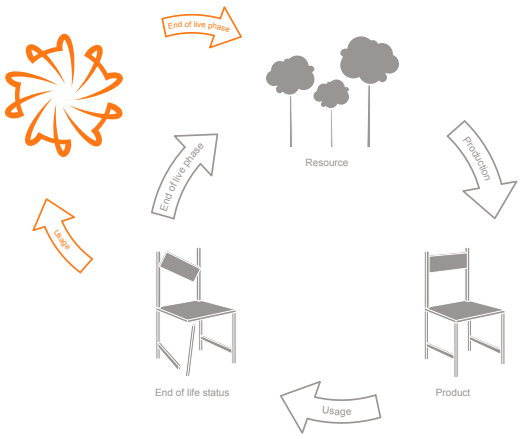


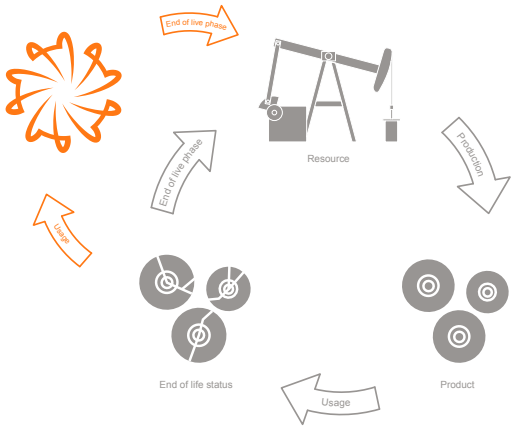
"Counter Entropy" lifecycle of a product

Counter Entropy

Since the ten "Solar Decathlon Europe" contests monitor data only during the building's lifetime but not incorporate its production energy, the team defined the 11th contest "Counter Entropy", meaning to save resources, avoid waste and convert less energy over all phases of a building's lifetime by using modern technology and fabrication methods, selected materials and reuse processes. Therefore the team avoids new resources and rather employs already used objects enhancing their usual life-cycle by assigning them to a second use with the ambitious aim to convert yesterday's waste to the material for tomorrow's buildings. This implies the "reuse" of certain items either in their original function or in a converted one achieving an exciting and individual architectural solution.

Material

Due to the idea of "Counter Entropy" the choice of material is a main aspect of the house, strongly influencing its atmosphere and spatial impression and thereby giving the chance to illustrate this aspect the most striking, showing that a high design aspiration and the challenges set up by the competition can be brought in line with the idea of reuse and super cycling. Due to regulations it was not possible to reuse material for the construction so the team mainly concentrated on non- bearing material. Nevertheless the use of composite materials was avoided and replaced by construction principles that can be easily disassembled.



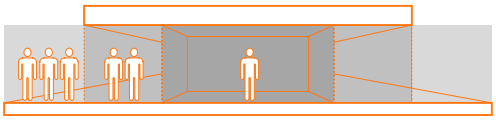
the enhanced "Counter Entropy" lifecycle of a CD

block facade. is made of old CDs, an aging medium that still everyone is familiar with. Since they are no more than coated macrolon, they are used for the facade by removing the coating and then melting them together only by heat forming panels.

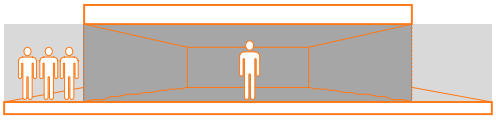
floor. inside as well as outside is made of reused old beams, of the old soccer stadium "Tivoli" of Aachen, cut into floorboards.

exterior. can be disassembled easily. The subconstruction of the exterior is made of lent scaffold. In addition the construction of the bench is composed of lent beer crates.

interior. The carcases of the interior are made of wooden boards collected from bulk rubbish or fail produced particleboard.



Vertical Zoning - Private to public

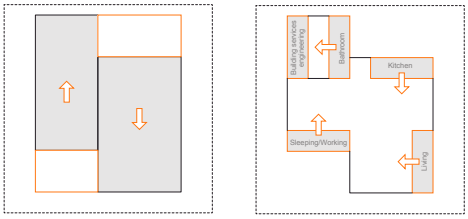


Vertical Zoning - Enlargement of the private zone by the curtain

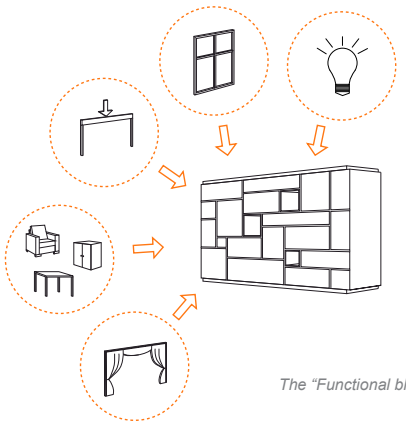
Zone 3 - First stage of privacy raised from the ground, unroofed

Zone 2 - Second stage of privacy raised from the ground, roofed

Zone 1 - Third stage of privacy raised from the ground, roofed, thermal or visually covered



Development of the layout



The "Functional block"

Architectural conception

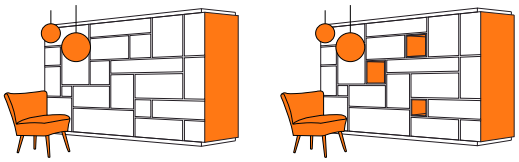
In order to achieve optimal usage of the small footprint predetermined by the organisation a smooth transition between interior and exterior is generated. Thereby the main focus is not only limited on a visual enlargement of the living space but rather on an actual enlargement of the private living zone.

three horizontal zones. The solid base serving as building foundation, the open floor composed of closed block elements and transparent glass surfaces, as well as the widely cantilevering roof are decisive in determing the stage of privacy for the three vertical zones. The first horizontal zone – the solid base – generates the first stage by raising the building from the ground and defining a clear border to the public space. The second horizontal zone – the roof – creates the second stage of privacy by clearly defining the space from two sides. The third vertical zone is the most private created by the building envelope within the open space. To enlarge the inner private zone a curtain can be pulled around the roof's edge. By dissolving the building's envelope the zones conjoin to one held together by the widely cantilevering roof.
Due to the clear zoning there is a smooth transition between the interior and exterior generated by strong visual axes and intensified by continuous floor and ceiling material.

layout of the building. Two rectangles displaced sideways divide the space into a private area in the west and a public one in the east. A shift generates outdoor spaces defined by two sides – the public entrance area and the private terrace. To keep the room as open as possible and still structured every area has its own "Functional block".
The living space can be divided into four areas with one "Functional block" each, whereas the bathroom makes an exception – the dining and cooking area, the living area, the sleeping and working area and the bathroom respectively the technical room.

functional blocks. are the only closed elements.
They completely host the:

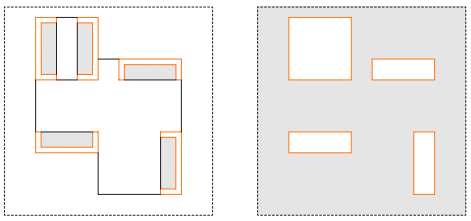
- building services engineering
- curtain
- glass facade
- wooden frame construction
- and most of the furnishing



Visibility of re-use objects

furniture. The “Functional blocks” consist of individual boxes and carcases defined by particular functions but especially by the size of the found reused material. Regardless of the range of units and materials that are used a simple and homogeneous impression is created by the clean white front face which is clearly seperated from the surrounding frame, generating a calm scenery for the free standing objects that the idea of “Counter Entropy” the most striking. The boxes are always assembled with the same space inbetween creating a 6 cm deep gap allowing a peek at the wide range of reused materials even in closed condition. Functions - like the completely storable bed or the working space - are fixed to boxes.

widely cantilevering roof. It not only serves as protection from sun and rain but also provides enough space for photovoltaic and solarthermic elements. Due to the size the team had the chance to employ thin-film photovotaic modules, complying much more with the aspects of “Counter Entropy” and still generating enough energy.



