solar decathlon europe

21»22

competition source book

solar decathlon europe 21»22

WUPPERTAL GERMANY

...goes urban!

teams

SAB | Bangkok, Thailand
Team Sweden | Gothenburg, Sweden
FIRSTLIFE | Prague, Czech Republic
LOCAL+ | Aachen, Germany
AuRA | Grenoble, France
X4S | Biberach, Germany
coLLab | Stuttgart, Germany
MIMO | Düsseldorf, Germany
EFdeN | Bucharest, Romania
Deeply High | Istanbul/Lübeck, Turkey/Germany
RoofKIT | Karlsruhe, Germany
UR-BAAN | Bangkok, Thailand
TDIS | Taipei, Taiwan
levelup | Rosenheim, Germany
SUM | Delft, Netherlands
VIRTUe | Eindhoven, Netherlands
Lungs of the City | Pécs, Hungary
Azalea | València, Spain

host & organizer

School of Architecture & Cvil Engineering
University Wuppertal | Germany







solar decathlon europe

21»22

competition source book

House Demonstration Unit
of the team from Aachen
© Steinprinz / University of Wuppertal

foreword

Dear Reader,

Retrofitting the building stock to become climate-neutral plays an outstanding role in achieving our climate targets. We need to tackle this challenge in both an efficient and socially acceptable way if we are to succeed. In my function as minister responsible for climate action, the energy transition and economic affairs, I am therefore delighted that the Solar Decathlon Europe took place in Germany for the first time in its 20-year history.

18 teams from eleven nations who share one common vision: the Solar Decathlon brings energy efficiency and sustainability together with urban planning and architecture. Embracing a broad range of participants, this year's SDE not only was a convincing showcasing event, but also sends out an important signal for strong international cooperation amongst the younger generation. The prototypes of buildings presented by students demonstrate different ways in which our urban neighbourhoods can be modernised and our energy supply can be secured without fossil fuels.

Thanks to the untiring work of students who have spent more than three years working together on interdisciplinary projects – from the initial idea through to the finished prototypes – the Solar Decathlon Europe has made the energy and resource transition visible and tangible for the general public. The best-practice solutions presented in Wuppertal and the inclusion of academia, companies, government and civil society create space for future cooperation, the transfer of expertise, and innovation.

I hope you will be inspired by this documentation, which illustrates the successful competition and shows how the transformation and the energy transition in the building sector can be successfully mastered in a sustainable, climate-friendly and architecturally appealing manner.

Yours,

Dr Robert Habeck
Federal Minister for Economic Affairs and Climate Action

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Solar Decathlon Europe 21/22

project partners

UTOPIASTADT

Wuppertal Institut

neue/effizienz

STADT WUPPERTAL

WSW.

The Solar Decathlon (SD) is a major worldwide university-level building competition. Students are challenged to design, build, and operate high-performance, low-carbon buildings that mitigate climate change and improve our quality of life through greater affordability, resilience and energy efficiency.

The event came to Germany for the first time in its 20 years history. The Solar Decathlon Europe 21/22 (SDE 21/22) in Wuppertal gathered architects, engineers, and multidisciplinary sustainability experts to communicate and showcase cutting-edge research and technologies in architecture, resource efficiency and renewable energy systems. The SDE 21/22 became an external event of the New European Bauhaus Festival and was awarded with the German Solar Prize. Sixteen university teams from ten countries demonstrated on the common solar campus how to close gaps between existing urban buildings, add storeys to buildings or renovate ageing urban buildings in a climate-friendly and cost-effective way.

The new competition profile with the focus on existing buildings was a great success. It was developed by the University of Wuppertal. After thrilling assembly and competition periods of hard work, heat, fun, and new friendships, the teams and their prototypes achieved remarkable outcomes. More than 115,000 visitors experienced the SDE in June 2022. They were inspired by the ideas and positive energy of 500 young international students. Although the circumstances of competition, cooperation and teamwork became the perceptible spirit of this SDE edition. This spirit underlines the power of international cooperation to overcome the ecological and economic challenges of the future.

This competition sourcebook summarizes the results, the teams' contributions and a first cross analysis of key topics. Additionally, an interactive 3D tour for all buildings is available on the event website. All buildings and monitored data are documented on the competition knowledge platform of the International Energy Agency for intensive post competition usage in research and education.

From spring 2023, eight remaining buildings on the Solar Campus will reopen to visitors as part of the follow-up project Living Lab NRW in Wuppertal.

