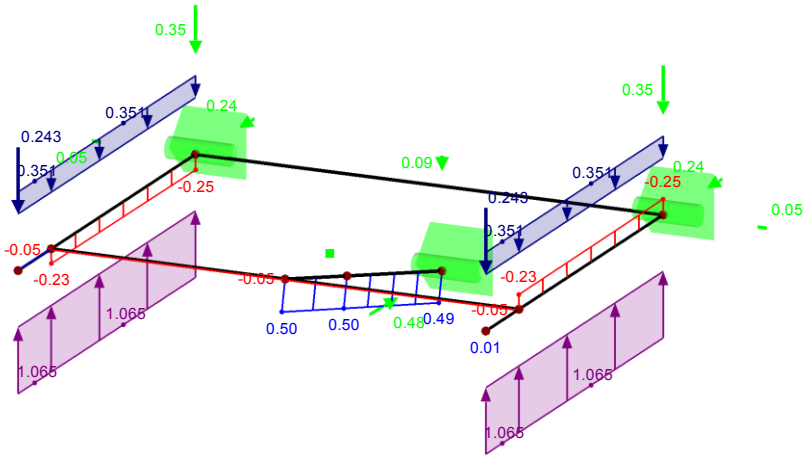
STAHL FA1
Sigma gesamt



Max Sigma gesamt: 0.14, Min Sigma gesamt: 0.00

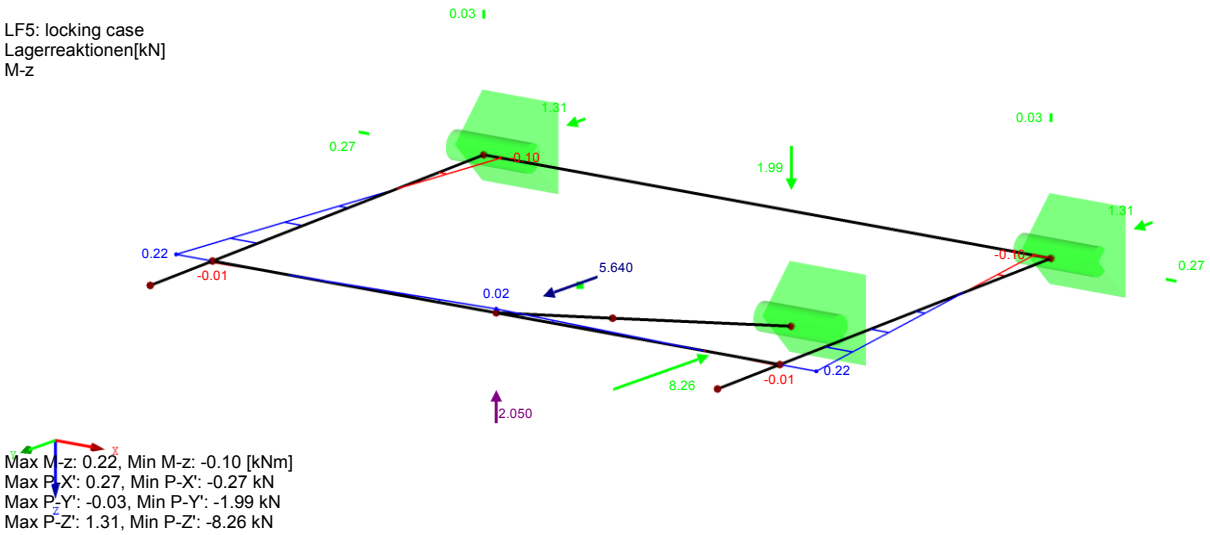
Wind suction:

LK3: (GzT)d - Windsog
Lagerreaktionen[kN]
N



Max N: 0.50, Min N: -0.25 [kN]
Max P-X': 0.05, Min P-X': -0.05 kN
Max P-Y': -0.09, Min P-Y': -0.35 kN
Max P-Z': 0.24, Min P-Z': -0.48 kN

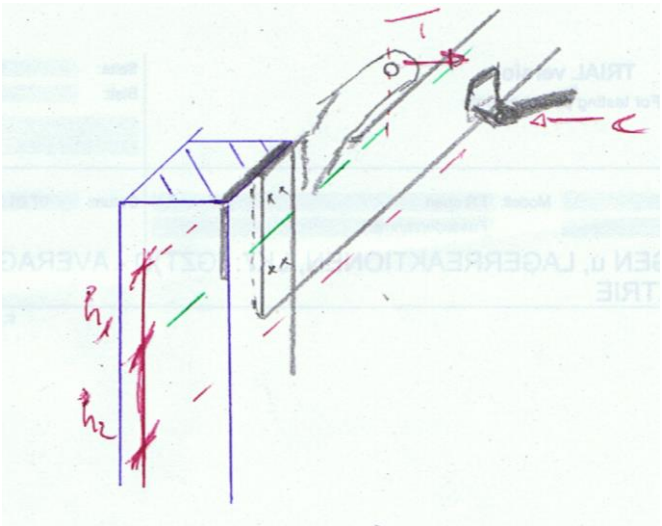
Locking case: 6kN “dynamic” force of actuator acts on system



The force that needs to be applied to the pillar is the resulting moment of the eccentricity of the tension force on the upper hinge and the compression force on the steel plate between the columns.

$$M_{connecting\ plate\ \ on\ pillar} = \underbrace{4.28kN * 0.162m}_{tension\ force\ on\ upper\ hinge} + \underbrace{\frac{8.56}{2}kN * 0.146m}_{compression\ force\ on\ actuator} = 1.32kNm$$

$$M_{\ on\ pillar} = 2 * 1.32kNm = 2.64kNm$$



So now a moment is introduced at the head of the pillar. The pillar needs to withstand this moment force.
Similar to a bowstring bridge horizontal compression and tension forces will be shorted in the frame construction and connections of the façade itself.

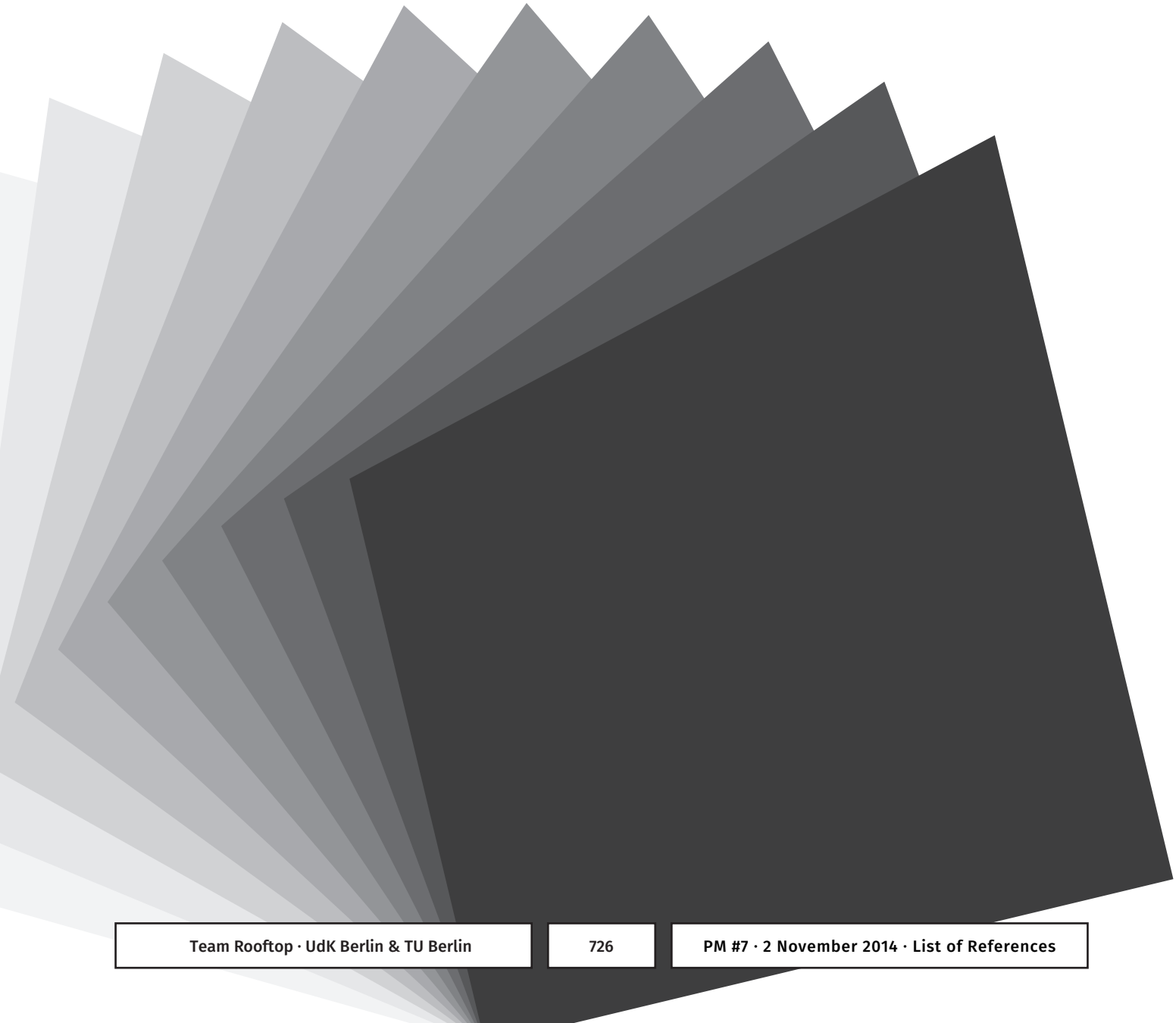
To hold the pillar in position the roof/bracing needs to support the column. This additional supporting force will be introduced in the pillar as a shear force, so that the moment force in the pillar 0 at its bottom. In the meantime that additional force needs to be considered for bracing.

$$V_{in\ \ Pillar,resp.supportingforce\ roof} = \frac{2.64kNm}{3m} = 0.88kN$$

APPENDICES

Some things just deserve their own, private space. This is where the design mavericks go, where extensive calculations hint at the exhaustive engineering process, and most importantly of all: the sources that lend credibility to the above.