Transition between interior and exterior

transition between interior and exterior. Continous floor and ceiling material, as well as the block facade‘s material extending into the internal space create a seamless transition from inside to outside space. The large glass elements, completely storable in the “Functional blocks” and the innovative glazed corner combined with the visual axes enlarge the living space visually as well as actually. The curtain, stored in the “Functional blocks” can be pulled around the roofs edge not only as sunshade but rather to

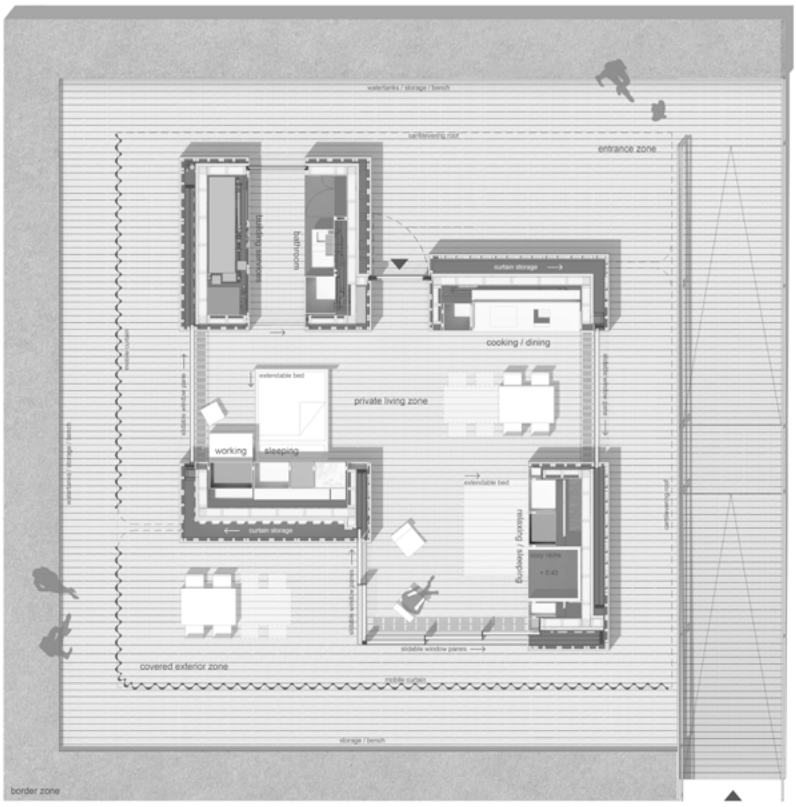
variability of the floor plan. Spacial flexibility is ensured by the space-saving arrangement as well as the multi-functionality of the furniture offering the residents a flexible adaptation to different utilization requirements.

making of light clouds

lighting design. The “Counter Entropy” lighting design evolves around the integration of daylight, electrical light, and the corresponding effect on the building’s energy balance. In a nutshell, the lighting design concentrates on using electric light efficiently while maximizing the use of natural daylight.
The large cantilevering roof ensures an efficient protection from high sun angles in summer while allowing desired solar gains at low sun angles in winter. During midday the glare of sunlight is prevented from entering the interior. Nevertheless, the large glazed elements ensure adequate supply of diffuse light, so that at daytimes no electrical light is needed.
To emphasize the separation between “Functional block” and

with linear LED strips. Furthermore to underline the linear shape of the house linear LED panels are used to illuminate functional areas. In addition, light drawers that provide illumination for reading and working are elegantly integrated into the sleeping block.

Being detached from the ceiling, floor and walls, the atmospheric luminaries are designed as autonomous objects independent from the strict cubic formula that dictates the surrounding interior design. They are made of the team‘s sketch papr follwing the “Counter Entropy” strategy. At night, these “light clouds” with their soft warm light induce a feeling of comfort and homeliness.



floor plan

section

post base

Idefix connector as used inside the columns

Idefix IFS connector threaded disc

The objective of the jury tour for construction and engineering, as stated in the rules, will be to demonstrate and explain the structure of the "Counter Entropy House", its technical installations and its integration in the concept and the architectural design.

Structure

foundation. The foundation consists of a steel grid, which is connected to post bases that are usually used for wooden columns. The advantage of these feet is that they are infinitely adjustable in height, which allows the team to react to any ground. Next to each foot, or drilling a strut is welded into the UPE-profiles to ensure that the foundation cannot collapse. The grid itself provides 34 threaded sleeves that are welded onto it, helping to place the floor elements.
This kind of adjustment-helpers can be found in each of the four layers that the house consists of.

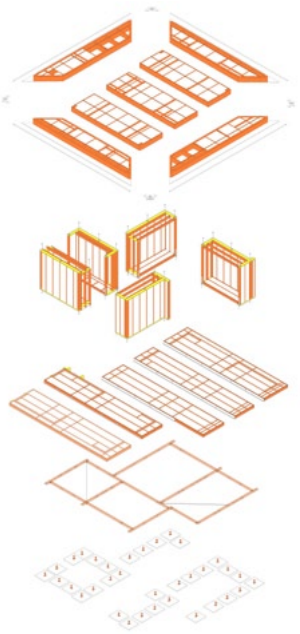
The five floor elements are wooden hollow boxes that are filled with cellulose blow-in insulation, made of shredded newspapers. That forms an insulation height of 16cm. To minimize thermal bridges, the second floor is insulated as well and its beams are set orthogonally to the ones inside the floor-elements.

boxes. The boxes can be placed on the floor elements, being oriented on the drillings. To do so, the boxes, which include the main columns for the roof, get a threaded rod that passes through the floor elements, right into the foundation grid, where it is fastened to the UPE-profile. This ensures a good connection of boxes and fastens the floor elements at the same time. The rods are fastened inside the columns with the help of grain-wood connectors named "Idefix" (see picture2). To ensure a safe house even in strong winds, the boxes have tension anchors on the front that can hold up to 14kN each.
The box itself is a regular wood frame construction, insulated with cellulose blow-in insulation. But they are planked with 22mm OSB on both sides, which double-reinforces each.
wall making them able to bear loads. This allows sparing any reinforcements other than the boxes and makes the boxes strong enough to withstand the stress during transportation.

beams inside the roof

steel band and gutter

Roof Just like the floor, the roof consists of wooden hollow boxes, insulated with cellulose insulation. It consists of three rectangular boxes that form a 7,5m square over the house. Four trapezoid-shaped elements are attached to the sides cantilevering up to 4m from the nearest wall.
The most important aspect regarding the roof is to get it as stiff and reinforced as possible, since the windows, especially the glass corner connecting sleeping room and living room, cannot withstand any stress from the roof. To do so, simple geometry and innovative measures have been used.
The trapezoid-shape of the cantilevering elements forms a strong outer ring supporting itself in the miter joints, they are slightly slanting upwards and obstruct each other from falling. Two types of wood have been used to build the roof. Big GLT-beams with dimensions of 140x440mm ensure a minimal deflection. LVL-beams with a width of only 75mm are used where fewer forces are expected. They form smaller thermal bridges and react less to heat and humidity than GLT. The planking on both sides is made of 33mm LVL-boards which strongly reinforce the elements. In addition, heavy duty roof connectors became necessary. They have multiple tasks: They provide holes for very long, full threaded screws that are used as reinforcement for the beams and they connect the roof elements to one another. Machine screws are used to ensure that the connection is detachable. During the construction the connectors can also be used as connection point for the team's safety gear. There are 5 different connectors on and underneath the roof.
In addition to the connectors a steel band made of 15x35mm flat steel runs along the upper rim of the roof. It is put under a lot of tension to press the roof elements together, forming a pane. The advantage in this is that it is adjustable in the unlikely event that the cantilevers would bend down.
For multiple reasons the main construction of the roof starts at 50cm from the attic. The 50cm gutter is a kind of safety zone after the safety fence to have something to step onto instead of a sudden drop. Furthermore it allows making the attic a lot lower than it would have to be if the construction would directly end at the outer rim.
The connection of the roof to the boxes is established through the same grain-wood connectors as those used on the bottom of the boxes plus three more connectors per box that are similar, but are not installed inside, but on top of the boxes. These connectors serve as the before mentioned adjustment-



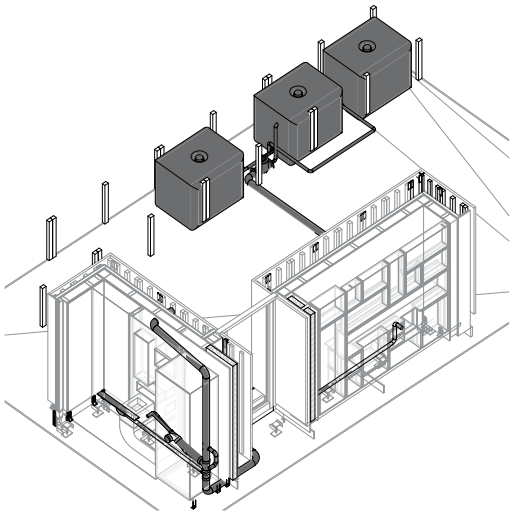
elementation of the house

helpers. Through the columns a direct transfer of forces from the roof to the foundation is generated. Since the threaded rods create strong thermal bridges, an aluminum coated, hardwearing, sloped insulation is installed on the roof. The bridges in the boxes are treated with 5cm vacuum insulation panels.

All in all, the house is built in a very strong and secure way, allowing untrained workers to set it up quickly and providing easy to use, adjustable and detachable connections. Its insulation ensures that the temperature provided by the house services will be kept inside the house.
No constructive elements are shown. the columns and connectors are installed inside the walls that are covered in either a CD-facade or the white laminated furniture doors. The foundation is of course loacated underneath the house and can hardly be seen. Nonetheless it is possible to reach the connectors with very little effort in case anything has to be refastened.

