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Innovation Report

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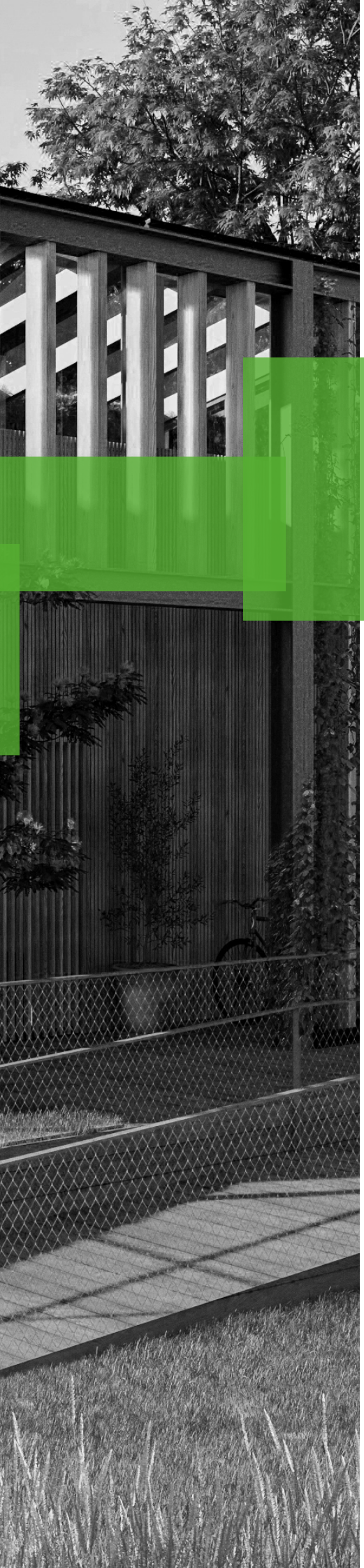

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Architecture

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Renovation and Addition of Storeys

Our system is designed to be flexibly applied to typical residential buildings from the 1950s to the 1970s. It offers the expansion of living space and provides multifunctional and communal indoor and outdoor areas, creating new social hubs for the community. The system is based on a grid that allows flexible adaptation to different building lengths and widths. The uniform wooden modules define the grid spacing and are positioned between the staircases. This flexibility creates compensatory areas that can be used as communal areas. Two storeys in timber module construction form the living areas of the addition. The prefabricated modules will be delivered to the building site and fully equipped. They are designed for the optimal transport size of a truck. The ceilings and floors are box girder elements, filled with recycled filling made from the shredded roof tiles from the existing building, ensuring a high level of sound insulation. Another advantage is the resulting large spans of 7.50m with a meagre material input. The modules do not require load-bearing interior walls that enable an open floor plan with a flexible interior design. The garden facade will be given a new exoskeleton structure that includes stairs, elevators, balconies and arcades. The entire system is covered with greenery. The new lifts ensure barrier-free access on all storeys of the addition and in a large portion of existing flats. All flats in the new storeys are barrier-free and adaptable to the users' needs. The existing building is renovated for energy efficiency with prefabricated timber façade elements. The renovation includes a LowEx façade heating system to do the energy renovation without interfering with the existing flats.

House Demonstration Unit (HDU)

Our HDU shows a modified section of the Design Challenge - changes resulting from the guidelines of the solar envelope. The competition area is entirely accessible, both the interior and the attic. The visitor can experience all rooms and innovative products independently.

A vacuum hybrid glass replaces the triple insulating glazing. The glass structure consists of two float glass panes with a vacuum in the space between the panes and an additional pane with a space between the panes of 12 mm argon gas filling. The Fineo HYBRID has a U-value of 0.4 W/m^{2}K, and thinner glass thicknesses can be realised than triple insulating glazing. Our university was involved in the invention of beech wood nails together with the Beck Fastening company. These are approved and used for glue-free and mechanical connections on the HDU. They fasten the diagonal formwork to the modules and are also used for securing the timber façade. The timber nails have a low environmental impact during manufacture and allow simplified deconstruction at the end of the life cycle. A unique feature of the interior design is the modular bathroom system. It is using a timber frame system with an easily demountable waterproof wall cladding of Resysta boards. Due to the easy dismantling on the room side, pipes and lines are freely accessible for maintenance or repairs. All seals are separable by type without adhesives. This LVL stud system with all pipe penetrations and connection fittings already pre-milled at the factory can respond to the most diverse floor plans as a modular „planning kit" with a high degree of industrial prefabrication. Retrofitting to the user's needs can be implemented without difficulty, and a turning circle of 1.50 m for barrier-free access is also guaranteed.