The SDE 21/22 Organisation was comprised of the University of Wuppertal’s School of Architecture and Civil Engineering and the Energy Endeavour Foundation, a Netherlands-based non-profit business entity endorsed by the U.S. Department of Energy to administer the SDE.

The project was funded by the German Federal Ministry of Economic Affairs and Climate Action.

BERGISCHE UNIVERSITÄT WUPPERTAL

energy endeavour FOUNDATION

GOVERNING BODY OF THE SOLAR DECATHLON EUROPE

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag


House Demonstration Unit
of the team from Prague
© Steinprinz / University of Wuppertal

The Solar Decathlon Movement

The Solar Decathlon has been a globally established competition for more than 20 years now. When it first came to Europe in 2010, a team from the School of Architecture & Civil Engineering of the University of Wuppertal was part of it. In 2022, the competition came to Germany for the first time, to Wuppertal.

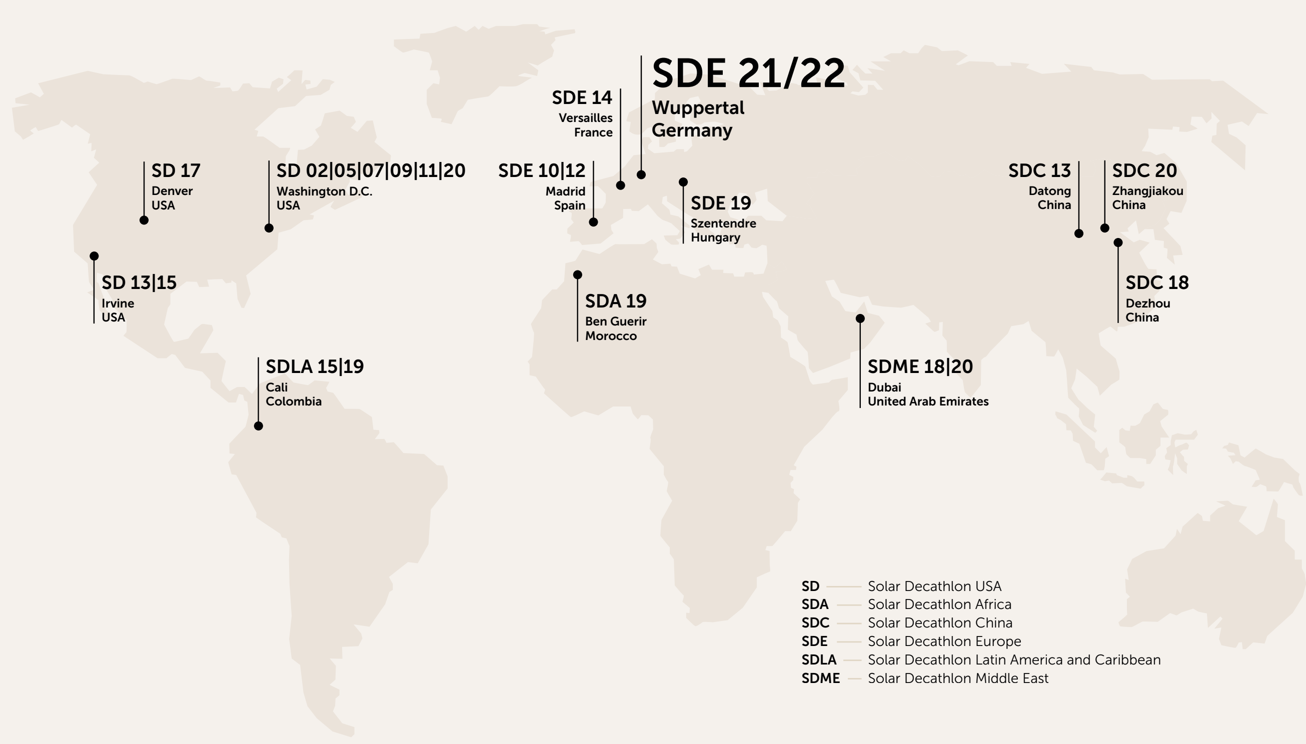
Solar Decathlon

Karsten Voss
(University of Wuppertal)