Engineering

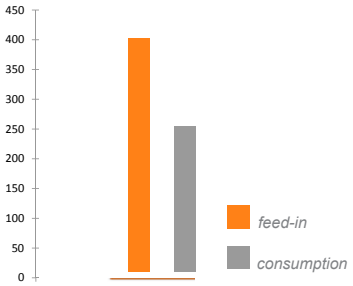
electrical installation. For a building being errected at a public fair like the “Solar Decathlon Europe”, the electric installation has to be implemented particularly careful. In close collaboration with experienced professionals, the team designed the electric installation according the recent rules both of Germany and Spain. The aim was to create a system, which features next to the undispensable safety requirements a superior user comfort and a minimum of space requirement. A selective main circuit breaker which inspects the flawlessness of the circuits automatically and combined residual current devices + circuit breakers shall only be mentioned as two examples of the various convenient solutions being adapted in the “Counter Entropy” house.
All electric safety devices and components of the building´s automation control are placed in an easily accessible cabinet in the entrance area. Cable ducts and solid plugs ensure a safe and durable connection of all electronic components.
The dimensioning of the system was done on the basis of all connected loads in order to install well fitting devices.



plumbing system

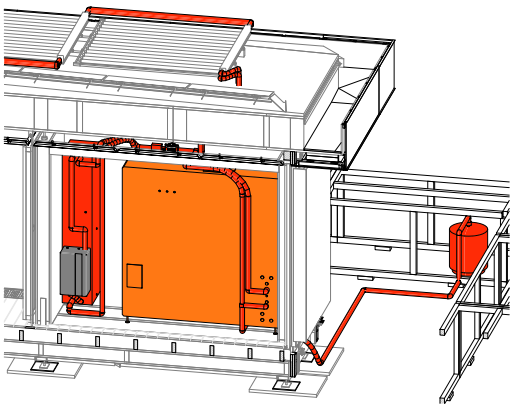
plumbing installation. Similar design criteria were adopted for the piping of the house. Reliability in usage and transportation had to be paired with a preferably energy efficient design. The team took care of minimizing flow velocities inside the pipes to values below 1 m/s in order to reduce pressure losses and floating noises. As there are mostly open fluid cycles, especially durable pipes made out

of stainless steel were chosen. For the brine in the sorption process, PVC pipes were used.
To minimize the consumed potable water, several water-saving mechanisms can be found in the house. The toilet for example uses flush water which has been collected from the wash hand basin, the system for radiation cooling has been designed to minimize water losses and all household devices were picked with special attention on its water consumption.



supply and demand

photovoltaic system. According the directive „Counter Entropy“, only a PV-system came into question, which meets the requirements of low embodied energy and investion costs by still high energy gains. Thin-film modules provide this compromise. At investion costs of 1.50 €/W they pay back their production energy after only 1.5 years. The calculated gains of electric energy are app. 8900 kWh in Madrid, Spain and 5500 kWh in Aachen, Germany.
The fed-in electricity to the grid exceeds the consumption by the factor 1.6. The surplus could be used in a “Counter Entropy” quarter for an E-Mobility concept. Equipping single houses with elaborate storage technology serves not as a sustainable approach for future building technology according the team.



solar thermal system

solar thermal system. The solar thermal system has been designed with special care to the “Counter Entropy House” needs. Additional to the standard fields of application, the heating and domestic hot water, the house uses solar thermal energy in a direct linkage with the dehumidification process of the air-handling unit. Evacuated tube collectors on an area of 13 square meters are in charge of supplying the necessary heat which is than kept in taylorde heat storage tank.
The chosen collectors have the advantage that they reach superior performance levels even under unfavourable radiation conditions and are driven by pure water instead of the environmentally questionable glycol mixture of usual solar thermal collectors.
Like those of the other mentioned assemblies, the characteristics of the solar thermal facility is adjusted specifically to the “Counter Entropy House´s” needs and complies to all recent safety regulations.

Example of a high entropic system

counter entropy. Energy is getting more and more valuable and its access is the social key factor of modern societies. On the other hand entropy production corresponds to the destruction of usable energy and takes place in any thermodynamic process. Reducing entropy production means making best use of available resources. This is why a "Culture of Counter Entropy" has to emerge.
Entropy is particularly produced during conversion processes of different energy forms and heat transfer at high temperature spreads. Accordingly the main Counter Entropy design principles have to be:
1. Avoid energy conversions if possible. Conventional systems use several preliminary energy forms to reach the final energy. However it is much more efficient to gain heat and cold directly through natural thermal sources
2. Use thermal energy with temperatures close to the surrounding temperature. Temperatures for the user's final application are usually near the surrounding temperatures. Never the less process temperatures in building technology are much further away from the latter. The Counter Entropy Team found many innovative technologies to diminish this Inefficiency.

Efficiency of the house's envelope

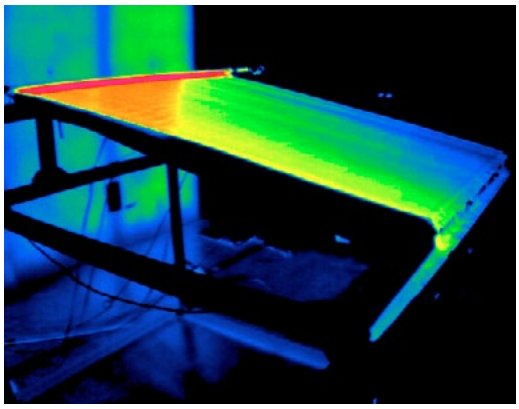
To reach the mentioned principle of producing as little entropy as possible during the operation of the house, a good design of a solar home has to start at its borders to the environment.
In conclusion, the "Counter-Entropy" team invested much effort to implement a hybrid insulation concept that both match thermal and architectural requirements.
The functional blocks each have two layers of insulation. Inside the wooden wallboards is located a layer of wood fiber insulation and wrapped around lies a layer of vacuum insulation, both with a heat conductance below 0.04 W/mK. The windows, roof and floor are capsulated the same way.
An optimal balance between shading in summer- and gaining radiation energy in wintertime is reached by the cantilevering roof. At its edge, a movable curtain serves as a sunlight protection and visual cover. Inhabitants are able to adjust it according their current needs.

Section of the cantilevering roof and curtain

Efficiency of HVAC system

As a main effect of the "Counter Entropy" design principles the combination of the installed equipment made a conventional heat pump redundant. Therefore the whole "Counter Entropy House" is working passively according to the Solar Decathlon

Europe 2012 rules. The only electrical consumers left are pumps, valves, fans and flaps. This way dispensable energy conversions using electrical energy as an intermediate step have been reduced. Natural thermal sources have been opened up and combined with phase changes at tailor-made temperature levels.



Thermography of a testing panel for the NRC

Water-paraffin PCM-dispersal

Fluid cooling. A combination of two fluid cycles is implemented for discharging one half of the house´s cooling load. A system for nocturnal radiation cooling (NRC) and a pumpable PCM-dispersal embody two innovative highlights of the “Counter Entropy” house.
NRC serves as a thorough substitution for a compression refrigeration machine. By sprinkling water during the night on the PV-modules, water can be cooled down to app. 12°C by means of radiation exchange, convection and evaporation. Presented before by former Solar Decathlon teams, this is first time to use NRC as a primary system for supplying cooling energy.
The cold water is used to discharge heat from the house´s latent heat storage system, the PCM-dispersal. It runs through a bespoke cooling ceiling during the day and absorbs heat from the room. Kept in a vast storage tank, the dispersal can be regenerated at night. The ingredients of the PCM-dispersal are water, paraffin wax and tensides. By mixing these components together, a fluid with a heat storage capacity 1.6 times higher than the one of water originates. Therefore, less fluid has to be circulated in the cooling ceiling which distinctly declines the necessary electric energy need for the pumps. The application of the dispersal in a real-life tested building is a world premiere. Nevertheless, the team relies on the promising performance factors of the combined system of NRC and PCM-dispersal of app. 20W of discharged heat by only 1W of consumed electrical energy.

Air Handling Unit (AHU). The second half of the sensible cooling load is inserted via air and deployed by an integrated AHU. In many working weeks of cooperation with Menerga GmbH it was designed exactly to the houses needs and follows the “Counter Entropy” concept consequently, based on our partner’s excellent know-how in this field and the student’s active input.
The core of the AHU is the adiabatic evaporative cooling. The house’s extract air stream is cooled down by injected water and at the same time exchanges heat with the outdoor air stream. The system is able to cool down outdoor air from 36°C to 20°C with a temperature efficiency of 94% in the cross-counter-cross air to air heat exchanger. At the layout air flow of 1100m³/h this equals a maximum cooling capacity of 5.6kW. By this indirect approach the supply air’s absolute humidity

Installation of the Air Handling Unit

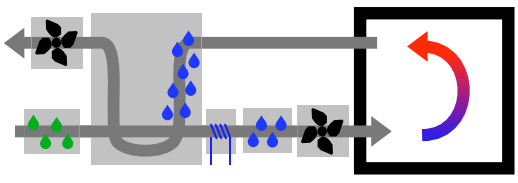
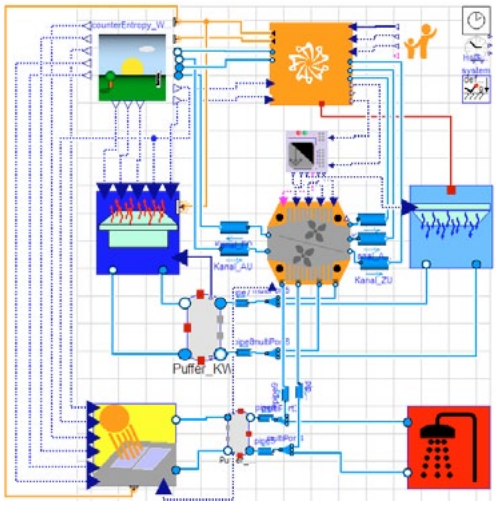