The kitchen unit and the free-standing kitchen island are accessible from underneath because the base units are made as mobile containers. The free-standing kitchen island can also be individually adjusted to the standing or sitting height of the residents using lift motors. The wall partition between the living room and the bedroom is designed with three roll-out laundry containers on both sides in the lower area. In case of use by wheelchair users, this enables the necessary accessibility underneath.

Lighting solutions are becoming smaller and often consist of more than one component per room. In addition, the increasingly widespread wireless protocols for controlling lighting components make it possible to think in terms of lighting scenes. Today, modern housing construction must offer solutions beyond the one ceiling outlet usually located in the centre of the room. Within the project's scope, a large number of the floor plan and furnishing variants were therefore examined, and possible positions for recessed, surface-mounted or pendant luminaires were identified. At these points, a self-developed mounting box is permanently integrated into the ceiling, which can then be activated by the respective users as needed. The mounting box, fitted with a blind cover and barely noticeable in the ceiling structure, is realised in 3D printing. Downlights for general lighting or a pendant luminaire for targeted illumination of a table can be attached. The electrical contact is ensured via a standardised GU10 base. These electrified mounting boxes are sensibly pre-grouped according to their functional context in the building automation system. The system implemented in the HDU avoids the subsequent drilling of ceilings and the distortion of cables. It allows users to create individual lighting solutions with little effort.

The three PV systems generate a balanced load profile throughout the day and thus reduce the required battery storage capacity. The double use of the surfaces is essential: Semi-transparent PV modules generate electricity and provide shade in the greenhouse. In addition to electricity, PVT modules generate heat during the day and cold at night via radiation. This reduces the energy demand for heating water, and the cold is used for room conditioning during the day via underfloor heating. Also, cell efficiency is increased by heat transfer. The architectural design thus enables an innovative and affordable use of solar technology beyond

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Engineering & Construction

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Heating and Domestic Hot Water

One of the primary goals of the levelup team was to develop a widely applicable and transferable concept. Thus, the energy concept has to allow for various renewable energy sources. The levelup solution is a facade heating system integrated into the curtain wall used for insulation of the existing building part.

Using facade heating has four key advantages:

- The maximal flow temperature will be as low as 25 to 28°C. The façade heating delivers a base heat load to keep the room temperature at about 17°C to 18°C, and the existing radiators control the individual room temperature to the user‘s need. Due to the small remaining heat load, they can be operated, depending on their original design, in most renovation cases with flow temperatures below 35°C.

- The low supply temperature of the heating system is compatible with any heating supply system and increases, especially with heat pumps and thermal solar systems, efficiency significantly. Thus, the concept is adjustable to any building location and energy availability.

- The façade walls, with their large storage capacity, become thermally activated. Adding the insulation creates a thermally extremely inert heating system. The walls will cool only by about 1 K in four days without heating. Thus the heating can adapt to the needs of the supply grid and the fluctuating availability of renewable energy sources. Also, the thermal mass can be used in the summertime to keep lighter weight added storeys from overheating via passive cooling through floor heating.

- A low-temperature heating system can be installed without construction work in the existing apartments. This is a significant cost reduction and acceptance factor.

- At our location in Nuremberg, a district heating with a primary energy ratio and a CO2-emission factor of zero is available. Also, groundwater is accessible. A LiBr-absorption-heat-pump was introduced to the system with groundwater as a heat source to reduce end energy usage further. The heat pump reduces external heat demand for space heating by 40%.

A part of the rooftop PV will be PVT, used in two functions: heating support and passive cooling. It is used for the façade heating and preheats the DHW of the additional storeys in heating mode. Doing so, the PVT stays at low temperatures to keep the power efficiency high. In summer, during night time it is used to withdraw heat from the façade walls to keep them from warming up over the summer period. The PVT emits heat by two effects, radiation cooling to the night sky and convection at cooler night temperatures.