A. LIST OF REFERENCES



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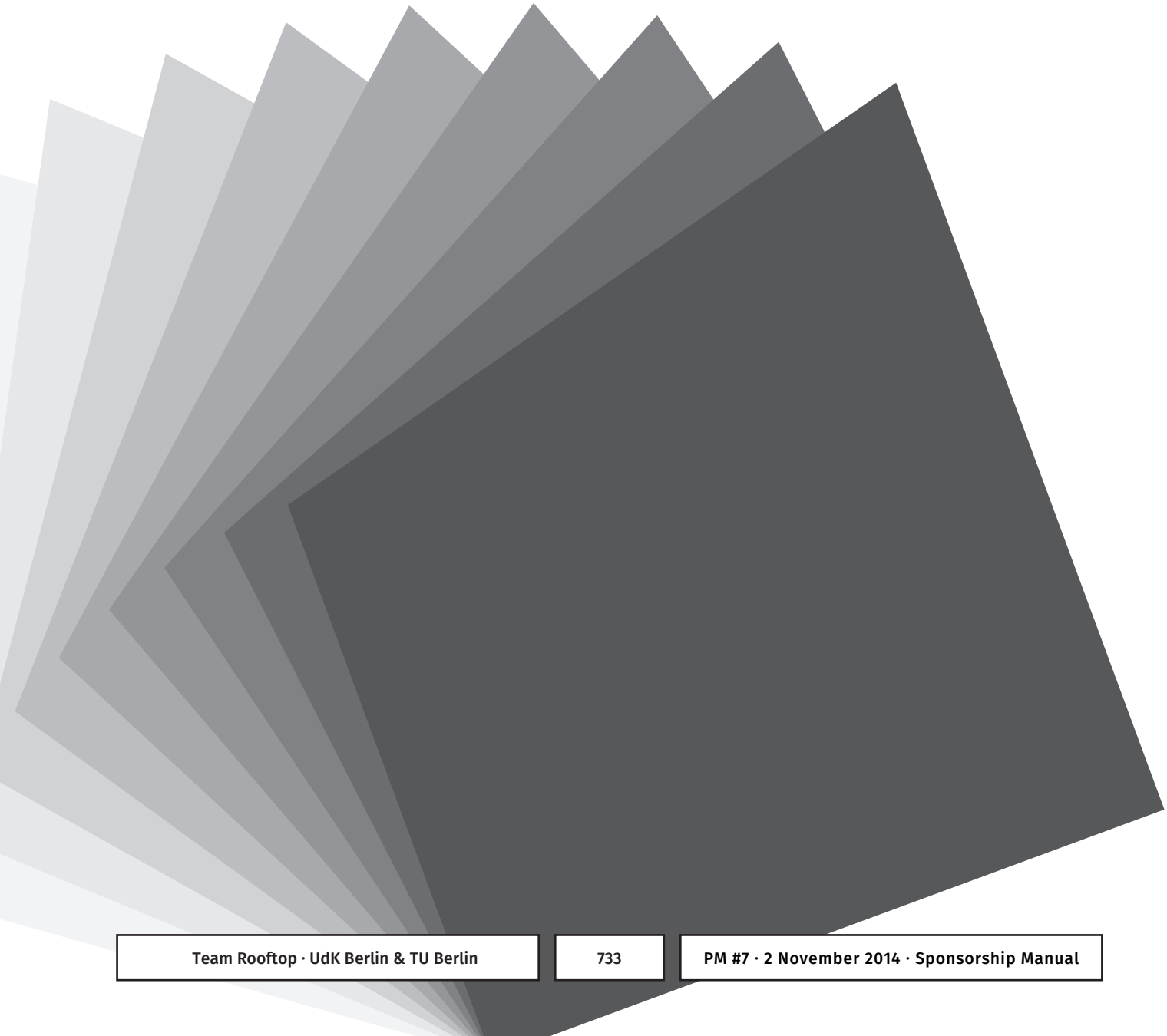
DIN EN 806- 1

DIN EN 806- 2

DIN EN 806- 3

DIN 12056-2

B. LIST OF APPLICATIONS USED



ArchiCAD 17

Word

Excel

Photoshop

InDesign

Mathmagic for Indesign

Final Cut

Dialux

Nova

Plancal

open office

inkscape

after effects

blender

SUPER by eRightSoft

Mol3D

pdf creator

tsol

polysun

GAMS

Rhino 5 beta for mac

Dlubal RStab

Nemetschek Allplan

iDraw

AutoCAD

Lexware

Solid Edge ST5/ST3

Gimp 2

U-Wert.net Online Calculation

IDA ICE

Illustrator

C. TEAM UNIFORMS

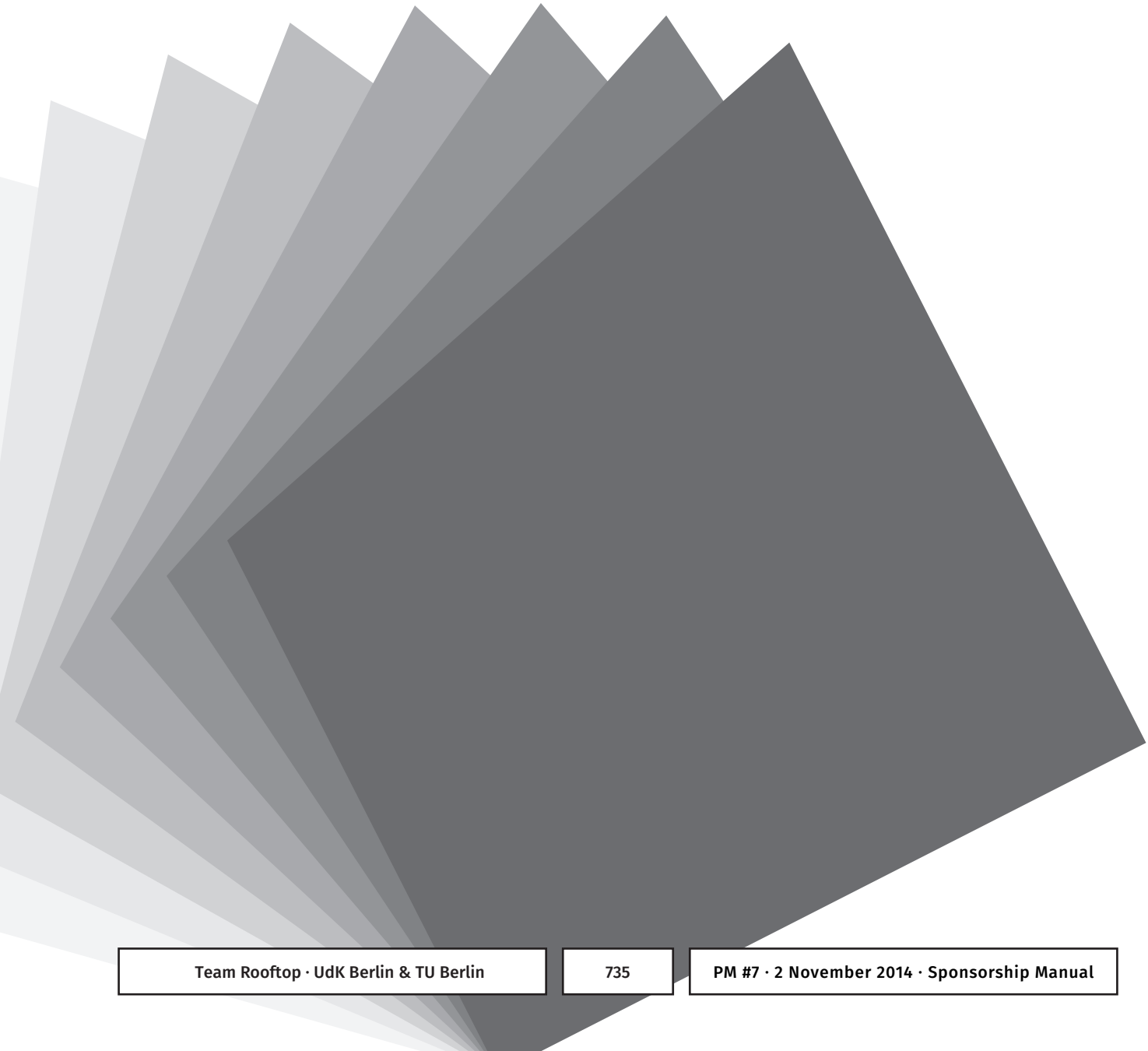
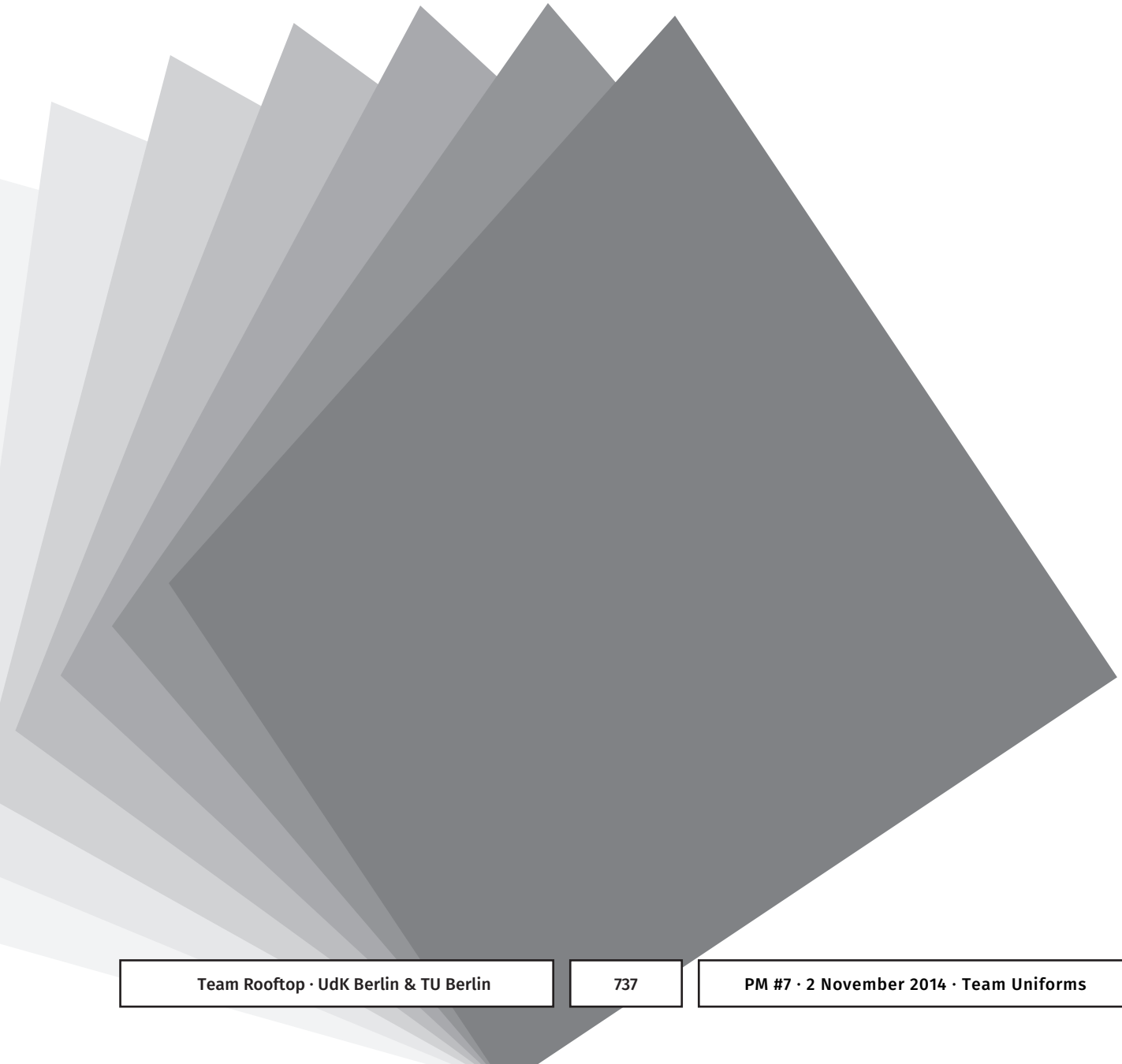