Diagram of the Air Handling Unit

stays untouched.
The evaporative cooling forms a sustainable and low entropic way of providing cool air. The only auxiliary energy needed is a pump for circulating the water through the spray valves.This results in an EER of higher than 7. The water usage of 20litres/day can be covered by rainwater quality and ...approximates the amount which can be saved in the house appliances like the combined washing basin and toilet. In case of very dry and hot outdoor conditions the process air can also be humidified directly deploying the most simple and effective regulation of indoor temperature and humidity in summer.
The latent heat contained in the air can be extracted in an open sorption process. The liquid desiccant used is an aquoes Lithium-Chloride brine with a floating concentration between 0.40 and 0.25 kgLiCl/kgWater. Its dehumidification potential can be used at any temperature below 30°C. In comparison to conventional system which cool the air down below the dew point it is avoiding highly entropic conversions via electrical and mechanical energy .
The desiccant has to be dehumidified in order to regenerate its absorptive capacitiy. The most superior quality of a LiCl-based sorption is its moderately low temperature of 50°C for desorption. It is therefore the optimal desiccant in a hot water system that is fed by solar thermal collectors because the regeneration can be operated also at mediocre outdoor conditions.
Another quality of the LiCl-brine lies in between these complementary steps. The liquid water's corresponding chemical potential can be stored loss-free in the brine tank. It can be buffered until the vacuum tube collectors are working most efficiently close to the maximum η0=68.7%. This also serves an optimal utilised capacity of the hot water system.
The complexity of the state-of-the-art system could be reduced in many details: natural backflow is installed in three systems, saving three pumps and a heat exchanger. The single brine storage tank for all different concentrations avoids another heat exchanger and reduces complexity in the plumbing system. The sensible part of the sorption energy which heats up the brine tank is cooled for free by the water used in the adiabatic evaporation which is not effected negatively by that.

Energy analysis of the house

For a sustainable energy concept it is inevitable to evaluate the loads of the building as accurate as possible to dimension the components only as large as necessary. The first attempt was a static calculation according to the VDI 2078 (standard for cooling load calculations of the Association of German Engineers) which is the common approach in the design



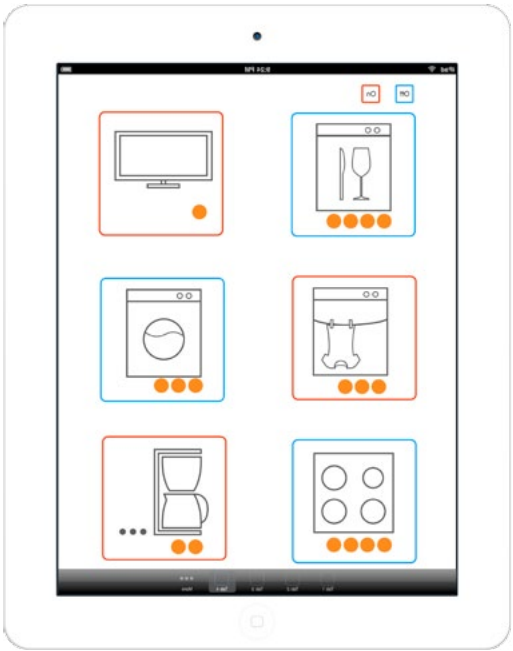
Schematic diagramm of the Dymola simulation

process for new buildings.
To model the dependency of the innovative technologies of the Counter Entropy House a more detailed dynamic simulation was required. With the help of the modeling-language Modelica, the complex behavior between weather, envelope, room air, air handling unit, storages and solar collectors was combined in one physical model. This way detailed performance characteristics of single components and the entire house during a typical year in Madrid and Aachen were obtained.

Energy saving appliances

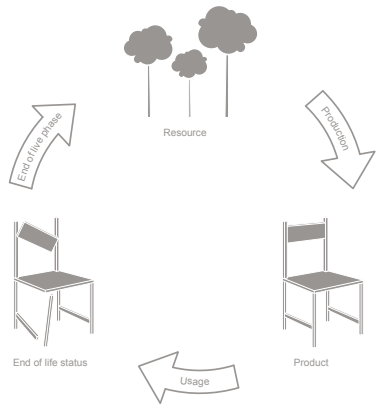
The prefabricated appliances of the house work very efficient. All white goods have the highest energy efficiency class available to save electrical energy. Furthermore the dishwasher and washing machine are supplied by hot water from the solar system so that electrical heating of cold water inside the appliance is avoided. The iPad app recommends the use of the domestic appliances in periods with high energy yields.
Special features of the bathroom is the combination of toilet and sink. It uses waste water from the sink to flush the toilet instead of valuable potable water.

Control System

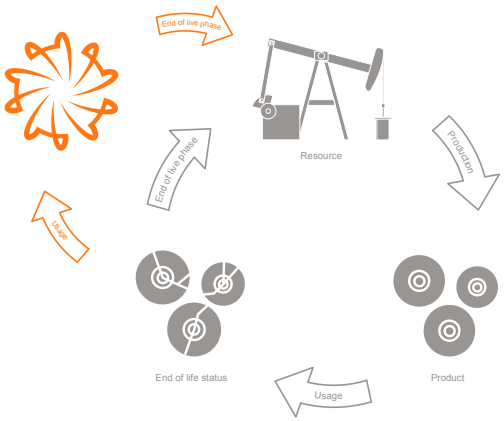


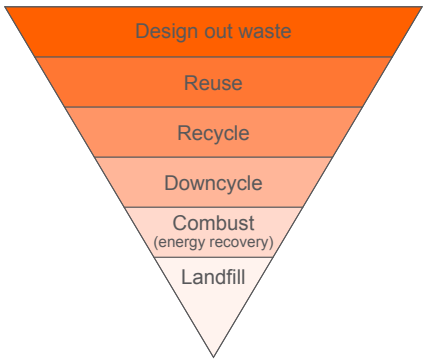
Draft of the iPad app

Only one central control unit manages all information of every sensor and actor of the house. This leads to a great deal of possibilities that a common control system with prefabricated decentralized control units cannot offer. Every part of the control is programmed uniquely for the Counter Entropy House so that all components are perfectly adapted to each other.
It combines different domains of home automation like air conditioning, energy generation and storage management, light and presence recognition amongst others. This offers advanced automated behavior like recommendations when to use the washing machine and dishwasher or room temperature adaption during absence of occupants. Detailed graphical presentation of operating conditions with temperatures, actuator positions and charging levels provide an overview for project commissioning and error detection.
A custom made iPad app is connected via WLAN to the control unit and can be used to operate climatic functions. The app accesses the control unit's data and provides the occupant with a brief and comprehensive summary of relevant information. This leads to an economic user behavior by choice without restricting the freedom of the occupants.



Usual lifecycle of a product





Quality level of of unused material
(Source: GRANTA Design)

Environmental catastrophes – scarcity of resources – global and local injustice – this is our world's state and it's worsening every day. Today's paradigms call for an urgent shift towards a way of human living and consumption that is designed to comply with our planet's essential limitations.
Late but irresistible this shift is taking place and the "Counter Entropy House" tries to merge the most striking aspects of sustainable development to an overarching design concept. These aspects concern the three phases of a product lifecycle: production, use and end-of-life.

production. All three phases must be implied in the early design of a new product. For a long time the environmental impacts of the production process were systematically ignored, because there is no direct link to the later user. But for most products this phase causes by far the highest ecological impact and therefore must be a focus of "Counter Entropy".

use. Obviously products like household appliances have to be as efficient in use as possible concerning electrical or thermal energy input. But products must also fulfil their functions as well and long as possible. Otherwise they get replaced and thereby increase the overall environmental impact. Thus, enhancing a product's lifespan is therefore a very effective way to improve the global balance of energy and resource efficiency. The "Counter Entropy house" brings old products back to life and thus defines a new, enhanced product lifecycle.

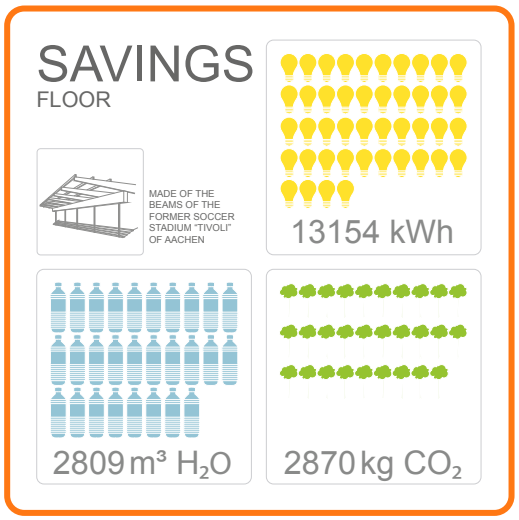
end-of-life. If the design also allows for a strict segregation of included materials, residual waste is avoided. Recycling and Reuse offer potential savings equally high to the production impacts of virgin material. That is why "Counter Entropy" leads to a clear hierarchy, shown in the figure on the left.

counclusion. After two years of working on the "Counter Entropy House" the team draws the conclusion, that often the described theory around "Counter Entropy" is at least intuitively well known. The real problem seems to be building up an infrastructure of knowledge and let everybody be part of it. Habits can only change if relevant information about product impacts on the environment are easily accessible by the user. The "Counter Entropy House" tries to rise this awareness through bracing approaches.