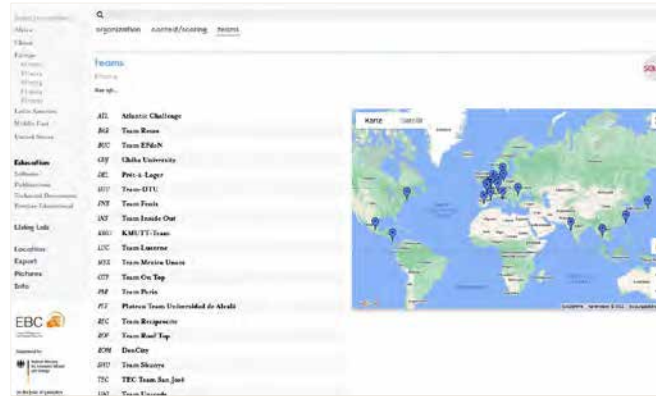
Initiated by the United States Department of Energy, the first Solar Decathlon was held in Washington D.C. in 2002. The competition quickly attracted international interest. Today, beyond the USA, competitions take place in Europe, China, Latin America, the Middle East, Africa and India. Each Solar Decathlon Competition is designed to address specific regional characteristics, economic conditions and evolving technologies for energy efficiency and renewable energy.

Thus far, the Solar Decathlon Europe has welcomed visitors twice in Madrid, Spain (SDE 10 and SDE 12); in Versailles, France (SDE 14); in Szentendre, Hungary (SDE 19); and now in Wuppertal, Germany (SDE 21/22).

World map of Solar Decathlon competitions
© SDE 21/22



Stimulated by the experiences from the first European SD edition, an international platform was created for mapping and linking the building competition experiences worldwide and working towards further improving existing as well as developing new formats. The Annex 74 "Competition and Living Lab Platform" ran between January 2018 and June 2021 within the Energy in Buildings and Communities Technology Collaboration Programme (EBC) of the International Energy Agency (https://annex74.iea-ebc.org/). Annex 74 was intended to stimulate the technological knowledge, the scientific level and the architectural quality within future competitions and living labs based on the development of a systematic knowledge platform as well as on the link to expertise from previous and current IEA activities. Solar Decathlon Europe 21/22 was the first competition profiting from the outcome of the Annex.



A specific website of Annex 74 provides information about previous competitions. https://building-competition.org

For the first time, the International Energy Agency (IEA) and the International Solar Energy Society (ISES) have partnered with a Solar Decathlon. The IEA Solar Heating & Cooling Programme and ISES were the organisers of the "Solar Award". In the picture: The award winners Team VIRTUe from Eindhoven and LOCAL+ from Aachen. © SDE 21/22

Solar Decathlon Europe

Louise Holloway
(Energy Endeavour Foundation)

Solar Decathlon Europe: unique & unparalleled

No Solar Decathlon Europe without the original United States Solar Decathlon!

Initiated in 2002 by the U.S. Department of Energy, the Solar Decathlon university-level student Competition was born with a clear vision: to create accessible clean-energy solutions for us on this planet. From the get-go, the Solar Decathlon has challenged university Teams to design, build, and operate highly efficient and innovative dwellings powered by renewables.

The first SDUS edition on the epic Washington Mall drew the attention of international audiences. Things moved quickly, first toward Europe, with an agreement between the U.S. and Spain for Madrid to host the first editions of the Solar Decathlon Europe beyond American soil. This was the bedrock of a growing global SD Community.

energy endeavour
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GOVERNING BODY OF THE
SOLAR DECATHLON EUROPE

The Solar Decathlon Europe was the first step toward the internationalisation of the outstanding competition in plus-energy architecture. Thus far, hundreds of thousands of visitors have celebrated five successful SDE editions during visits to Spain (SDE10, SDE12); France (SDE14), Hungary (SDE19), and Germany (SDE 21/22). While the overall SDE objective of a regenerative human habitat is always front and centre, each edition of the Solar Decathlon Europe reflects specific topics related to the physical, geographical, socio-economic or cultural conditions of the Host City and its surrounding European region. The SDE is tuned to current European concerns, and is thus in constant motion and forward evolution.

The multinational nature of Europe itself is an integral part of the SDE's DNA. This is a robust feature which requires a neutral, non-institutional, governing body to oversee the evolution of this thriving movement, in which many languages, cultures, and customs intermingle and connect. The Energy Endeavour Foundation (EEF) is entrusted with this mission, providing the structure and framework of the Solar Decathlon Europe, from one edition to the next.

In these ways, the Solar Decathlon Europe is singular, as it supports the unique format whereby the Decathletes, our international energy ambassadors, unite in-situ to build simultaneously, in record time, creating solar villages that are transformed into public forums and exhibitions for broad audiences. The Decathletes become our teachers, and show us that each and every citizen can act on behalf of our beloved planet.