Figure 278: **Uniform Team Rooftop 1**

D. SPONSORSHIP MANUAL



ROOFTOP

SPONSORSHIP MANUAL



Federal Ministry
for Economic Affairs
and Energy

CONTENTS

1. Solar Decathlon Europe 2014
2. Influence
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1. SOLAR DECATHLON

The Solar Decathlon is a student-run building competition, initiated by the U.S. Department of Energy in 2002. Universities from all over the world are invited to participate and offered the unique possibility to realise their vision of an innovative solar housing prototype.

»The goal is to improve the international transfer of knowledge and experiences as well as to actively participate in research and development of renewable energies«



The competition takes place on National Mall in Washington D.C. every second year. Since 2010 there is a biannual European counterpart „Solar Decathlon Europe“.

Every new competition offers the possibility to redefine the rules of the project. Whereas the U.S. competition of 2013 put a focus on green energy production the European competition emphasises sobriety and efficiency.

After an open selection round 20 projects have been selected in December 2012. In the following 18 months teams from 16 different countries have time to design and build their prototype. The houses will be built within ten days in June 2014, ready for the public by 28th June, and disassembled starting 14th July.

2. INFLUENCE

Since the start in 2002 112 student teams have participated in the competition. The creation of the houses has always been shaped by a close cooperation with the industry — the materials don‘t magically appear on our four walls. The houses don‘t simply provide space for our vision but also an excellent opportunity for firms to present their products in a very direct and special way.

Thus this is the chance to distance yourself from the classical paths of marketing. Let your product work its charm in a hands-on composition with an idea and a clear vision.

Young people build the houses of the future — and a young, future-minded public cherishes them. More than 300‘000 people are expected for this year‘s public fair next to the Versailles Chateau.



3. TEAM ROOFTOP

Our team members come from two universities in the center of Berlin — the Technische Universität Berlin and Universität der Künste Berlin, both situated on the Campus Charlottenburg next to the old Western center of Berlin. We bring our knowledge from a great number of disciplines: architects, structural engineers, interior designers, energy engineers, building services engineers, industrial engineers and communication students. Our focus lies on interdisciplinary learning and innovative research. We believe that the contrasts will make provide fertile ground to nurture the ideas of the future.

We decided to adapt the Solar Decathlon‘s ideas to Berlin‘s dense urban context. Our concept focuses on the adaption, the responsibility and the interdependence between house and inhabitants. Our proposed solution is a realistic contemporary option for urban city-dwellers — perfectly tailored to Berlin‘s turn-of-the-century buildings (‚Altbau‘) but adaptable to roof situations all over Europe. We not only want to win the Solar Decathlon but develop a product that can and will be implemented and built in Berlin. Berlin‘s Altbau-building came close to serial production — we want to achieve the same for its rooftops.

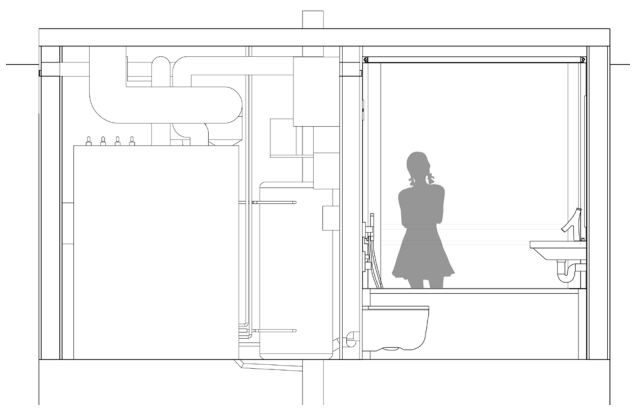
Team Rooftop is the biggest student-run project ever of the Campus Charlottenburg universities. This indicates the immense trust the universities put into every team member — and our responsibility to do the best we can.

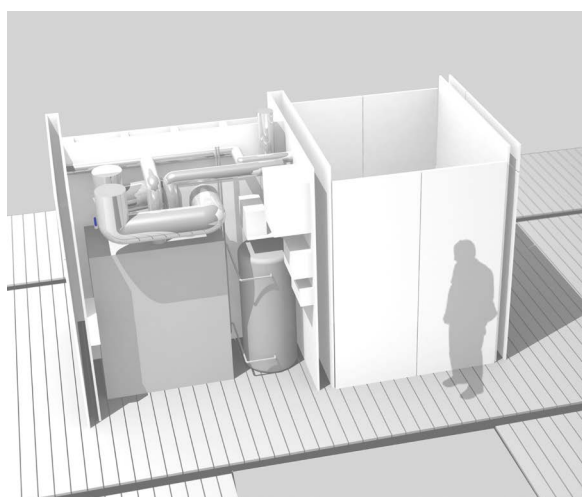


The universities support us mainly through providing rooms, a hall to build, press contacts and their professional knowledge. The different professors repeatedly give us the chance to extensively present the project, to address any challenges that arise and to solve them together.

4. CONCEPT

Two developments have shaped our conceptual process: the increasing gentrification in Berlin and the constant warming of our earth. After an analysis of the local housing market it was simply a logical conclusion to go on top of the roofs. We don‘t want to spoil the abundant green areas or close the remaining war‘s wounds. Removing the old roof truss and docking the rooftop house next to the existing masonry staircase transforms the unused living space into an energy-efficient living unit — densifying instead of replacing.
The surplus energy is fed back into the grid, whilst energy production stands to profit immensely from the high position of the solar panels in the roofscape. It doesn‘t just look good: this perfect symbiosis between state-of-the-art technical appliances and sensible architecture makes for a useful and essential new living space in the heart of Berlin.
We want to present two features of our house that condense what defines our proposal:



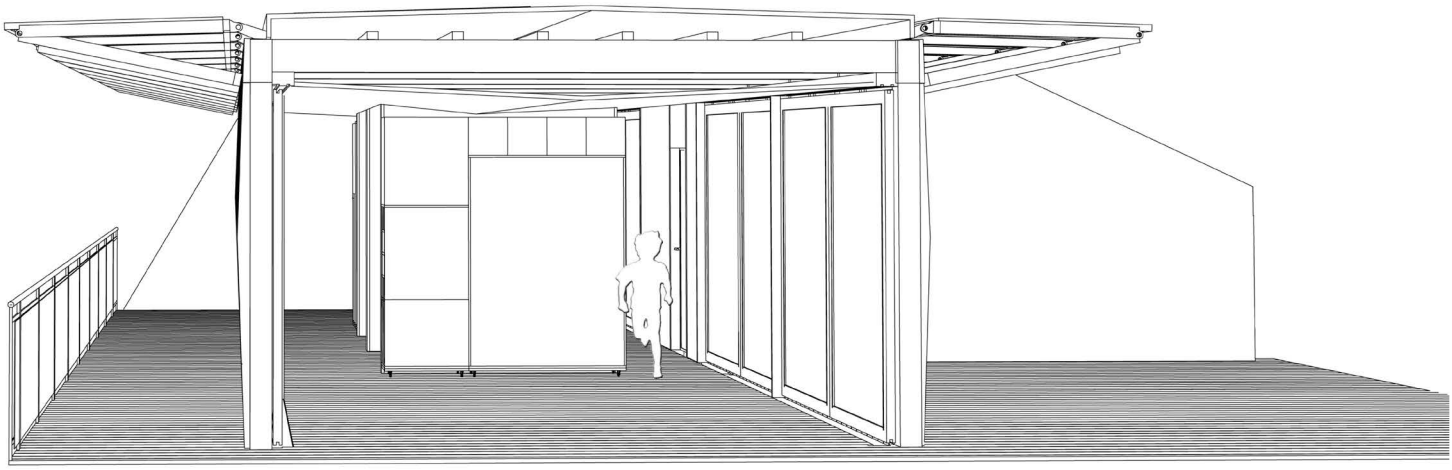


1. CORE MODULE:

The Core Module is the heart of our building. Standing in its center it defines individual adaption of the living space by opening and closing different parts of it.