During the demolition of the "Tivoli"

The "Tivoli" beams after the demolition

Sawing the former "Tivoli" beams to wooden floor boards



Savings floor

Sustainability in architecture and material

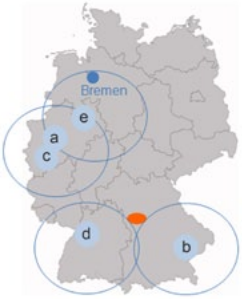
Regarding the idea of "Counter Entropy" the choice of material is a main aspect of the house, concerning the architecture. Due to regulations it was not possible to reuse material for the construction so the team mainly concentrated on non- bearing material. Still the use of composite materials was avoided and replaced by construction principles that can be easily disassembled.

Examples for upcycling in the "Counter Entropy House"

floor material. The city of Aachen recently got a new soccer stadium. Thus the old one was torn down in autumn 2011. The team had the idea of reusing the old beams of the stadium as floor material. However, first of all, they had to be tested for pollution. Although these beams were used in a public building from 1980 the team received a certification that the material does not include harmful substances. Under this prerequisite and with permission of the city of Aachen, the students could saw the huge wooden beams to manageable blocks. The former „Tivoli-beams" got sawn to panels, oiled and are used as wooden floor in the "Counter Entropy House".

facade material. Since CDs are replaced more and more by other media like USB-sticks, mobile phones and others there is a big amount of recyclable material available on the market. Furthermore, CDs are basically nothing more than coated macrolon which can easily be used as facade material. Therefore the team had the idea of reusing it. The facade consists of about 46.000 CDs which were partly collected thorugh public events and by recycling centers. After the coating was removed by an external recycling firm the pure macrolon was left and could be shingled and melted together to panels in a heating cabinet. Old shelf elements were used as baking sheets.

interior material. A lot of furniture gets thrown away though it can still be used. Therefore the team had the idea of collecting wooden boards from bulk rubbish to use them for the inner boxes of the "Functional blocks". Furthermore, fail produced particleboard was collected from local carpentries.
For the supporting parts of the freestanding furniture plywood from old packing boxes is used. Truck tarpaulin covers the furniture holding the single boards together.



Come-or-bring decisions

Elemental technical components
a) air handling unit
b) cooling ceiling
c) Fuse panel
d) Hot-water tank
Solarthermics
e) Photovoltaik
Windows, incl. entrance door

Youtube channel "Re-Use TV" – revealing in short movies the idea of reusing objects in a simple and innovative way

pen as merchandising product – provided with the "Re-used by "Counter Entropy" sticker

Sustainability in industrialization and market viability

To validate the house's market success, the team set up a business plan for the fictitious company Counter Entropy Ltd.
To optimize its sustainable supply chain Counter Entropy Ltd. launches an online network of suppliers. This database connects potential material suppliers like f.i. recycling depots to each other. The platform facilitates and simplifies the logistics around reusable or recyclable materials and is linked to the virtual house configurator offered to customers on the website. Based on current material supplies it makes suggestions to customers. In logistics, come-or bring decisions have been made to minimize emissions. Moreover, transportation as combined cargo not only reduces costs but also makes its contribution to less emissions. Of course, all packaging materials consist of biodegradable compostable products and therefore help to protect the environment and safe costs for the business.

Sustainability in Communication and Social Awareness

The communication concept is defined by the idea of "Counter Entropy" which for that instance results in saving resources and energy. Correspondingly, the team primarily communicates via digital media, such as the homepage, Facebook, Twitter or videos on YouTube, instead of using traditional print media.
Thus mainly the homepage is advertised to get information about the competition and the project. A lot of flyers are usually thrown away instantly. To reduce this waste production and the overwhelming information input the students decided to mainly advertise the brand, respectively the logo and homepage by durable advertising objects like a banner or buttons. Therefore the team is focusing on catching the people's attention by unique events for a broad audience following the idea of "Counter Entropy", incorporating that in every aspect. They also decided not to produce extra merchandising products, but to convert objects, like pens, by providing them with the "Re-used by "Counter Entropy" sticker.

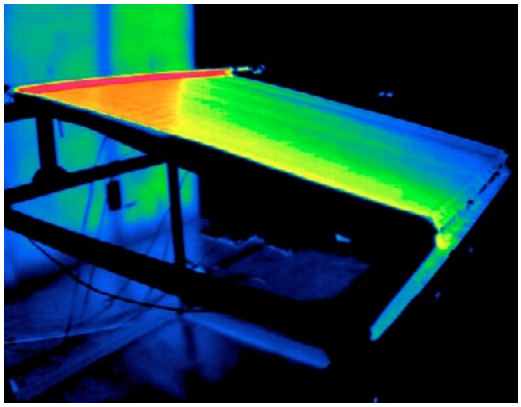
Sustainability in Engineering and construction

Following the idea of "Counter Entropy" during the house's construction process the team avoided the use of composite materials and rather used construction principles that can be easily disassembled. Furthermore the whole house is recyclable and over 90% is made of re-used, recyled or renewable resources.

Sustainability in technical equipment

Installation of the Air Handling Unit

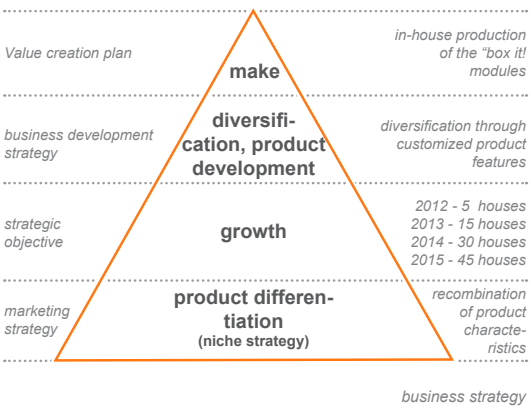
Entropy production corresponds to the destruction of usable energy and takes place in any process happening. On the other hand access to usable energy is the key factor of modern societies. Therefore a “Counter Entropy” culture has to emerge: Reducing entropy production means making best use of available resources. Entropy is particularly produced during conversion processes of different energy forms and heat transfer at high temperature spreads. Accordingly the main technical “Counter Entropy” design principles have to be:
1: Avoid energy conversions if possible. Conventional building technologies use several preliminary energy forms to reach the final energy. However it is much more efficient to gain heat and cold directly through natural thermal sources.
2: Use thermal energy with temperatures close to the surrounding temperature. Temperatures for the user’s final application are usually near the surrounding temperatures. Never the less process temperatures in building technology are often far too away from the latter. The “Counter Entropy Team” found many innovative technologies to diminish this inefficiency and ban a heat pump completely. In effect the whole “Counter Entropy House” is working passively according to the Solar Decathlon Europe 2012 definition.

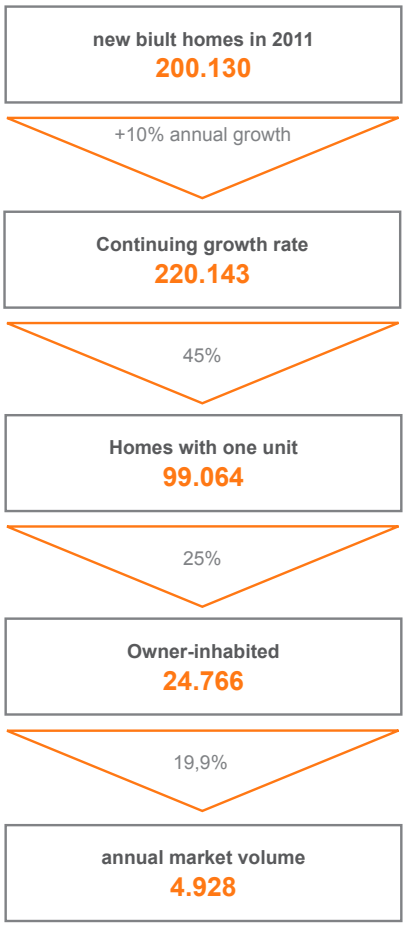


Thermography of a testing panel for the NRC

components. In the installed nocturnal radiation cooling system water is sprayed onto the photovoltaic elements at night, exchanges radiative energy with the cold nocturnal sky and cools down to 12°C. The cold is stored mainly in a reused water-paraffin PCM-dispersal (phase change: 16 to 22°C). This pumpable latent heat storage medium is at day used in the cooling ceiling and allows for a 59% higher cooling density than water. The second half of the cooling load is deployed by an Air Handling Unit which is developed exactly to the house’s needs. It includes an adiabatic evaporative cooling where water is sprayed into the air stream and is able work at an EER of 7.1. The water usage of only 20litres/day can be covered with rainwater quality. The latent part of the air’s heat can be removed by an open sorption process using a liquid LiCl-brine. This phase change potential is buffered loss-free until the desiccant can be regenerated most efficiently by vacuum tube collectors(η0=68,7%).

building automation. A self-made iPhone-App continuously informs residents about current demands of energy and encourages them to adapt their demands, like f.i. running the washing machine, to the systems capacities.