Honouring the SDE legacy, building for tomorrow

The SDE has indeed flourished since its inception in Madrid, in 2010. In this edition, innovation, knowledge, and awareness were shared objectives, resulting in almost 200 000 visitors. By generating a critical mass of technicians and green-energy ambassadors, the Decathletes have since become leaders, improving the performance of buildings in their professional design activities. Next, the SDE12 shifted the focus from North American single-family dwellings to European habitation and market conditions.

The SDE gained momentum in the 2014 edition in Versailles, where the Decathlete teams accepted the challenge to design for a broader social and urban perspective; the zero-energy housing solutions addressed questions of mobility and cost efficiency. While diversity in cultures and design challenged Teams to re-energise Old Europe, they did so while considering the context and specificities of the Teams' cities and countries of origin. Another featured involved solutions for major natural threats and human evolution. New housing typologies were inherent features in this SDE14 edition.

Through its initial SDE Call for Cities, the EEF designated the first Central European SDE Host City in Szentendre, Hungary. In the SDE19, emphasis was placed on solutions for renovations of existing building stock in European cities. Decathletes investigated traditional Hungarian rectangular ground-floor buildings, and rooftop apartments were reviewed to increase urban density. Here, Teams were again encouraged to solve renovation projects that could apply to their country of origin. The SDE19 included a two-month extended exhibition.

The most recent SDE 21/22 has truly invigorated the movement. More than ever, the SDE antennae is up for the pressing topics of our time: energy efficiency, innovation, sustainability, retrofitting, and collective housing. Re-using, building up, and re-defining existing dwellings are some of today's architectural tasks, and the SDE 21/22 Teams addressed these with ambitious ingenuity. The living lab is a testament to this vision, through research and awareness activities that engage us in the urban landscape.

The SDE celebration continues to raise awareness of responsible energy use. Each edition stimulates the next, and in turn, fosters behavioural change. We are steadfast in our pursuit, and dedicated to the upcoming editions of the Solar Decathlon Europe. The SDE pushes us all to thrive.

Commitment to creativity, continuity, cooperation

The Solar Decathlon Europe thrives best when it is stewarded through consistent messages and values of optimism, curiosity, safety, solidarity, and professionalism. The Energy Endeavour Foundation was established to galvanise this effort, as the SDE's vitality depends on the EEF's pan-European vision and leadership. With an emphasis on international cooperation, the EEF sets the tone for the SDE.

The EEF is endorsed by the U.S. DOE as the governing body of the SDE, entrusted to foster the continuity and spirit of the Solar Decathlon Europe. Through a replicable business model anchored by standardised European-wide Calls for Cities and international Calls for Teams, the EEF provides an equitable playing field. The EEF's revitalisation of the SDE has established and cemented the Competition as the most international chapter in the broader context of the Solar Decathlon worldwide movement.

Since 2017, the EEF has been the driving-force behind the SDE, acting as custodian of the SDE brand and Rules. While focusing on the continuity, progress, and longevity of the SDE, the EEF transfers strategic tools, best practices, and project-specific knowledge to SDE Host Cities. In a spirit of collaboration, the EEF works with each SDE Host City to raise the bar.

The inspiration to foster this agenda has always been, and remains, the SDE Teams. The Energy Endeavour Foundation seeks to stimulate green-energy entrepreneurship and workforces by encouraging and reinforcing the new and invigorated pool of talent that springs from the Solar Decathlon Europe.

Teams, remain in light!

The SDE Decathletes represent the concerns of our time. They are bold, dare to stand up, express their innovative ideas, and cultivate even their most outlandish sketches. They are intrepid, embracing each phase of the SDE project: from team-building, initial brainstorming, through concept and design maturation, prototyping, to the demanding construction phase, leading to the juried finale. When they greet and guide visitors through their beautiful, smart buildings, Decathletes demonstrate courage and acumen, inspiring us all with the precise interplay of science, design, technology, innovation, systems, materials and management.

The true value of the SDE is the experience: the Teams' in their collective learning-bybuilding; the visitors' who explore the solar village in wonder; the engagement at the community level, as Teams demonstrate smart-grid home interaction, balancing needs and availability to reduce the environmental footprint of homes and communities. This kind of interaction also engages industry and investors interested in 'proptech'. At every level, the start-up mind-set stimulates viable business concepts and solutions.

The biggest takeaway of all is the sense of belonging that Decathletes gain from the SDE experience, the knowledge that they are forevermore part of a unique and dynamic European, and worldwide, community. The SDE opens a door, providing an unparalleled opportunity, often life-changing for Decathletes, who come from varied fields, and hail from different cities, countries and cultures. This opening empowers them to make important career and life decisions. The SDE broadens their horizons. SDE alumni are, by default, citizens of the world. Worlds apart, Decathletes are united.