For DHW, the existing building part is equipped with electrical flow heaters. Introducing a wastewater heat recovery system in the shower drains saves about 40% of the heating power for the DHW. In the new building part, the effect of the heat recovery is reduced as the PVT partially heats the DHW. It is still essential to use it here, as it reduces the energy consumption at times without solar thermal energy.

For adaption to the all-electric HDU, a version of our system with an electric heat pump was used: the thermally driven heat pump was replaced by an electric one, which delivers all heat needed beyond the PVT supply. The PVT additionally functions as the environment heat source. A buffer tank replaces the storage capacity of the façade. The heat pump is the first one commercially available with the natural refrigerant propane (GWP = 3) for indoor installation.

Ventilation

The necessary ventilation system is designed with an innovative concept: a central ventilation system for the apartments supplies the fresh air only into the hallway. From there, the air is supplied to the rooms by CO2-controlled room-to-room fans. Keeping the ductwork limited to one room is a huge benefit for retrofitting ventilation systems. Additionally, the reduced duct length reduces the energy consumption of the fans.

Building Automation

Building automation can reach significant energy savings. However, it also comes with 24/7 energy consumption. Even when small, like 0,5 W per actor or internet connection, it will add up. Therefore it has to be used wisely and carefully to ensure the savings exceed the additional consumption. We use a 12 channel knx-actor/measuring system connected to an energy management system (EMS) with a standby consumption of a single actor. The system connects appliances and other electrical consumers to the EMS. They can be switched off to cut the standby consumption but are still available for excess PV power usage or grid demand. The built-in metering enables correct excess PV power usage with any connected device. Also, it tells the user the consumption of his devices, the state of battery charge, PV production, and finally, a house app will show rankings to engage the user in energy-saving behaviour. We calculated the smart readiness indicator (SRI) according to EPBD 2018/844 to be at least 77%. If all the predictive control algorithms in development are functional, it will be 91%.

The electrical wiring also follows an innovative concept. Switches are wireless with batterie free Enocean technology, and a plinth cable duct provides flexible placement of power outlets. This installation form makes the installation level obsolete, an essential effect for the indoor climate.
The installation level thermally decouples the room and wall. By removing it, the increased thermal mass stabilizes the room temperature and eliminates the need for cooling.

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Sustainability

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Circularity

The entire concept is based on the idea of „Design for Disassembly“. We are only using recyclable or recycled materials, and therefore, a fully circular economy is guaranteed. For this reason, we use among other things, LIGNOLOC® wooden nails from Raimund Beck KG, which enable single-material recycling after the product life cycle. The product is the world‘s first shootable wooden nail, saving 70 % CO2 compared to conventional systems, and was co-developed at the Rosenheim Technical University of Applied Sciences. It is the only fastening system that fully supports the requirements of the circular economy in terms of recyclability and has recently been approved for outdoor use. LIGNOLOC® is used to nail the diagonally installed, solid spruce sheathing on our solid glueless exterior walls.

Figure 1 - University President Prof. Dr. h.c. Heinrich Köster and Bavaria‘s former Minister for Housing, Construction, and Transport, Kerstin Schreyer shooting in the innovative LIGNOLOC® wooden nails with a compressed-air nail gun at the topping-out ceremony of our House Demonstration Unit.

Special mention should also be paid to the wall and floor claddings in the HDU’s bathroom, which is fixed entirely mechanically and does not use any silicone joint sealant. Using no silicone means that individual elements can be replaced quickly, and there is easy access to all pipes and utilities. Nevertheless, the bathroom is entirely watertight even though there are no sealant joints. We also want to point out that our timber construction comes exclusively from sustainable forestry. The wood is either untreated or treated with bio-based, VOC, and pollutant-free oils, which improves its cascading use before the end of its life. The furniture is made of 100 % recycled wood to reduce construction costs and increase recyclability. Easy repair of all furniture and spare parts is guaranteed. Especially exciting is the damage-free maintenance and replacement of pipes and cables because utilities are not buried beneath gypsum or plaster. The entire supply system runs in easily accessible maintenance panels. We use recycled Magna® glass for our kitchen worktop. Kitchen surfaces and bathroom wall and floor coverings are made from recycled rice waste. The entire building was fitted with clay wallboards, which are fully recyclable and ensure a very healthy indoor climate. In this manner, we avoid the use of cement and gypsum products. Our greenhouse is made of an ETFE (Ethylene tetrafluoroethylene) foil façade. The foil is lightweight, is less energy-intensive to produce than glass, and is fully recyclable. Our windows are equipped with the latest vacuum insulating glass from Fineo. Beyond the materials, we have also paid attention to sustainable building technology, such as a propane heat pump with a very low greenhouse gas potential compared to conventional systems.