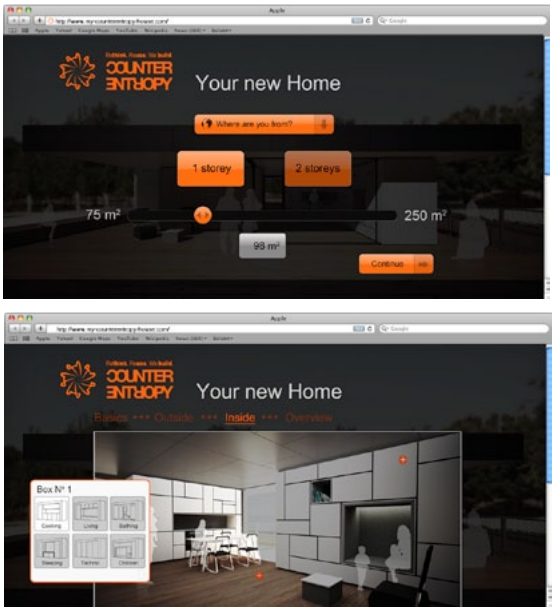
derivation of market volume

Business Planning

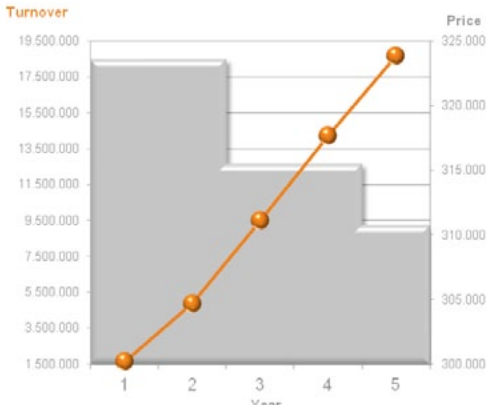
To validate the house's market success as a product, the team set up a business plan for the fictitious company Counter Entropy Ltd. The Counter Entropy Concept is consequently applied at each stage of the production and marketing process and results in an innovative business model.

product. Each and every component in the house has been selected carefully based on a thorough **life-cycle analysis**. Never before has there been a prefabricated home that combines exclusive architectural design and finishing with **reused and recycled materials** as elegantly as the Counter Entropy house does. The house is full of innovative solutions to take the combination of comfort, flexibility and ecological performance to the next level.
The wide range of the house´s flexibility, modularity and adaptability offers the possibility of addressing different target groups and markets. The team conducted an extensive business environmental analysis before defining the main target group as **young design-focused couples** with a sense for energy efficiency and an economical and considerate exploitation of resources. These attributes are fulfilled by 19,9 percent of the German population equivalent to an annual market volume of 4.928 houses. Competition within the market is limited since no competitor offers the same mix of product features. Hence, Counter Entropy Ltd. is applying a **product differentiation strategy** and thereby occupies the market niche of recyclability and modular construction.

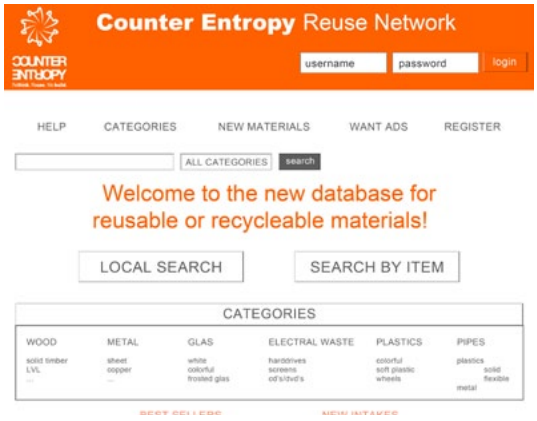
The sales market can easily be extended by families, older or disabled people. Especially for these groups the „Counter Entropy House" displays advantages as a single storey house. Besides, **horizontal expansions** that result in extensive residential structures facilitate **multi-generation living**. With regard to demographic changes, this aspect presents a competitive advantage. Living in today's performance-oriented society, people yearn for safety, security and constants in their private life. The Counter Entropy House is a place of rest, a retreat where mental balance is found and energy for everyday life can be charged. Certainly, an association with these terms is as individual as people themselves, but therein lies the advantage of the Counter Entropy House: it is as **adaptable, individual and flexible** as the people themselves. Moreover globalization requires workers to be extremely mobile and flexible. Here again, the Counter Entropy House displays an advantage by offering the possibility of a quick



virtual house-configurator



financial bottom line



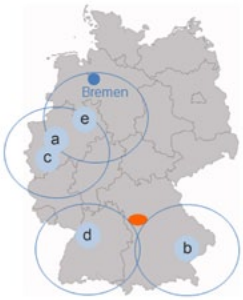
Counter Entropy Reuse Network

and easy relocating based on **modular construction**.

sales and customer service. The company developed a unique e-commerce concept. As part of its website, Counter Entropy Ltd. offers a **house-configurator** to enable its clients to design their virtual dream house. By means of the sophisticated distribution system the company predicts to realize a sales volumes of 5, 15, 30, 45, 60 houses each of the first five years of operation. The product's selling price will be continually reduced over time, but steadily position the house in the upper price range of the market due to its wide competitive advantages.

financial management. Production is done in-house. Within the first 5 years a sum of 5.800.000 euros are to be financed. The majority is covered by an ERP start-up loan, contributions of the venture capitalist Rock-PortCapital, the High-Tech Gruenderfonds and a 100.000 euros investment made by the founder. In a nutshell, the chances associated with the foundation of Counter Entropy Ltd. overweigh the risks. Among other aspects, the house's costs of sales will significantly decrease over time while sales volumes are very likely to increase. According to the extensive analysis carried out by the team the company will **break even in the fourth year of operation**. Already one year later, profits after tax of 2.118.769 euros will be generated. Last but not least, the innovative concept developed by Counter Entropy Ltd. bears the potential to expand bejond th German market in the future.

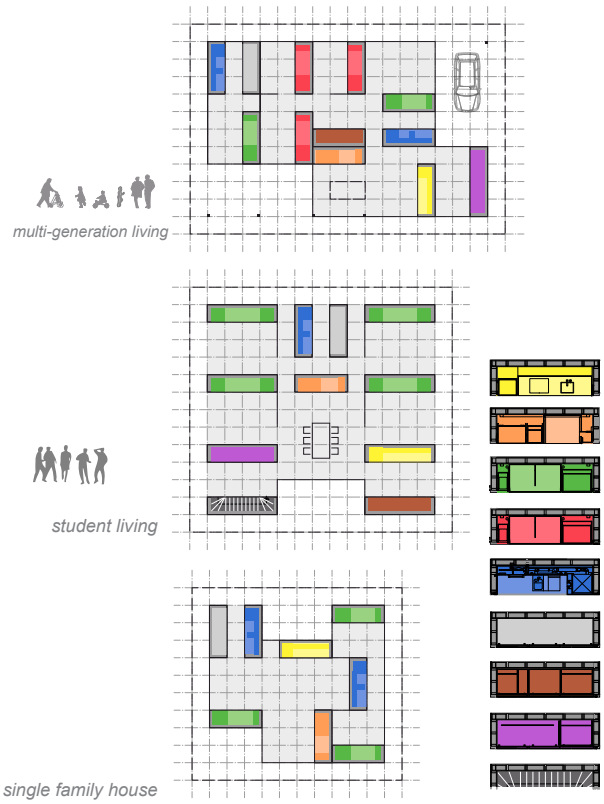
supply chain management. A consequent application of the Counter Entropy concept in procurenment involves an active management of reusable material supply. Counter Entropy's supply chain management strategy has the potential of becoming a **trendsetter for the global prefababrication industry**. nearly the whole interior and exterior is made of reused materials, as Counter Entropy focuses on the use of **green, recycling or reusable materials**. For these kind of materials supplies are hardly predictable and therefore a bottleneck is likely to occur and cause time delay. To nevertheless guarantee a fluent and solid supply chain **Counter Entropy Ltd. launches a network of suppliers**. This database connects potential suppliers of reusable materials like f.i. recycling depots to each other. This way, Counter Entropy's architects and building contractors get an overview of available building materials. The platform facilitates and simplifies the logistics around reused materials and is linked to the virtual house configurator offered to customers on the website. Based on current material supplies it makes suggestions to customers.