Kitchen, bathroom and technical appliances room are all integrated in it. The space around it flows freely, allowing thoughts to fly through the windows, out into the city.

It also minimizes construction time as it comes pre-fabricated and is put in place as a single piece. The rest of the house is built around it. The modular construction method allows us to build the structure of the house within a day.



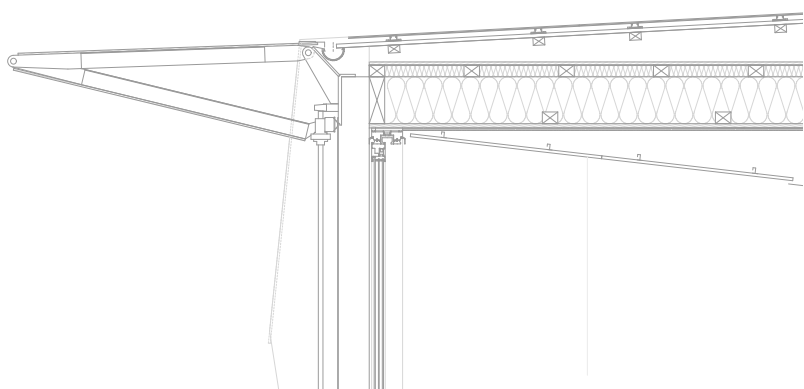
2. THE FOLDABLE FAÇADE:

Our foldable façade is our answer to the temperature shifts in northern Europe.

Opening up in summer it shades the area below, lets fresh air flow through the building, collects additional sun rays and energy by means of its photovoltaic panels on its upper side. It closes at night and provides an additional insulation against the fresh breeze of summer nights in Berlin. In the morning it wakes you up in the sleeping room, then one by one, it lets light flow into the house while you pass your daily routine: bathroom, kitchen, working.

In the cold Berlin winter it can remain closed to provide an additional skin to the house and act as an insulation — much as one puts on more clothes when December comes near. Of course this brings down heating costs and allows us to provide all house functions with the decreased sun energy. To provide light during the short day, some panels remain open.

This sensible and clear adaption of the rooftop house to its surroundings reinforces the ecological and energetical consciousness and makes for a unique living experience.



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5. HOW TO HELP US



Team Rooftop is the ideal opportunity to present your company in Germany and on an international platform. The possibilities to help us are manifold. We are always happy to adapt to your wishes and ideas.

Support us with:

- Materials for building in interior
- Assistances-in-kind
- Mechanical concepts and parts
- Media contacts
- Mobility
- Urban strategies

6. WHAT WE OFFER YOU

In general

- position yourself as a young, sustainable and future-minded enterprise
- use ROOFTOP as a reference project
- receive regular updates on the project's progress
- work together with a motivated crowd of students
- get insights into our monitoring data for your research

Before the competition

- be referenced by name and logo on our website under the section "supporters"
- be mentioned on every piece of official communication — audiovisuals, posters etc.
- come to one of our parties
- actively participate in the design and construction process of our house

During the competition

- use the international fair to contact future customers
- see your logo and a heads-up on our work together on posters around the house
- be referenced in our manual
- be invited on a private tour through our house
- take a bath with one of our orange squeaky bath ducks
- enjoy a candle-light dinner on our terrace

After the competition

- team up with us on research and development on the ROOFTOP house and use the resulting data
- use your high recruiting potential thanks to direct contact to a number of motivated and experienced students
- find your contribution on a prominent location on the Campus Charlottenburg
- we will continue to present our house on fairs and promote our relationship to the public
- optionally continue to develop the ROOFTOP house
- look for a market-solution for this prototype
- a welcome back opening party in its permanent location



CONTACT

If you are interested in supporting our partnership or if you wish to have more information, just drop us a line.

www.teamrooftop.de
contact@teamrooftop.de

Alessandro Jänicke (UdK Berlin)
Student Team Leader
ajaenicke@teamtooftop.de
T: 0176 707 44 658

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E. PRESS

DATUM	NAME OF MEDIA / TITEL / LINK	ONLINE	PRINT	MENTION	BROADBAND	SPECIALISED	PRESS RELEASE	INTERNATIONAL	ACTIVE	PASSIVE
13/02/01	**DGS - SONNENENERGIE** *Solar Decathlon 2014* http://www.sonnenenergie.de/index.php?id=30&no_cache=1&tx_ttnews%5Btt_news%5D=255	●							●	
13/03/01	**FRAUNHOFER INSTITUT** *»Hybrid Plattform« Transdisziplinäre Zusammenarbeit* http://www.ipk.fraunhofer.de/fileadmin/user_upload/IPK_FHG/publikationen/futur/Futur_3_2013/HybridPlattform_Futur_3_2013_140212_Sal.pdf	●							●	
13/03/26	**DGS** *SONNENENERGIE 2/2013: Solar Decathlon 2014* http://www.dgs.de/index.2888.0.html	●				●			●	
13/03/31	**ENERGIE ZUKUNFT** *Solar Decathlon 2014* http://www.energiezukunft.eu/bauen-wohnen/bauzukunft/solar-decathlon-2014/			●					●	
13/05/04	**BAUNETZWISSEN** *Flachdach Solar Decathlon 2014: Team Rooftop aus Berlin* http://www.baunetzwissen.de/standardartikel/Flachdach-Solar-Decathlon-2014-Team-Rooftop-aus-Berlin_3563277.html	●				●			●	
13/06/01	**SONNENENERGIE** *Wir verändern die Baumkrone Berlins* http://www.sonnenenergie.de/sonnenenergie-redaktion/SE-2013-06/Layout-fertig/PDF/Einzelartikel/SE-2013-06-s045-Solares_Bauen-Team_Rooftop.pdf	●							●	
13/06/01	**GI - GebäudeTechnik** *Solar Decathlon Europe 2014* https://www.di-verlag.de/de/Zeitschriften/GI-GebaeudeTechnik-InnenraumKlima/2013/06/Solar-Decathlon-Europe-2014		●						●	
13/10/12	**EnOB** *Solar Decathlon 2014* http://www.enob.info/de/veranstaltungstermine/veranstaltung/details/solar-decathlon-europe-2014/			●					●	
13/11/07	**Ministère du logement et de l'égalité des territoires** *Solar Decathlon Europe 2014 : la compétition est lancée !* http://www.territoires.gouv.fr/solar-decathlon-europe-2014-la-competition-est-lancee	●						●	●	
13/11/09	**Ecotrinova** *Null- und Plusenergiegebäude - Definitionen, Projekte, Erfahrungen* http://ecotrinova.de/downloads/2013/131109%20VortragProf_KarstenVoss_Samstags-ForumRegioFR.pdf			●					●	
13/11/29	**European Commision Directorate - Genreal Joint Research Centre** *SOLAR DECATHLON 2014* http://ec.europa.eu/dgs/jrc/downloads/events/20131129-eeb-roundtable/20131129-eeb-roundtable-rollet-mesureur.pdf	●						●	●	
13/12/06	**Campus Kollision - UdK** *Project rooftop – design your solar vision* http://www.campus-kollision.de/project-rooftop/1417	●								●