Sufficiency, Flexibility & Environmental Performance

Durability is a decisive criterion for keeping raw material and energy consumption as low as possible. For this reason, all pipes in the building are accessible without damage through maintenance panels. In addition, the HDU has no sub-surface installed electrical wiring in the wall, as all switches and pushbuttons are operated by wireless. Wall and floor coverings can be removed and replaced as they are not glued. Wood is our primary building material and comes from domestic forests. The roof tiles from existing buildings, which will be removed upon installation of the addition of storeys, will be shredded and used as fill material. The material enables good sound insulation and avoids waste. All interior materials are moisture-regulating, free of harmful substances, and create a comfortable, even indoor climate. We can expand living space without sealing up valuable, undeveloped green spaces with our concept. On the other hand, we create new green areas through intensive and extensive ‘greening’ on existing buildings and the addition of new storeys. We create new natural habitats for small creators, birds, and insects, and biodiversity is increased significantly. Greening also creates a healthy microclimate, reduces CO2, and counters the urban heat-island effect. Here, ever-increasing dryness coupled with an increase in heavy rainfall often leads to drainage-system overloads. Moreover, the sealing of ground surfaces is affecting the natural circulation of rainwater. Collected rainwater from roofs can be used to irrigate the greenery and plants. The rainwater holding tanks are combined with greywater treatment systems to avoid wasting drinking water, especially during dry periods.

In terms of the buildings’ community and society, the flats are kept small, but there are communal areas on the roof to counteract any feelings of isolation. On average, 21 m^2 of living space is available per person, which is about half of today‘s average. In addition, all flats are barrier-free and therefore designed for a wide social diversity. The modular ceilings are all load-bearing, which negates requirements for interior load-bearing walls. This variable use of floor plans for different needs makes it possible to change layouts with reduced effort.

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Affordability & Viability

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Housing is a foundation of human life. It is a fundamental right that adequate and affordable housing be made for everyone, but in reality the implementation of this is very different. Let us make it a priority with redesign and added value of existing!

Affordability

The rents (9,50€/sqm) our residents pay will remain stable, as we believe that rents should not continue to increase simply for the fact that buildings are to become climate-neutral. Our energy and water concept offers potential operating cost savings for the residents. Our aims go beyond helping tenants reduce their ancillary costs and counteract the waste of energy and water. They also serve to encourage residents to adopt climate-friendly and economical behaviour in their lives. According to the Federal Environmental Agency, water consumption in litres per inhabitant per day was 129 l/E*d in 2020. The "levelup" system could save 49 litres per day, per capita. This corresponds to a savings of 58€ per annum in a 2-person household. Our building generates more electricity than it acutally consums. This enables us to generate, for each kWh supplied, a profit. The average annual consumption is between 2000 kWh - 3000 kWh and we are consuming 1991,60 kWh per flat. This shows very well that we use much less electricity and can therefore also significantly reduce the costs. Our construction costs for the renovation and addition of storeys amounts to 15,098,328€. One of many advantages is that no property costs are incurred, because no building land is required. This keeps undeveloped areas undeveloped and perhaps green. The higher the price of real-estate, the greater the economic advantage over new construction. The construction costs, plus the ancillary construction costs that amount to 15%, must be financed. The capital requirement to be financed is 17,363,077.20€, which could be financed by the investor with the help of a bank loan. Assuming that all flats are already rented out, the investor has already made a profit of 33,825.89 as of the 29th year, which amounts to 622.890€ in the following years. Another option is crowdfunding. Instead of a single person or entity investing a large sum of money to build, renovate, or purchase, a large number of individuals each make a smaller contribution to do the same thing. Depending on what is agreed upon, the crowdfunding investors earn returns corresponding to the amount they invested. Once the project is completed, each investor receives their investment back plus the predetermined interest. The concept of real-estate crowdfunding allows us to create an alternative that permits the investor to follow their project(s) closely in real time, even when dealing with smaller investment amounts - and with a fixed interest rate from the outset. Financing through the 'Kreditanstalt für Wiederaufbau' would also be an option, but this type of financing has been discontinued by the federal government state for the time being.