Come-or-bring decisions

Elemental technical components
a) air handling unit
b) cooling ceiling
c) Fuse panel
d) Hot-water tank
Solarthermics
e) Photovoltaik
Windows, incl. entrance door

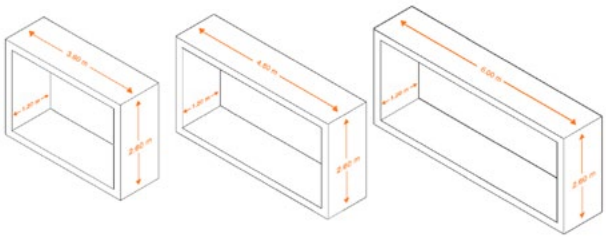
Brand Community Blog



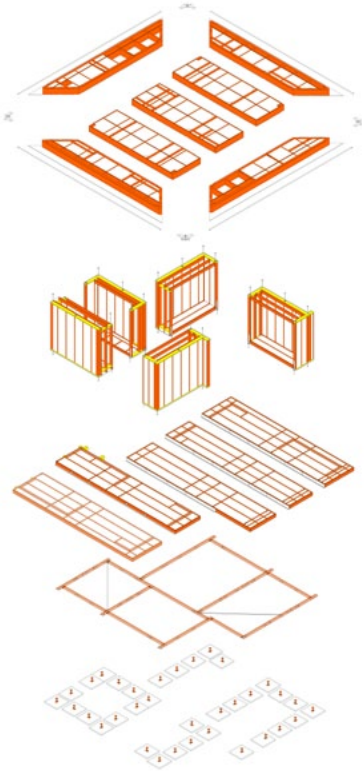
logistics. To minimize emissions at every stage of the supply chain, come-or bring decisions have been made. In case a customer orders a house in a region within the radius of a supplier, the component, for example a water tank, is delivered directly to the customer‘s site instead of being delivered to the Counter Entropy plant first. Moreover, transportation as combined cargo not only reduces costs but also makes its contribution to less emissions. Of course, all packaging materials consist of biodegradable compostable products and therefore help to protect the environment and safe costs for the business.

brand community management. Another innovative feature of Counter Entropy‘s marketing strategy is the management of an active brand community through its website. Thereby “Counter Entropy“ in fact can become a lifestyle. Several interactive features feed the interaction between customers on the **internet platform**. A photo gallery encourages customers to upload pictures of their “Counter Entropy House“, self-made modifications in the interior design, etc. A forum allows users to exchange experiences of all kind. Now and then the company invites its customers to events and roadshows as another possibility to interact with others and to learn about Counter Entropy‘s new product developments. Moreover, once a year the company runs a competition. Customer can apply by submitting pictures and descriptions of self-made designs based on reused materials. The best interior design or furnishing idea is honored with the “**Counter Entropy Award**“. Through all these activities, Counter Entropy Ltd. hopes to spread its vision and establish **customer brand loyalty over the long term**. Thereby the company becomes an integral part of customers‘ life, quickly responding to evolving needs and adapting easily to changing user requirements over the course of a customer‘s lifetime. Moreover, by the help of the internet platform the customers are not only able to design and buy their dream house but also their awareness for energy efficiency and an ecological, economical and considerate exploitation of resources is raised.

degree of industrialization. the “Counter Entropy House” presented at the “Solar Decathlon Europe 2012” is a prototype. Concerning industrialization future residents can design their own dream house and chose between different materials, functional block, degree of building automation etc. In general, the functional blocks form the basis of every house. They include the furnishings and serve as primary structures.

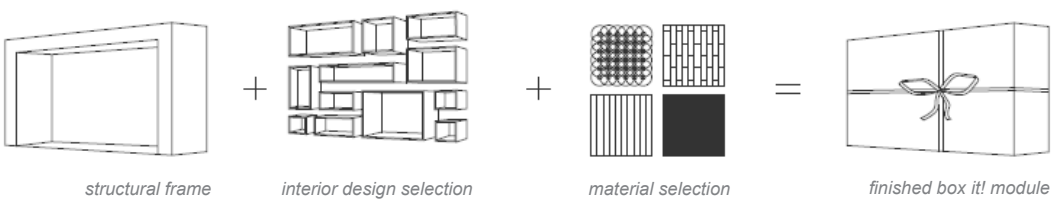


Different sizes of Box it! modules - S - M - L

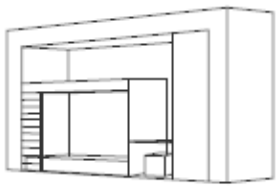


Each block relates to a specific part of the house. Thus, in the “basic house”, there is a kitchen block, a living room, a sleeping area, a bathroom, and a block for building services. Since a broad product range reaches a larger target market and offers a higher degree of individuality, “**box it!**” modules can be customized with regard to functionality and material.

Apart from the SDE, some adaptations are necessary to reach an efficient degree of industrialization resulting in mass production at a later point in time. The static system is based on a 1.2x1.2m grid offering uncountable possibilities for designing the layout of the house. The “box it!” modules connect floor and ceiling. All modules, besides their interior finishings, are produced as standardized products in an industrialized production process. As the primary material is wood, it is easy to prefabricate the blocks in a carpenters´ workshop. During construction insulation is placed in-between the structural layers of the block. In a last step the vacuum insulation panels are installed at the block´s outside surfaces. Afterwards they are covered with soundproofed insulation boards for transportation purposes in order to protect the insulation layer. Now, the pre-fabricated blocks can be equipped with interior finishing and accessories. Similar to the “Box it!“ modules the roof and floor elements are entirely prefabricated in a carpenters´ workshop. Only the finished floor may differ as the customers can choose between various designs.

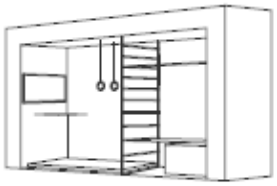


structural frame *interior design selection* *material selection* *finished box it! module*

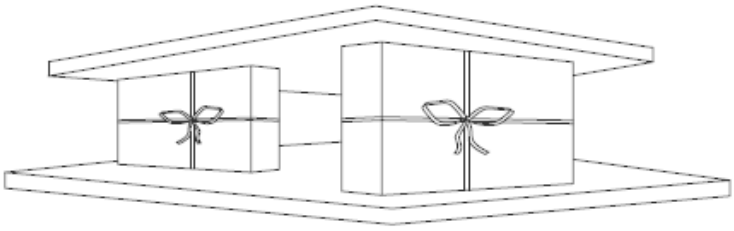


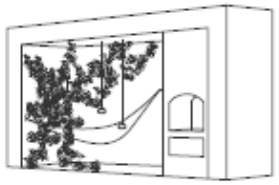
Children´s room

shipping



Sports





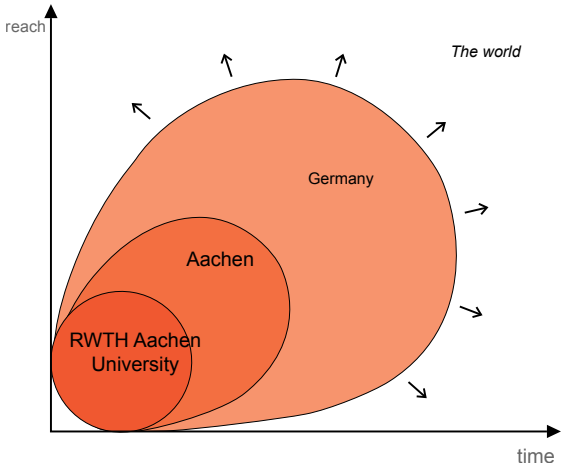
mission. The construction industry is responsible for 40% of worldwide greenhouse gas emissions. This shows the large potential embedded in the minimization of energy consumption in that sector.
Our Concept is based on an energy-optimized life cycle approach. We evaluate a component's environmental performance during its production, transportation and assembly as well as its recyclability after the utilization phase in the "Counter Entropy House". Secondly, based on technological innovation we create a self-sufficient intelligent housing machine running solely renewable energy. The third part of the concept is to communicate the fact that sustainability is no longer in conflict with high quality living and design. This is where the communication plan steps in.

communication strategy. The Counter Entropy team wants to raise awareness of global ecological challenges and communicate our unique solution as an example and inspiration for meeting these challenges. We thereby want to convince people of ecological living and make them rethink their behavior concerning energy consumption and product life cycles.

name. The term "Entropy" describes the disorder and chaos underlying a physical system. In the context of our house it refers to the disordered one-way life cycles of products and materials. By rethinking the current usage of objects and by giving product life cycles an ordered structure, we want to raise the full energy potential embedded in materials and objects. The name "Counter Entropy" describes this strategy of minimizing entropy with reference to the materials and building processes of our house.

logo. To establish a visual identity for our brand we use a logo. It consists of the writing, a symbol and a slogan.
With the writing style we want to picture the chaotic meaning described by the word "Entropy". Moreover, the viewer's interest is captured in this way. Orange was chosen as brand color because it connects to solar energy usage very well and has a positive warm appeal. By that, the color helps to emphasize our brand meaning.

symbol. In addition to the writing, we use a symbol to raise brand awareness. The symbol is very rich in imagery. First of all, it reminds of the sun, which is, as known, the center of our energy concept. This association is enhanced by the choice of color as mentioned above. The sunbeams represent the ten disciplines of the Solar Decathlon Europe. Moreover, the round shape links to the integrated life-cycle view that guides the team's design process and material choice. In addition,



Regional dissemination of information in the course of time

Rethink. Reuse. We build.