DATUM	NAME OF MEDIA / TITEL / LINK	ONLINE	PRINT	MENTION	BROADBAND	SPECIALISED	PRESS RELEASE	INTERNATIONAL	ACTIVE	PASSIVE
13/12/09	**Hybrid Plattform** *Team Rooftop, Teilnehmer des Solar Decathlon 2014* http://www.hybrid-plattform.org/de/projekte/projektideen/262-team-rooftop-teilnehmer-des-solar-decathlon-2014	●								●
13/12/09	**TU Pressestelle Berlin** *Neu bedacht* http://www.pressestelle.tu-berlin.de/medieninformationen/2013/dezember_2013/medieninformation_nr_2862013/	●								●
13/12/09	**energie experten** *Rooftop erschließt Wohnraum und PV-Potenzial Berliner Altbaudächer* http://www.energie-experten.org/experte/meldung-anzeigen/news/rooftop-erschliesst-wohnraum-und-pv-potenzial-berliner-altbaudaecher-4301.html	●							●	
13/12/09	**News4Press** *TU Berlin: Neu bedacht - Projekt Rooftop im Solar-Decathlon-Wettbewerb im Finale* http://www.news4press.com/TU-Berlin-Neu-bedacht---Projekt-Rooftop_792542.html	●							●	
13/12/09	**Internetmarketing** *TU Berlin: Neu bedacht – Projekt "Rooftop" im Solar-Decathlon-Wettbewerb im Finale* http://www.internetmarketing.or.at/tag/rooftop/	●							●	
13/12/09	**Campus Charlottenburg** *Rooftop ein Projekt der UdK und TU Solar Decathlon - internationaler Wettbewerb zur Entwicklung innovativer Solarhäuser* *http://www.campus-charlottenburg.org/index.php?id=108*	●								●
13/12/12	**photovoltaik** *Berliner Studenten im Finale des Solar Decathlon Europe* http://www.photovoltaik.eu/Berliner-Studenten-im-Finale-des-Solar-Decathlon-Europe,QUlEPTU2NjM4NSZNSUQ9MzAwMjE.html	●							●	
13/12/12	**SolarServer** *Solares Bauen: Berliner Studierende im Finale des Solar Decahtlon 2014* http://www.solarserver.de/solar-magazin/nachrichten/archiv-2013/2013/kw50/solares-bauen-berliner-studierende-im-finale-des-solar-decathlon-2014.html	●							●	
14/01/01	**DBZ** *Energy Spezial* http://www.dbz.de/media/downloads/energie-spezial-1-2014.pdf			●					●	
14/01/09	**BerlinOnline** *Kollisionen in der Welt der Kunst* http://www.berlinonline.de/nachrichten/wedding/kollisionen-in-der-welt-der-kunst-46990			●					●	
14/01/12	**Oekonews** *TU Berlin: Neu bedacht - Projekt "Rooftop" im Solar-Decathlon-Wettbewerb im Finale* http://www.oekonews.com/index.php?mdoc_id=1086512	●							●	

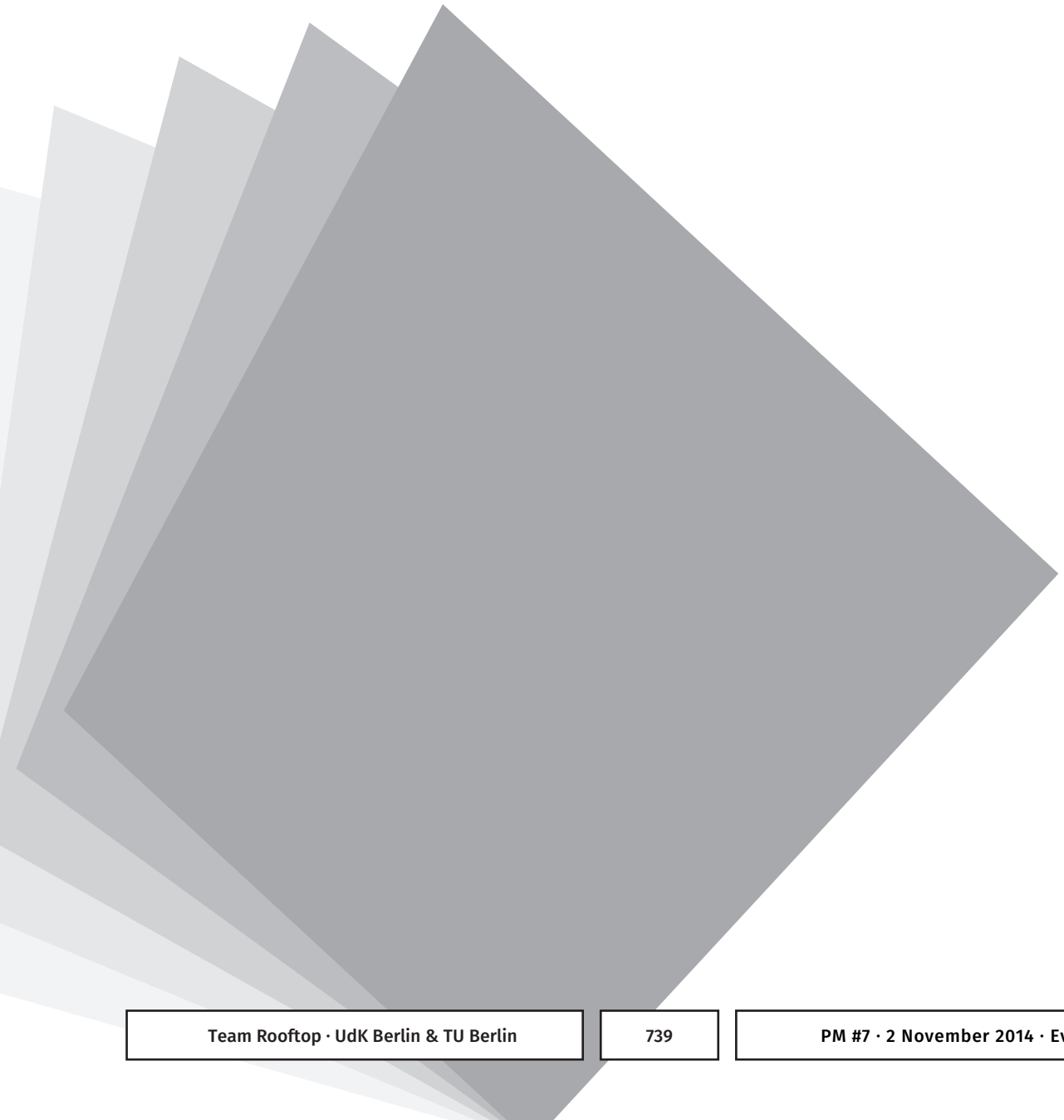
DATUM	NAME OF MEDIA / TITEL / LINK	ONLINE	PRINT	MENTION	BROADBAND	SPECIALISED	PRESS RELEASE	INTERNATIONAL	ACTIVE	PASSIVE
14/01/20	**Architizer** *Team Rooftop Solar Decathlon* http://architizer.com/projects/team-rooftop-solar-decathlon/	●			●				●	
14/02/09	**BAUFACHINFORMATION** *Solar Decathlon 2014. Team Rooftop aus Berlin erhält Zuschlag* http://www.baufachinformation.de/zeitschrift/Solar-Decathlon-2014/2014029011223	●				●			●	
14/02/09	**EN LLAVE** *Las casas solares de Solar Decathlon Europe 2014 (II/III) #SDe2014* http://www.enllave.es/actualidad/noticias/2014/02/19/las-casas-solares-de-solar-decathlon-europe-2014-iiiii-sde2014/	●						●	●	
14/03/01	**Holzbau Austria** *Zehnkampf über den Dächern Berlins* http://www.holzbauaustria.at/index.php?id=111&tx_ttnews%5Btt_news%5D=5374&cHash=dedc200f5d48fd34f774ccc8e31f7ccc		●					●	●	
14/03/07	**Berliner Abendblatt** *Energie vom Dach* http://www.abendblatt-berlin.de/2014/03/07/energie-vom-dach/	●					●			●
14/03/14	**DETAIL** *Energieeffizienz auf neuen Wegen: Solar Decathlon 2014 in Versailles* http://www.detail.de/architektur/news/energieeffizienz-auf-neuen-wegen-solar-decathlon-2014-in-versailles-022799.html	●				●			●	
14/03/18	**BLOG HABITAT DURABLE** *20 prototypes à énergie positive au Solar Decathlon 2014* http://www.blog-habitat-durable.com/2014/03/20-prototypes-a-energie-positive-au-solar-decathlon-2014.html	●						●	●	
14/03/31	**IMMOBILIENSCOUT24** *Wohnen auf dem Dach: Das Berliner Team des Solar Decathlon Europa im Gespräch* http://blog.immobilienscout24.de/wohnen-auf-dem-dach-das-berliner-team-des-solar-decathlon-europe-im-gespraech/	●							●	
14/04/01	**ELEKTROTECHNISCHER VEREIN ETV** *40 Studierende der TU Berlin und der Akademie der Künste entwickeln ein Konzept* http://www.vde-etv.de/index.php?option=com_content&view=article&id=178:energie-erlesenes&catid=45:etv-news			●					●	
14/04/16	**Holzbau Austria** *Zehnkampf über den Dächern Berlins* http://www.holzbauaustria.at/index.php?id=111&tx_ttnews%5Btt_news%5D=5374&cHash=dedc200f5d48fd34f774ccc8e31f7ccc	●						●	●	

DATUM	NAME OF MEDIA / TITEL / LINK	ONLINE	PRINT	MENTION	BROADBAND	SPECIALISED	PRESS RELEASE	INTERNATIONAL	ACTIVE	PASSIVE
14/04/17	**RHEINZINK** *Weiteres Studenten-Team beim Solar Decathlon mit RHEINZINK-Produkten* http://www.rheinzink.de/news/newsdetail/article/2376/weiteres-studenten-team-beim-solar-decathlon-mit-rheinzink-produkten/				●				●	
14/04/17	**IMMOBILIENSCOUT24** *Richtfest beim Team Rooftop* http://blog.immobilienscout24.de/richtfest-beim-team-rooftop/	●							●	
14/04/28	**Lignum** *Dachausbau mit Holz geht in den solaren Zehnkampf* http://www.lignum.ch/auf_einen_klick/news/lignum_journal_holz_news_schweiz/news_detail/?tx_ttnews[tt_news]=1993&cHash=22d7fa9a332e946c0b60c75e6f891210	●							●	
14/05/01	**Berliner ImpulsE** *Berliner Studententeam im Solar Decathlon Europe 2014 auf Berliner Energietagen* http://www.berliner-impulse.de/nc/aktuelles/news/artikel/browse/1/artikel/berliner-studententeam-im-solar-decathlon-europe-2014-auf-berliner-energietagen-932.html?tx_ttnews[backPid]=71&cHash=359d43e0d9c4dd82b05a9c72f6602400	●							●	
14/05/01	**allevents.in** *Ready for Versailles Party* http://allevents.in/berlin/ready-for-versailles-party/683174101746201	●							●	●
14/05/01	**URBANPLANET** *Solar Decathlon 2014 in Versailles – Frankreich* http://urbanplanet.info/architecture/solar-decathlon-versailles-frankreich/	●							●	
14/05/01	**TIMBER ONLINE** *Zehnkampf in Versailles* http://www.timber-online.net/?id=2500%2C5339297%2C%2C	●				●			●	●
14/05/01	**Berliner Abendblatt** *Sechs neue Projekte für die City West* http://www.abendblatt-berlin.de/2014/05/07/sechs-neue-projekte-fuer-die-city-west/	●				●				●
14/05/12	**DE – DER ELEKTRO- UND GEBÄUDETECHNIKER** *Berliner Team mit nachhaltigem Gebäude* http://www.elektro.net/35388/berliner-team-mit-nachhaltigem-gebaeude/	●							●	
14/05/15	**Bochumer Zeitung** *TU Berlin: Für Berlins Dächer: „Rooftop“* http://www.bochumer-zeitung.net/aktuell/vermischtes/67221910-tu-berlin-fuer-berlins-daecher-rooftop	●								●