Creativity affects the way we think, speak, behave. And clearly, it affects the way we live. The SDE Teams blend pragmatics with sensitivity, and the results are simultaneously understandable and engaging. They show us that power can be graceful, and that precision can be beautiful. By marrying creative thinking with passion for regenerative habitation, SDE Decathletes show us that our world will definitely be a better place. They are living proof, an inspiration, and we thank them for this.

«And the heat goes on where the hand has been.»

from Born Under Punches
(The Heat Goes On), Remain in Light
by Brian Eno, David Byrne, Tina Weymouth, Jerry Harrison, Chris Frantz

House Demonstration Unit
of the team from Stuttgart

Solar Decathlon Europe & University of Wuppertal

Katharina Simon & Karsten Voss
(University of Wuppertal)

In 2010, the University of Wuppertal participated in the first European Solar Decathlon in Madrid, with an interdisciplinary team led by Professors Anett Joppien and Karsten Voss from the Faculty of Architecture and Civil Engineering. It left a lasting mark - and not just on the university itself.

An international network of stakeholders was created, with the motivation to share experiences and improve the competition on a continuous basis. In 2015, a project funded by the German Federal Ministry of Economic Affairs and Climate Action (BMWK; formerly BMWi) was launched at the university under the leadership of Professor Voss in order to analyse and prepare the results and experiences of international competitions at the scientific level.

As a result of this, within the framework of the International Energy Agency, an initiative began under the leadership of the University of Wuppertal: the "Competition and Living Lab Platform" group of experts.

In 2017, the BMWK launched a national call for proposals with the title "Concepts for an international energy competition". This wasn't just about a Solar Decathlon in Germany. Other concepts were also possible and were subject to internal competition. Accordingly, on the basis of longstanding experience and the availability of an undeveloped inner-city area of suitable size, an interdisciplinary team from the University of Wuppertal created the concept of an "Urban Solar Decathlon".

© SDE 21/22

"The young students, with their positive attitude, were fantastic. Wuppertal, with our university as host, succeeded in showing itself from its best side. We are very proud to have brought specific climate-saving measures to life with the Solar Decathlon."

Rector Prof. Lambert T. Koch

From the start, the project participants were

→ the city of Wuppertal,
→ the “Utopiastadt” non-profit initiative as the owner of large parts of the competition area,
→ the Wuppertaler Stadtwerke public utilities company, as the local partner for the energy and water infrastructure,
→ the Wuppertal Institute for Climate, Environment and Energy as a research partner, and
→ the “Neue Effizienz” (New Efficiency), a spin-off from the University of Wuppertal in the field of energy efficiency and renewable energies.

In December, the proposal was awarded one of the top two prizes at an event in Berlin. With this success under its belt, a team from the Faculty of Architecture and Civil Engineering led by Dr. Daniel Lorberg, Dr. Katharina Simon and Professor Dr. Karsten Voss worked with local partners to develop the Call for Cities application for the Solar Decathlon Europe 2021.

The Wuppertal team at the SDE 2010.
© University of Wuppertal

The Wuppertal stakeholders together with the Energy Endeavour Foundation celebrate winning the bid to host the SDE 2021 in late 2018.
© SDE 21/22

The solar house from the Wuppertal team took second place in architecture and sixth place overall at the SDE 2010
© University of Wuppertal