Viability

Our plan is to transform the outdated, energy-inefficient building stock of the 1950s – 1970s into attractive, innovative, efficient and affordable housing. The levelup team aims to conduct the development with an adaptable design which could not only be adapted in Germany, but also across the globe on using similar building stock. For structural reasons alone, timber construction is the building method of the future. The relatively low weight of wood allows for much more extensive additions to living spaces. The high degree of prefabrication of the modular construction system decisively reduces construction time. During renovation work and the addition of storeys, the impact on residents and neighbours is to be kept to a minimum. Only one intervention is needed in the existing flats, and no tenants are required to move elsewhere during the construction. Using our revolutionary levelup system could create over 1.1 million housing units on top of existing multi-family buildings from the 1950s - 1980s in Germany alone. New buildings already meet strict energy regulations, but existing buildings more than often do not. This is where energy-efficient renovation comes into play, which, in addition to the positive effect on the climate, also has financial advantages and offers modern comfort.
Considering the housing problem in Germany, the selected target group for the levelup strategy are residents facing extremely high rents and operational costs in relatively substandard flats. Our goal is to increase the quality of life of the residents in the long term. Lifts and balconies will be added to the existing structure, and the entire building and all its flats will be redesigned to be barrier-free. This will permit residents to be able to remain in the neighbourhood until they are elderly, even if physical limitations arise. Adding such facilities will increase user comfort, increase the size of required movement areas, give resident a sense of security while providing more space. The integration of community spaces, greenhouses, and roof-top gardens on the upper floors offer the possibility for private and communal activities. Such areas will significantly improve recreation and leisure activity offers, while having a positive effect on the social cohesion of the residents. Green environments, whether they be green façades, roof-top gardens, common lawns or parks, provide relaxation and reduce stress, which in turn improves people's common well-being, while promoting biodiversity. In addition, greening creates a pleasant and cooler ambient climate, because plants absorb sunlight. Green façades also reduce noise pollution. The sharing concept also contributes to the quality of life, because the accessibility of the app and the variety of car-sharing options increases living satisfaction.
It makes everyday life easier and increases independence. In addition, the conscience is also rewarded, as each individual resident contributes to producing fewer goods and thus saving resources through the shared use of cars, bicycles, goods or services.

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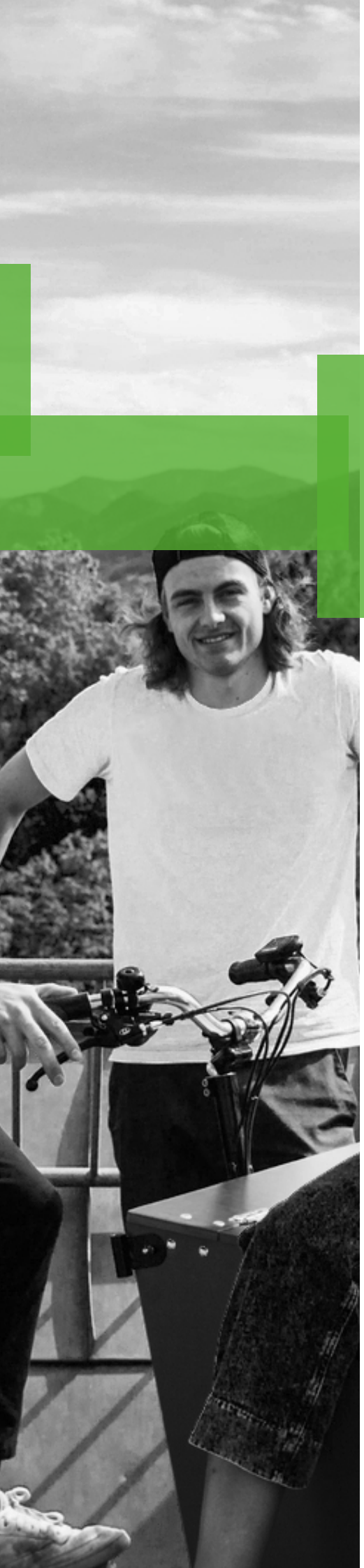

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Urban Mobility

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Vision

The levelup urban mobility concept includes various measures to enhance sustainable living in urban areas without restricting or neglecting the individual needs of its residents. Instead, it strengthens the community among them and offers incentives to lead an environmentally conscious life.