DATUM	NAME OF MEDIA / TITEL / LINK	ONLINE	PRINT	MENTION	BROADBAND	SPECIALISED	PRESS RELEASE	INTERNATIONAL	ACTIVE	PASSIVE
14/05/19	**Berlin Energy Days** *Gründer- und Innovationsmesse 2014* http://www.berliner-energietage.de/ausstellungen/gruender-und-innovationsmesse.html			●					●	
14/05/22	**Pressestelle TU Berlin** *Für Berlins Dächer: „Rooftop“* http://www.pressestelle.tu-berlin.de/medieninformationen/2014/mai_2014/medieninformation_nr_1062014/	●							●	●
14/05/22	**Uni Protokolle** *TU Berlin: Für Berlins Dächer: Rooftop* http://www.uni-protokolle.de/nachrichten/id/278722/	●							●	
14/05/22	**Presse Anzeiger** *TU Berlin: Neu bedacht - Projekt "Rooftop" im Solar-Decathlon-Wettbewerb im Finale* http://www.presseanzeiger.de/pa/TU-Berlin-Neu-bedacht-Projekt-Rooftop-im-708945	●							●	
14/05/22	**wn.com** *Für Berlins Dächer: „Rooftop“ (Technische Universität Berlin)* http://article.wn.com/view/2014/05/22/22052014_Nr_106_Fur_Berlins_Dacher_Rooftop_Technische_Univer/	●								●
14/05/22	**pressrelations** *Für Berlins Dächer: „Rooftop“* http://www.pressrelations.de/new/standard/result_main.cfm?r=565724&aktion=jour_pm&quelle=1	●							●	
14/05/22	**AD HOC NEWS** *Für Berlins Dächer: „Rooftop“ (Technische Universität Berlin)* http://www.ad-hoc-news.de/tu-berlin-fuer-berlins-daecher-rooftop--/de/News/37094111	●							●	
14/05/22	**PR MAXIMUS** *TU Berlin: Für Berlins Dächer: "Rooftop* http://www.prmaximus.de/105848	●							●	
14/05/22	**UPGO** *SOLAR DECATHLON 2014* http://www.univ-upgo.fr/solar-decathlon-2014/			●				●	●	●
14/05/22	**idw - Informationsdienst Wissenschaft** *TU Berlin: Für Berlins Dächer: „Rooftop“* http://idw-online.de/pages/de/news588574	●							●	
14/05/22	**momentum MAGAZIN** *Solar Decathlon 2014: Berliner Studenten präsentieren nachhaltiges Wohnkonzept* http://momentum-magazin.de/de/solar-decathlon-2014-berliner-studenten-prasentieren-nachhaltiges-wohnkonzept/	●							●	
14/05/22	**UdK Berlin** *Team Rooftop (Wettbewerbsbeitrag UdK Berlin/TU Berlin Solar Decathlon Europe 2014)* http://www.arch.udk-berlin.de/nytsch/	●							●	●

DATUM	NAME OF MEDIA / TITEL / LINK	ONLINE	PRINT	MENTION	BROADBAND	SPECIALISED	PRESS RELEASE	INTERNATIONAL	ACTIVE	PASSIVE
14/06/02	**deutschlandradio Kultur** *Wohnen auf Berliner Altbauten - Rooftop-Projekt der Technischen Universität* http://www.deutschlandradio.de/audio-archiv.260.de				●					●
	Berliner Zeitung		●							●
	Deutsche Welle				●					●
	IMMOBILIENSCOUT24	●								●
	Deutsche Welle				●					●

F. EVENTS



DATUM	NAME OF EVENT / LOCATION	COMPETITION	WORKSHOP	PRESENTATION	DATUM	NAME OF	COMPETITION	WORKSHOP	PRESENTATION	DATUM
12/12/21	**Competition Affirmation**	●								
13703/22	**Workshop in Paris #1** *Paris (France)*		●							
13/04/15	**Presentation of the project in lectures** *Berlin (Germany)*			●					●	
13/06/09	**Presentation of the ventilation concept in front of Prof. Ziegler** *Berlin (Germany)*			●					●	
13/06/12	**INTERSOLAR Europe 2013** *Munich (Germany)*				●				●	
13/06/19	**Presentation in front of the seminar for doctoral students of Prof. Ziegler** *Berlin (Germany)*			●					●	
13/07/12	**Rundgang 2013 in der UDK** *Berlin (Germany)*					●			●	●
13/07/23	**EUREF Campus Presentation** *Berlin (Germany)*			●					●	
13/11/01	**Workshop in Paris #2** *Paris (France)*		●							
13/11/05	**Signin of Memorandum of Understanding** *Berlin (Germany)*	●								
14/01/10	**Collision Week (UdK)** *Berlin (Germany)*		●							●
14/02/18	**Bautec Berlin** *Berlin (Germany)*				●				●	

DATUM	NAME OF EVENT / LOCATION	COMPETITION	WORKSHOP	PRESENTATION	FAIR	PUBLIC TOUR	DEMONSTRATIO	PARTY	ACTIVE	PASSIVE
14/03/21	**EnOB Symposium** *Essen (Germany)*			●					●	
14/04/02	**Presentation in front of the senate department of Berlin-Charlottenburg** *Berlin (Germany)*			●					●	●
14/04/03	**SPEED PEER REVIEW - Boot Camp** *Live Stream*	●							●	
14/04/05	**Barcamp "stadt:gestalten"** *Berlin (Germany)*				●				●	
14/04/11	**Efficiency Plus Presentation** *Berlin (Germany)*			●					●	
14/04/11	**Social Media Think Unit Presentaton (TU)** *Berlin (Germany)*			●						●
14/04/17	**Topping out** *Berlin (Germany)*							●	●	●
14/05/10	**Energy transition-demonstration** *Berlin (Germany)*						●		●	
14/05/10	**Children Science Slam** *Berlin (Germany)*			●						●
14/05/10	**VIP-Tour at the “Long night of science”** *Berlin (Germany)*					●				●
14/05/16	**Science Slam Potsdam** *Potsdam (Germany)*			●						●

DATUM	NAME OF EVENT / LOCATION	COMPETITION	WORKSHOP	PRESENTATION	FAIR	PUBLIC TOUR	DEMONSTRATIO	PARTY	ACTIVE	PASSIVE
14/05/19	**Berlin Energy Days** *Berlin (Germany)*				●				●	●
14/05/30	**Ready-for-Versailles-Party** *Berlin (Germany)*							●	●	●

G. MATERIAL FOR PROJECT DISSEMINATION

MERCHANDISING

	PRODUCT	TIMING	COMPANY	QUANTITY	COST
FLYER	INTERSOLAR Europe 2013	June 13	Copystation	500	19.75 €
	Recruiting	July 13	Copystation	200	12.23 €
	Bautec	February 14	Copystation	500	19.75 €
	Update	May 14	Copystation	1000	27.99 €
	SDE	June 14	cewe-print.de	20000	109.19 €
BROCHURE	UdK Tour	July 13	Copystation	50	12.33 €
	SDE	June 14	wir-machen-druck.de	10000	520.47 €
POSTER	EnOB	October 13	Copystation	2	30.00 €
	Recruiting	December 13	Copystation	25	75.00 €
	Bautec	February 14	Copystation	2	30.00 €
	Connect the Dots	March 14	UdK CAD Lab	30	120.00 €
PROJECT DESCRIPTION	Version #1	December 13	Copystation	100	77.94 €
	Version #2	April 14	Copystation	150	116.91 €
BUSINESS CARDS	Version #1	June 13	Copystation	300	49.89 €
	Version #2	May 14	Copystation	500	39.95 €
POSTCARDS	SDF	May 14	Flyeralarm	5000	95.50 €
PENCILS		April 14	Werbeartikel Dresden	2000	391.20 €
COTTON BAGS		April 14	cotton.de	300	369.00 €
YARDSTICKS		May 14	ihr-werbedruck.de	300	354.00 €

MEDIA

	PRODUCT	TIMING	COMPANY	QUANTITY	COST
ONLINE ADVERTISEMENT	Facebook Promotion	January 14	Facebook	10 days	80.00 €
	Display Ads	February 14	D3Media	100 Clicks	80.00 €
	Mobile Ads	February 14	App Brain	2000 Clicks	100.00 €
	PreRoll TrueView Ads	February 14	YouTube	1000 Clicks	150.00 €

ABOUT ROOFTOP

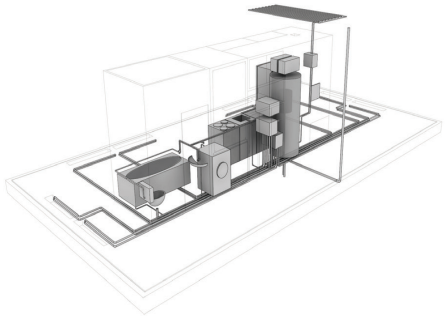
We have taken on the task of densifying city centers with energy efficient dwelling units. Our housing units dock onto existing structures, profiting from the elevated site and the existing infrastructure. As well as providing the city with energy-efficient living space. They feed their surplus green energy into the city's power grid.