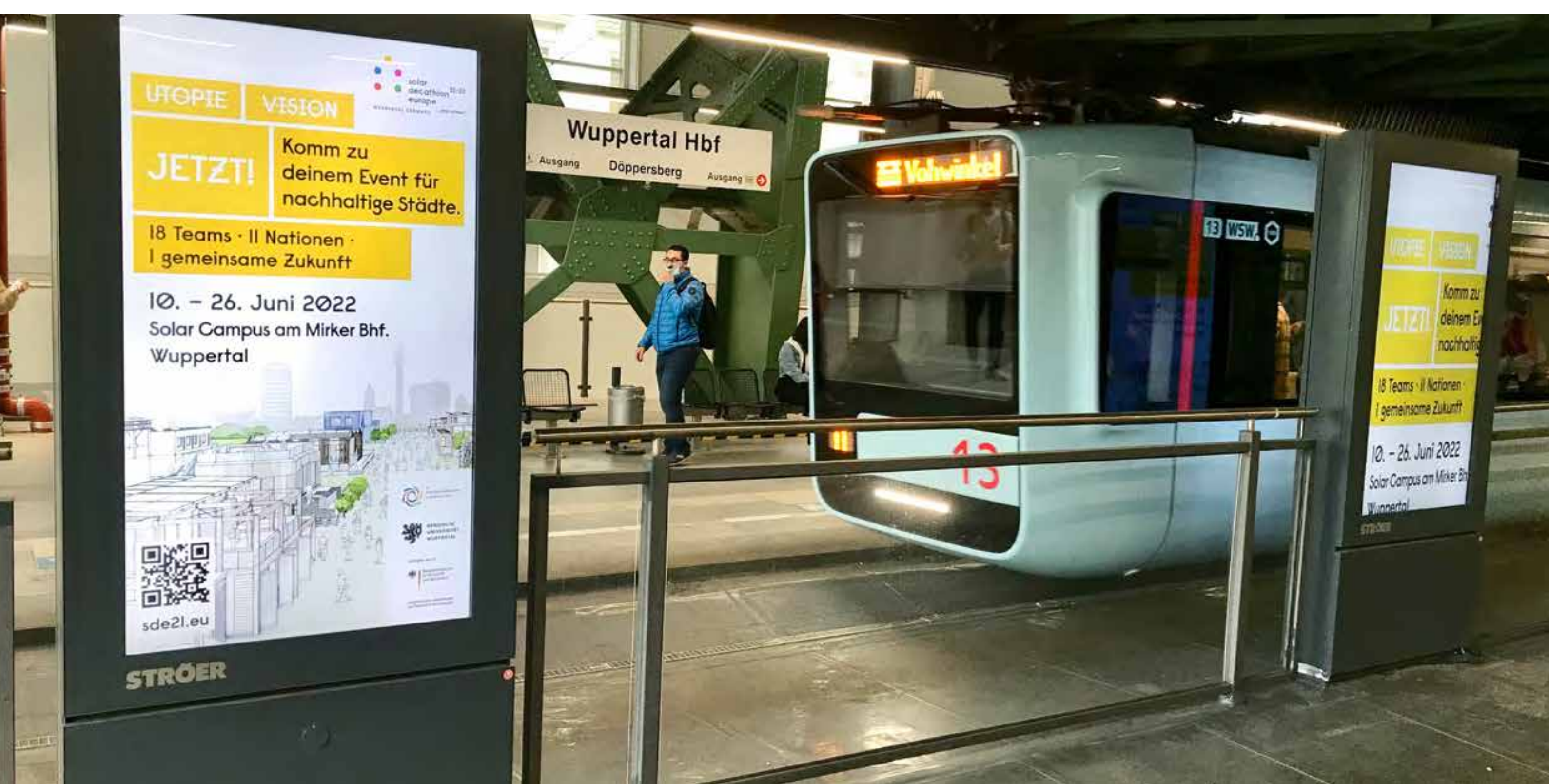
Wuppertal was officially confirmed as the venue at the end of 2018. The funding decision by the BMWK was followed by intensive planning work in a large, interdisciplinary team. The young project team quickly grew to include several team members and participated in an exhibition at the SDE 2019 in the Hungarian city of Scentendre, and was able to inspire several of the participants for its concept of an "Urban Solar Decathlon Europe" in Wuppertal. After 18 teams were selected from an extensive field of applicants by an international jury, by the start of 2020, it was clear that everything pointed in the direction of a great competition in Wuppertal.

In 2019, in response to the global pandemic, the important and correct decision was taken to postpone the competition from September 2021 to June 2022 to give the teams the opportunity to adapt to the new situation. Despite the ongoing pandemic and the outbreak of the war in Ukraine which followed in 2022, 16 teams ultimately succeeded in setting up their buildings in Wuppertal. Despite exceptionally difficult conditions, the SDE 21/22 was a great success for the participating teams.

For the University of Wuppertal, the SDE 21/22 proved to be the highlight in the year of its 50th anniversary in 2022. In October 2022, the Faculty of Architecture and Civil Engineering was presented with the German Solar Award 2022 for the SDE 21/22 in the category of "Education and Training".

The faculty was awarded with the German Eurosolar Solar Prize 2022 in the category education.
© Eurosolar e.V.