Mobility

The core of the concept is a particular developed "sharing- and mobility" web application. To get everyone involved the application is multilingual, for free, and accessible by every web-enabled device. Illiterate or disabled persons can access via voice control and residents without internet access can enter via public terminals in the entrance hall or parking garage.
The mobility function of the app offers a sharing pool of electric vehicles and different types of bicycles perfectly fashioned to the residents' mobility demands. The number and variety of vehicles, as well as additional features, fit the different social structures, lifestyles, personal needs, ages, and budgets. Moreover, the number of vehicles is capable to compensate all private vehicles in the existing building. This results in a potential saving of 133 cars in the existing building and reduces the car density per 100 residents from 41 cars to 8.25 cars.

Booking, unlocking, tracking, returning, and billing of the vehicles is all accomplished over the application and works fully automated with a few clicks as soon as it is initiated. The sharing pool is non-commercial and therefore offers the vehicles at cost price, leading to consumer prices that are far lower than from commercial sharing providers.

Apart from the optimization of individual transport, the public transport is to be adjusted perfectly to the residents' needs as well. Therefore, both the frequency of departures and the distance to the nearest stations are minimized. This can be made possible with only one additional bus route for short-distance targets within the district, one additional night bus, and an adaption to the schedule of an already existent suburban train. The result is that the maximum waiting time for any means of transport is only ten minutes, and the walking distance to the next station should not be longer than two minutes.

Sharing

The sharing function of the app enables the exchange of goods and services among residents. It gives residents a platform to offer and request things they need in their daily lives, such as tools, kitchenware, or simple activities like grocery shopping. In exchange, the counterpart receives so-called "points" which can be reinvested to obtain goods or services within the platform. As a result, the utilization of shared goods increases significantly and so does the interaction among residents. Furthermore, it gives residents with low purchasing power new opportunities to use desired goods and offers residents with physical handicaps the help they need.

Apart from the core functions of mobility and sharing, extended functions are implemented to further increase sustainability as well as usability for the residents. The formation of carpools within the building reduces the number of vehicles used and thus traffic congestion. Smart meters will automatically transfer and document the residents' consumption of electricity and water in the app to raise their awareness of their consumption pattern. On this basis, a reward system is set up divided into three categories. These are CO2 consumption based on vehicles used, water consumption, and electricity consumption. Every month, the residents with the lowest consumption in any given category receive a reward that can be redeemed for goods, services, or towards a shared vehicle.
The app's structure allows it to be easily scaled to the entire district or even city. Thus, allowing residents to access an extended search offer if goods or services are not available within their own building. Offers and requests are then displayed on a map, enabling the user to choose the most convenient options.

Sharing

Of crucial importance for the whole concept is the new parking garage close to the existing building. It will be the main parking lot for residents and all sharing vehicles. The garage houses charging columns for all-electric vehicles, workshops for cars and bicycles, storage facilities for bicycle accessories, parking spaces for families and senior citizens, in addition to parking spaces suitable for the disabled. The charging columns have the possibility of retrofitting. The construction of the parking garage is fully recyclable and is connected with steel dowels and screws. The primary structure consists of laminated beech veneer lumber and precast reinforced concrete elements for the floor and ceiling. It allows the parking garage to be expanded and reduces maintenance and costs for renovation measures. On the roof, there are green areas with sufficient seating facilities. The electricity for charging infrastructure and lighting is partly generated by integrated PV surfaces.

The aim is to combine parking, communication, and leisure in one place, creating an active parking garage that is given life by its timeless offer, with added value.

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energy endeavour FOUNDATION

BERGISCHE UNIVERSITÄT WUPPERTAL

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

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