The rooftop house works with two main innovative design principles:
Our fold-up facade allows for an optimal adaption to weather conditions in summer and winter. The shading elements covered in photovoltaic panels fold up to extend the solar intake roof surface or fold down as an insulation layer for the winter.





The core module in the living space centers the functional elements and technical units, provides space saving storage room as well as a comfortable bathroom with an incredible view. It's intelligent design and Human Machine Interface enables a new form of dialogue between the resident and the house. The duality of the open roof in summer and the closed shell in winter create a unique feeling of energy and climate awareness.



The Module is easily preassembled on ground level, thus minimizing the installation costs of the rooftop house.

Our goal beyond the SDE is to make a contribution to the world's knowledge of sustainable housing, through research and development of new technologies and concepts.
We are focusing on 3 different aspects of sustainability:

1. Ecological
   Lessen adverse impact to the environment
   Conservation of nonrenewable resources
   Integration of alternative energy sources
   Lower carbon footprint
   Use of recycled/reused materials

2. Social
   Healthy and clean environment
   Enhanced quality of life
   Access to clean water and clean energy
   Development in harmony with culture and available resources

3. Economic
   Positive or neutral return on investment
   Enhances economic development of the community
   No adverse impact to economies

ROOFTOP

University of the Arts Berlin
Technische Universität Berlin

ADRESSE

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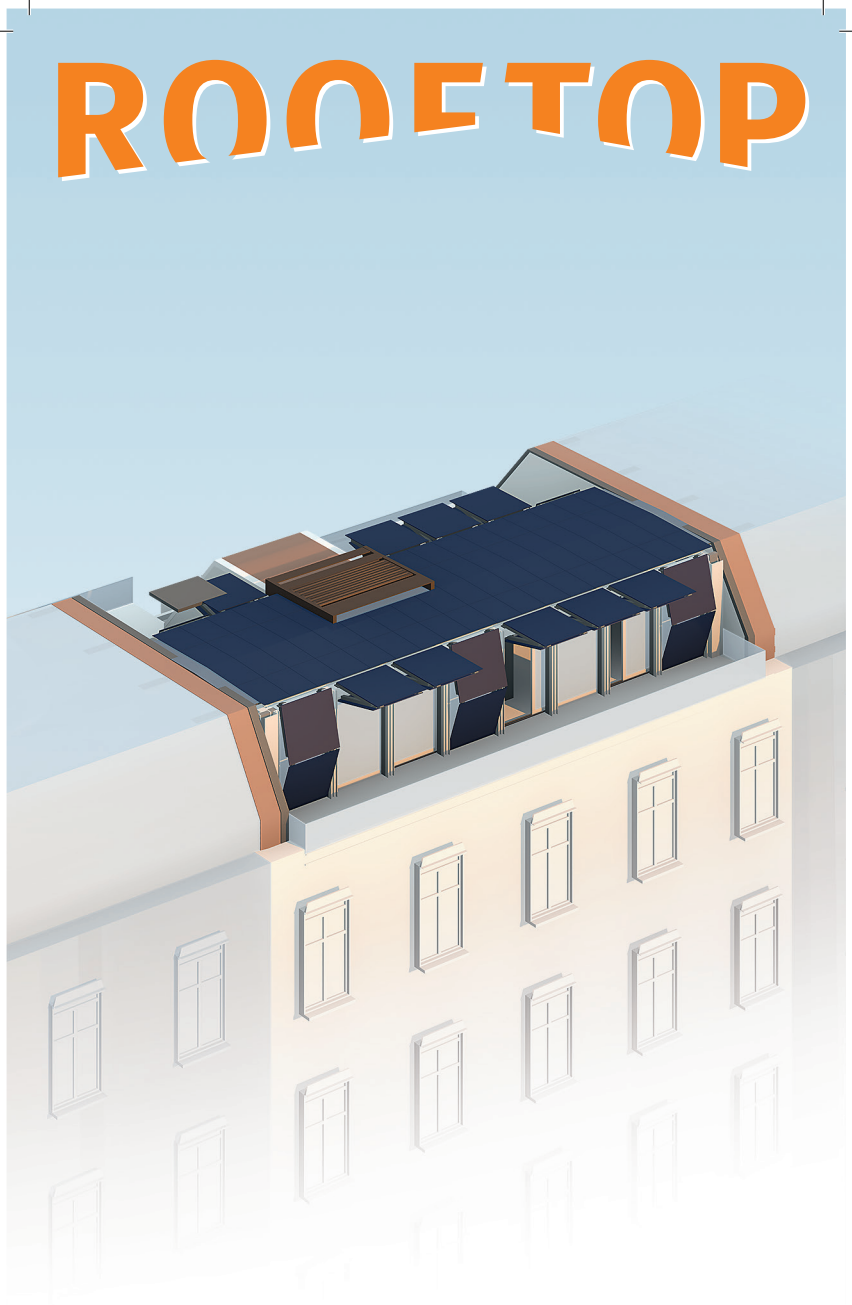
ROOFTOP

BAUTEC

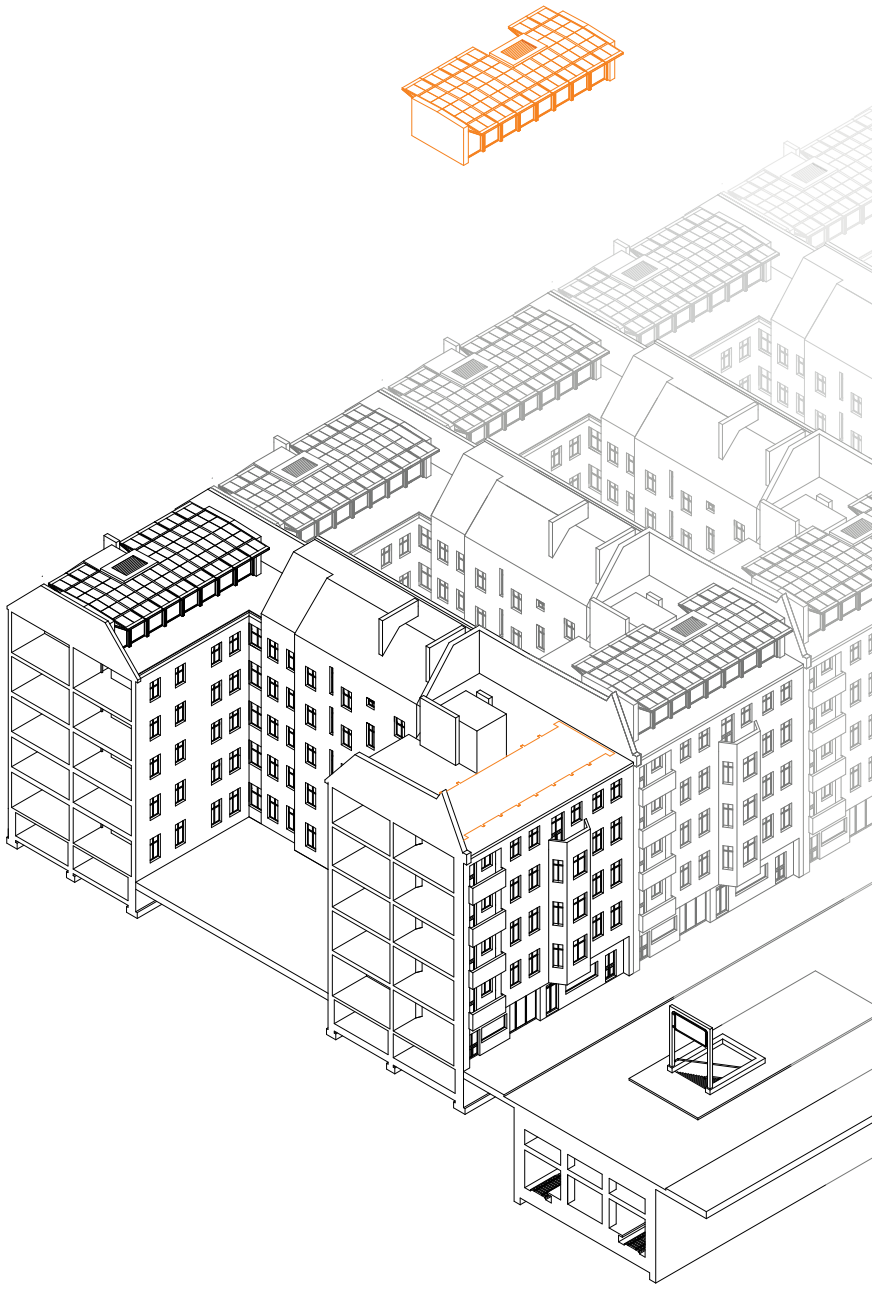
ROOFTOP



ROOFTOP

FLYER MAY 2014

ROOFTOP



ENOB POSTER

EnOB
Forschung für
Energieoptimiertes Bauen

Gefördert durch:
Bundesministerium
für Wirtschaft
und Energie
aufgrund eines Beschlusses
des Deutschen Bundestages

Team rooftop Berlin - Solar Decathlon Europe 2014 en France



Das Team rooftop ist eine interdisziplinäre Gruppe aus Studenten der Universität der Künste Berlin und der Technischen Universität Berlin, welche mit ihrem innovativen Wohnkonzept unter den 20 Finalisten des Solar Decathlon Europe 2014 en France gewählt wurden. Parallel zu 19 weiteren Teams aus aller Welt entwerfen, erforschen und entwickeln die Studenten eigenständig ihre Vision einer energetisch und konzeptuell sinnvollen Stadtverdichtung um sie dann real umzusetzen.