Advertising in the city
of the suspended monorail.
© SDE 21/22



The team

Marvin Backes
Andrea Balcerzak
Janine Baleis
Jutta Bedehäsing
Marina Bier
Önder Bölükbasi
Julius Bykowski
Claudio Cappelli
Amrei Feuerstack
Melina Freudenthal
Ralf Glörfeld
Arndt Goldack
Florian Hafner
Heiko Hansen
Florian David Haupts
Birgit Heinemann
Josefine Herrnstadt
Annette Hillebrandt
Gamze Hort
Mauricio Inostroza Trujillo
Tom Ipers
Marvin Kaliga
Isil Kalpkirmaz Rizaoglu
Lea Kings
Marcus Kistmacher
Kathrin Kopietz
Tim Korbmacher
Christopher Koslowski
Lena Kowalsky
Helmut Krapmeier
Karolyn Kruse
Miriam Kuckuk
Fabian Ladzinski
Ronja Lehmann
Daniel Lorberg
Jonathan Lunkenheimer
Steven März
Hannah Meichßner
Anica Meins-Becker
Nicolas Meintz
Aleksandar Mitic
Charlotte Monhof
Jan Martin Müller
Bärbel Offergeld
Jana Pahlkötter
Felipe Parada
Virginia Pillmann
Lukas Preß
Corina Puiu
Ulrike Rader
Ulrike Reuter
Michael Ritthof
Edwin Rodriguez-Ubinas
Leoni Römer
Anja Rosen
Frauke Rottschy
Nils Schäfer
Dennis Schlizio
André Schmale
Kirstin Schreiber
Cara Schwalbe
Jelka Seidel
Katharina Simon
Olivia Spiker
Moritz Stark
Pia Steffen
Ines Stelk
Franziska Stelzer
Lubna Sukhni
Christian Szterbin
Theres Täumer
Jens Teubler
Karsten Voss
Karl Walther
Matthias Wanner
Marion Wittfeld

On 19th May 2022 the waiting was finally over: The organising team is ready for the ground-breaking ceremony.
© SDE 21/22

Solar Decathlon Europe & City of Wuppertal

Uwe Schneidewind
(Lord Mayor of Wuppertal)

The Solar Decathlon offers us a glimpse into the future of our cities: It is a source of inspiration for our society and the worlds of science and politics, shows people what a sustainable urban society can look like today and provides an excellent basis of knowledge for all of those who want to reshape their cities. And yet besides the important accumulation of knowledge, the SDE stands for one thing above all else: Courage and confidence for a sustainable future.

Interview with Prof. Dr. Uwe Schneidewind, Lord Major of Wuppertal
© SDE 21/22

With its international orientation and integrative elements, the SDE is, quite rightly, the most important international university-based architecture competition: Its conceptualisation as a real-life laboratory stands for a science that allows for an integration and reflection function in processes of social change and therefore responds to the advanced requirements attributable to science.