Team Slogan

Target Group	1.	2.	3.	4.	5.
Public	x	x	x		
Kindergarten		x	x		
School	x	x	x		
Young people	x	x	x		
Adults	x	x	x		
University	x	x	x	x	
Employees	x	x	x		
Students	x	x	x	x	
Students of our team				x	x
Partners and Sponsors	x	x	x		
Media	x	x	x		
SDE Organization			x		

Target groups and communication objectives

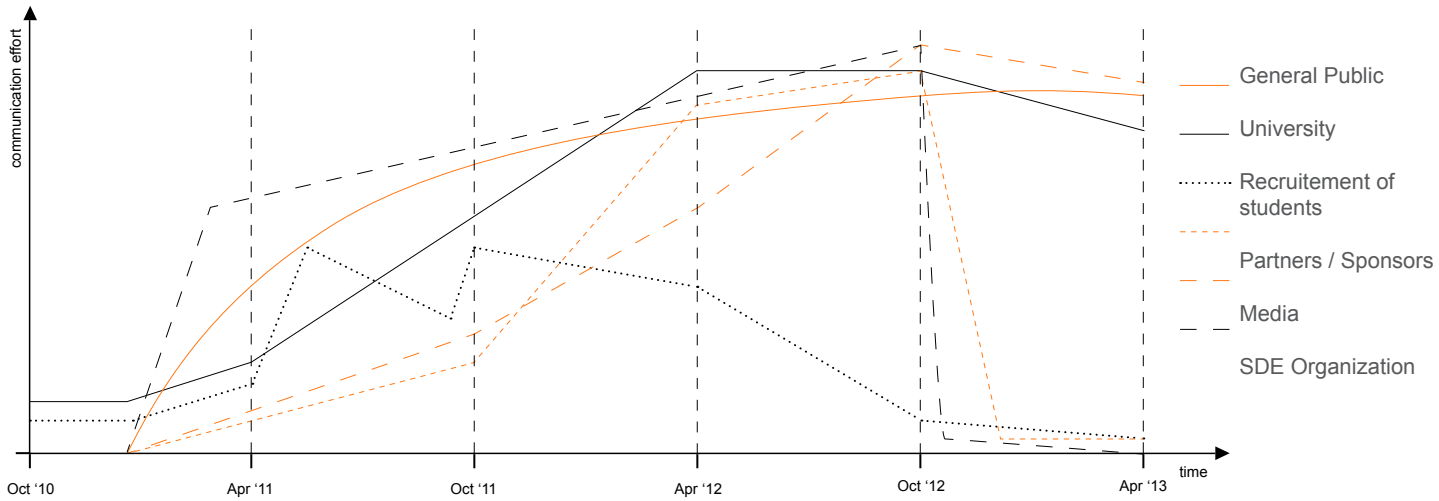
the symbol has a very dynamic appeal which represents the motivation and energy the students put into this project. Apart from that it performs very well in terms of likability and memorability. Moreover its compact round shape allows a practical reproduction of stickers and buttons.

slogan. The slogan finally ensures that everybody grasps the meaning of the "Counter Entropy" brand. "*Rethink*" describes our idea of reconsidering the end of product life cycles. "*Reuse*" is the strategy that results from the rethinking phase. By reusing and recycling we minimize the primary energy consumption of the materials and objects used in our house. "*We build*" expresses what we acutally do in practice based on the "Counter Entropy" design strategy. The word "*We*" has a motivating and energetic appeal and emphazises our team spirit. It, moreover, resembles in sound and pronounciation the first syllable "*Re-*" of the other two words used in the slogan.

Communication objectives

1. **Increase Popularity of the Solar Decathlon**
2. **Raise awareness for ecological building and living**
3. **Advertise the „ Counter Entropy" brand**
4. **Recrute Students for the team**
5. **Audit and improve the internal communication**

Each target group has particular interests.Therefore groups have to be reached in different ways. Eventhough they coincide, it is important that specific target groups are approached at certain time and place . Therefore events have to be coordinated, the way that every group is adressed.



communication channels. In general, of course, the team tries to adress as many people as possible. In the first few months we concentrated on anouncing the SDE and the “Counter Entropy House” in the wider area of Aachen. We publicized the SDE on a regional level trough broadcasts on radio and television. Moreover, the project is continuously presented on Facebook, YouTube and Twitter to reach an international level.

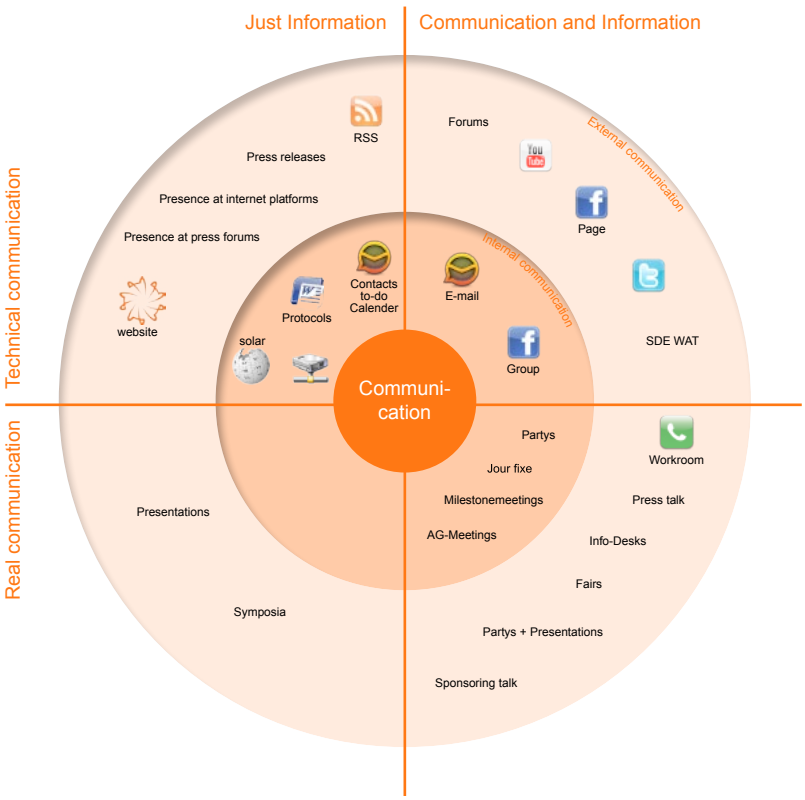
We had a group of Kindergarden kids visit our construction site in Jülich a few weeks ago.
Two team members went to a school in Aachen to give a presentation on the project, recycling and environmental issues in class.
Through posters, contests and seminars the team tries to involve students from other faculties in the project.

The project would not work without sponsors and partners. We advertise the project to our partners through sponsor portfolios, which inform about the project, invitations to fairs and festivities and keep them up to date by mail and phone.

The media is a special target group. Radio, TV and internet give us the opportunity to get in touch with the public. First the PR-team refered to regional media stations. In the second step the circle was extended to bigger and more influencial media stations.

The SDE organization is a special target group. It is very important for us to keep the organization up to date and give and receive feedbacks.

Promotion strategy Promotions follow the general resource-saving concept of “Counter Entropy“ just as all other



Communication channels

Target Group	Homepage	Fairs	Local journals	Architectural journals	Lectures	You-Tube-Channel	Re-UseTV	Social Networks	Partys/ Festivities	Radio/TV	Merchandising	Actions in Aachen	Teambuilding	Blogs/portals
Public	x	x	x			x	x	x		x	x	x	x	x
Kindergarten														
School						x	x							
Young people	x					x	x					x		
Adults	x		x			x	x			x	x	x		x
University	x		x		x						x	x		
Employees	x		x		x							x		
Students	x		x		x	x			x	x		x		
Students of our team	x								x		x		x	
Partners and Sponsors	x	x	x	x		x			x	x	x			x
Media	x	x	x	x						x				x
SDE Organization	x		x			x								

Communication channels and target groups

project activities do. Correspondingly, to minimize paper waste, we primarily communicate via digital media, such as the website, Facebook, Twitter or videos on YouTube, instead of using traditional print media.
Nevertheless, to distribute them on fairs and public events we printed flyers on ecological paper. To raise brand awarenes we created buttons, showing our logo. These were handed out, always combined with information about the competition and our project. Due to the fact that some people need more and other less business cards, we decided to print uniform business cards on ecological paper for everyone. So we will not produce more than needed and save resources that way.

Merchandising products

reuse in promotions. According to the reuse-strategy of our Counter Entropy concept we decided not to produce extra merchandising products, but to convert objects, like pens, by sticking our “Re-used by Counter Entropy“ sticker to them.
To recognize us as a team we created teamshirts that wear in everyday life situations and at team-, promotion- and information events. For the second t-shirt we used shirts we already had, illustrating our “Re-Use“ concept.

reuse TV. “Re-Use TV“ can be regarded as a serial video concept that reveals the idea of reusing objects in a simple and innovative way.
Several team members present in short clips how to create new useful objects out of old products which are no longer in use. In each video an individual instruction and the needed materials are given. The presenting person explains and demonstrates the steps of converting reusable objects

Wallet made of beverage carton

Bag made of film reel

Lamp made of plastic bottles

note dispenser out of an old book