Energieeffizienz über den Dächern Berlins
Das rooftop Haus ist eine auf dem Dach eines typischen Berliner Altbaus errichtete solare Wohneinheit.
Im Fokus der Wettbewerbsausschreibung stand die energetisch nachhaltige Stadtverdichtung.
Die Vorgaben des Wettbewerbes limitieren die Größe der Wohneinheit dabei auf 70 m2 Bruttofläche. Dadurch wird die Interaktion mit dem Außenraum zu einem zentralen Element des Wohn- und Entwurfsprozesses.



Interdisziplinärer Schwerpunkt
Die einzigartige Kombination von Studenten mit künstlerischer architektonischer Ausbildung und solchen in verschiedenen Ingenieursstudiengängen ermöglicht in diesem einzigartigen Wettbewerbsformat eine intensive, früh beginnende Zusammenarbeit der Gewerke. So entsteht ein interdisziplinäres Bauwerk, in welchem jedes gestalterische Element einen technischen Nutzen, und jedes technische Element eine gestalterische Ausarbeitung hat.

Integrative Energiekonzepte
Diese Zusammenarbeit ermöglicht ein genaues Abstimmen aller Elemente aufeinander und so die Implementierung sehr viel komplexerer energetischer Konzepte. So ist die Zonierung des Innenraumes auf die speziell für das Projekt entwickelte Faltfassade abgestimmt und reagiert ebenso in ästhetischer wie auch energetisch sinnvoller Weise auf die Terrassen und den Sonnenstand. Die Zusammenführung aller technischen Gewerke in einem zentralen Kernmodul, welches gleichzeitig die Räume klar sortiert, erspart nicht nur Zeit in der Bauphase sondern ermöglicht den technisch einfachen Aufbau der thermischen Hülle. Die Reaktion des Hauses auf das Außenklima wirkt sich direkt auf das Wohnerlebnis aus und ermöglicht dem Bewohner ein klares, direktes Verständnis der passiven und aktiven energetischen Vorgänge im und ums Haus.

Realisierung studentischer Forschungsergebnisse
Ziel des Wettbewerbes ist die Errichtung von 20 Prototypenhäusern in einem Versuchsdorf im Schloßpark von Versailles, Frankreich. Das über eineinhalb Jahre entwickelte Wohnkonzept muss also real umgesetzt und modular geplant werden um im Sommer diesen Jahres in Frankreich gegen die 19 Konkurrenzhäuser in zehn verschiedenen architektonischen Disziplinen anzuteten.

Projektlaufzeit
2013 - 2015

Projektdurchführung
Universität der Künste Berlin / Technische Universität Berlin

Industriebeteiligung
Augusta Solar, Solibro GmbH, Geberit, Hans Grohe,
Kieback & Peter Gebäudeautomation, Solarwerkstatt Berlin,
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Dr.-Ing Farshad Nasrollahi, Universität der Künste Berlin

Förderkennzeichen
03ET1238B

Universität der Künste Berlin

CONNECT THE DOTS





PROJECT DESCRIPTION VERSION #2

ROOFTOP

Team Rooftop

Wir sind eine Gruppe von Studenten der UdK und TU Berlin und arbeiten seit Dezember 2012 daran, die Baumkrone Berlins ein wenig grüner zu gestalten. Im Rahmen einer behutsamen Stadtverdichtung möchten wir den noch ungenutzten Wohnraum auf den Dächern der Berliner Altbauten entwickeln und Klimawandel und Gentrifizierung entgegenwirken.

Solar Decathlon

2002 in den USA ins Leben gerufen, avancierte der Solar Decathlon zum größten studentischen Bauwettbewerb. 2014 bietet er 20 Teams aus 16 Ländern die Chance, ihre Vision vom nachhaltigen Wohnen in die Tat umzusetzen. Vom 26.6 bis zum 14.7 schmückt die Cité du Soleil den Schlossgarten von Versailles.



Umsetzung

Nach abgeschlossener Planung bauen wir nun in der Peter-Behrens-Halle im Berliner Humboldthain unser Haus auf. Nach erfolgreichem Test der Gebäudetechnik Mitte Mai wird das Haus für den Transport nach Versailles vorbereitet. Pünktlich zum Wettbewerbsstart Ende Juni errichten wir das Gebäude innerhalb von zehn Tagen im Garten des Sonnenkönigs. Nach dem Wettbewerb findet es ein Zuhause auf dem Campus Charlottenburg. Dort wird es ein Anlaufpunkt für Studenten, Forscher und Interessierte sein.

Konzept

Statt charmante Lücken im Berliner Stadtbild zu schließen oder bestehende Grünflächen zu zerstören, orientieren wir uns am Berliner Altbau der Jahrhundertwende. Hier ersetzen wir die nach dem Weltkrieg notdürftig errichteten Dachstühle. Auf die frei gewordene Fläche wird das Core-Module gestellt, in dem die gesamte Gebäudetechnik bereits installiert ist. Anschließend wird die Gebäudehülle aus vorgefertigten Bauteile zusammengeführt. In kürzester Zeit schaffen wir somit eine ökologische, energieeffiziente und moderne Wohneinheit, die durch ihre erhöhte Position und ihre mobile Fassaden die Sonnenstrahlen perfekt einfängt. Eine einzigartige Aussicht, intelligentes Mobiliar sowie drei verschiedene Terrassen runden unser Konzept ab und kreieren ein einzigartiges Wohnerlebnis.

Bundesministerium für Wirtschaft und Energie

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BUSINESSCARD VERSION #2

ROOFTOP

Federal Ministry
for Economic Affairs
and Energy

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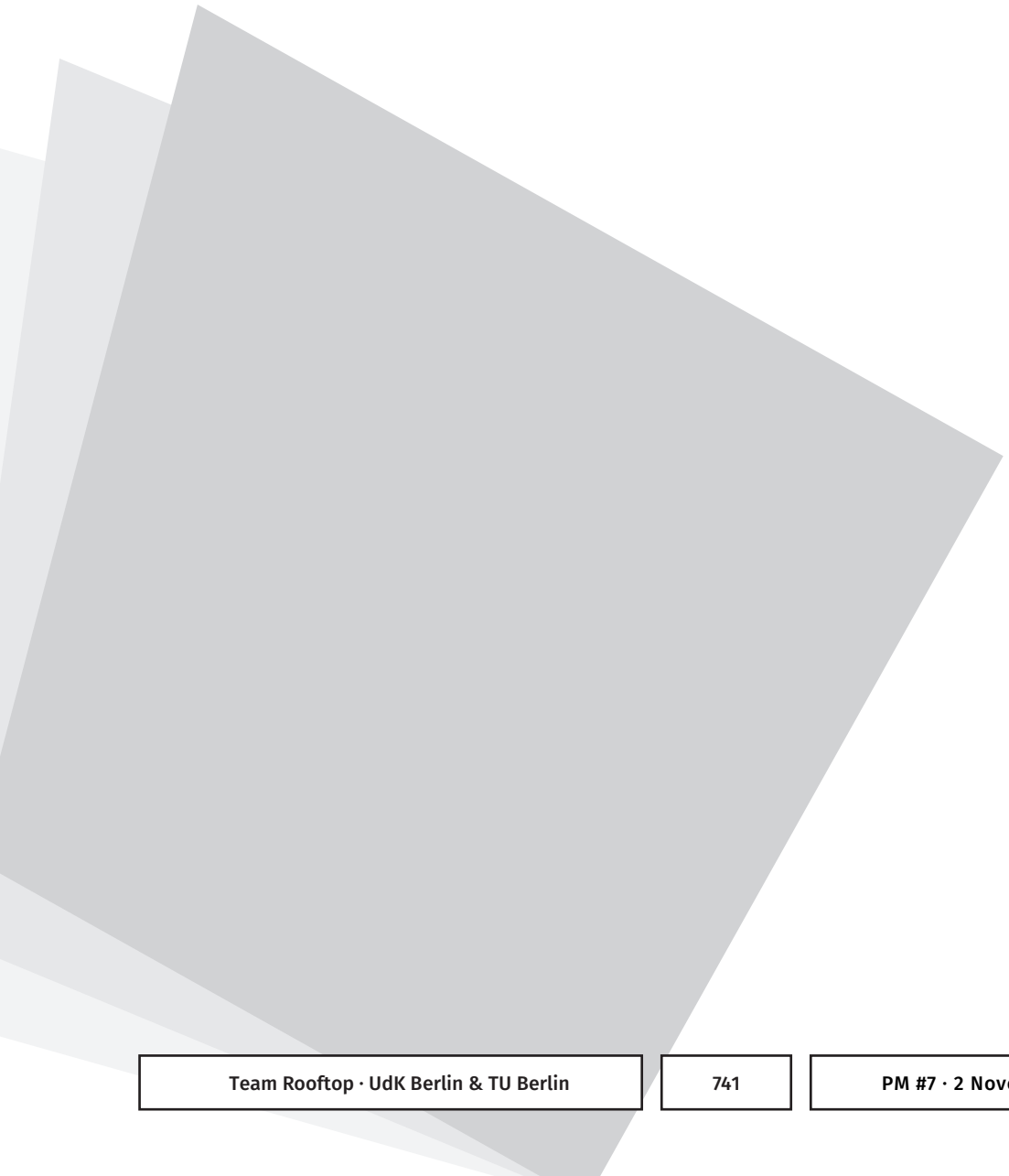
COTTON BAGS





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