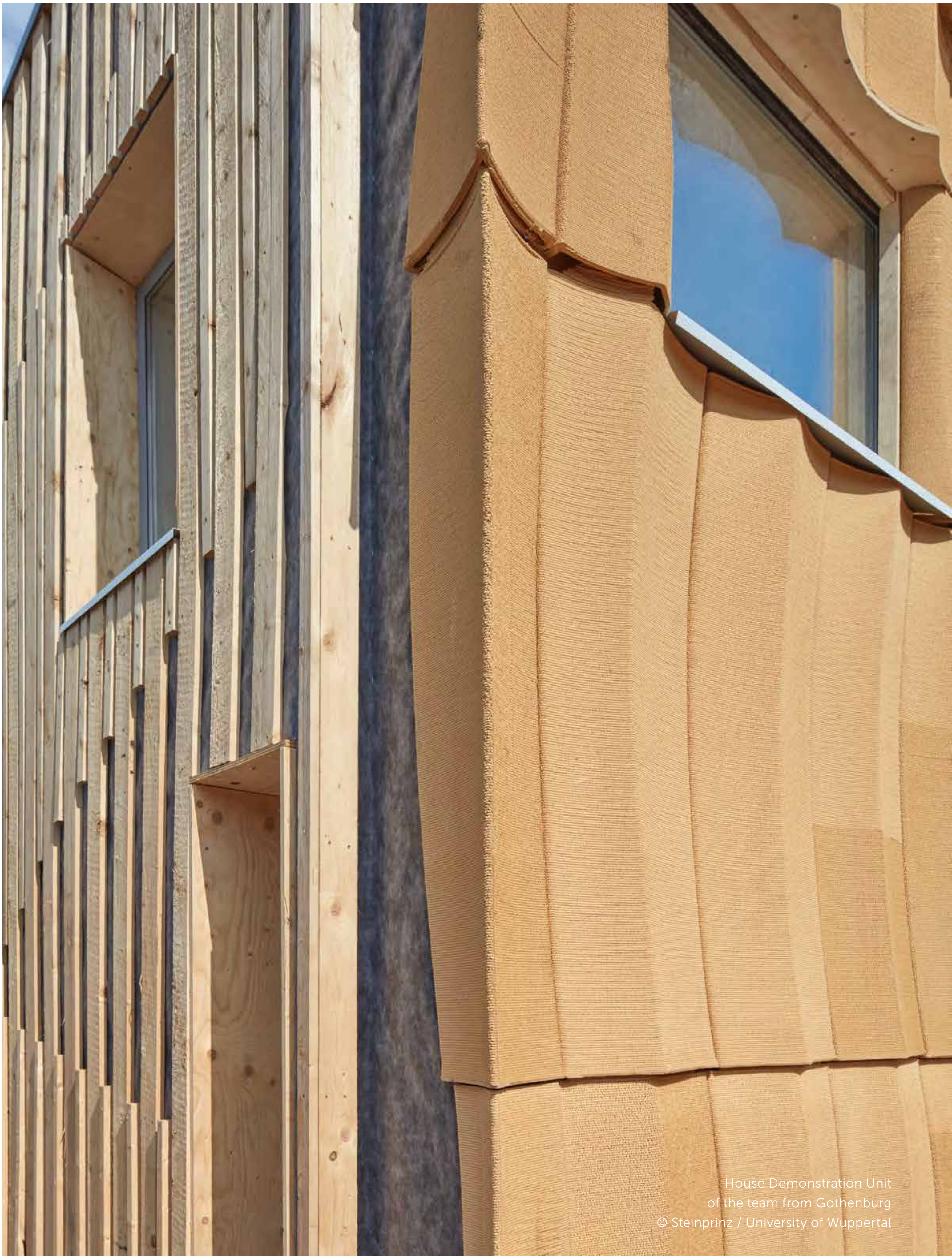
Over the past two years, the young, international teams have invested a considerable amount of time and energy into their projects and motivated stakeholders all over the world to pursue their ideas and visions.

In this context, Wuppertal, as a city undergoing transformation and renaissance, with the Mirke district as a real-life laboratory and “living lab” proved to be an excellent venue for the first urban Solar Decathlon Europe in Germany. The individual teams not only focused on the challenges of their projects from the perspectives of architecture and design, but also took a close look at the social, environmental and social aspects of their surroundings.

A key part of the innovation competition is a shared understanding of a future which reflects the wants and needs of all generations and is completely in the spirit of sustainable development. In addition to their innovative ideas for sustainable building, the teams brought a considerable amount of energy, optimism and desire to create a positive future with them to Wuppertal, which will continue to stay here after the competition.

The utopian momentum that the various teams brought to our city through their cooperation won’t just serve to inspire other scientists, but also urban society as a whole. It is now necessary to make use of this momentum, and in the spirit of the SDE, to turn ideas into action: For a sustainable city which doesn’t just build sustainably, but in which people also live sustainably.

House Demonstration Unit
of the team from València
© Steinprinz / University of Wuppertal


House Demonstration Unit
of the team from Gothenburg
© Steinprinz / University of Wuppertal

Solar Decathlon Europe 21/22

The Solar Decathlon Europe in Wuppertal addresses the building stock; it went urban. Its implementation required many changes and innovations. Results and experiences will remain and inspire the universities, the students, the public and further competitions.

towards climate-neutral cities

Katharina Simon
(University of Wuppertal)

The Solar Decathlon Europe in Wuppertal had a new and, to date, unique concept which focused on the further development of existing buildings in multi-storey housing. The SDE 21/22 showed the building potential and technical feasibility on the journey towards a climate-neutral building stock.

This evolutionary step of the competition was already beginning to take shape following the first European iteration of the competition held in Madrid in 2010. At that time, the focus was on solar-powered, energy-efficient small homes located on greenfield sites, in keeping with the tradition of the original American event. The European city and its challenges were not yet addressed in that competition. It was clear to all in this edition participating team leaders that an evolution of the competition towards the further development of the existing building stock in an urban context was imperative for the future. The result was the signing of the “Declaration of Madrid”, formulating a focus on redeveloping existing buildings.

Wuppertal,
a typical
European city
® SDE 21/22

An architectural dialogue with existing buildings is of imperative importance, as most cities in Europe are already largely built up. The construction of new buildings only plays a secondary role. There are already buildings for living and working; schools and factories, recreational facilities and the associated technical and transportation infrastructure. Many cities were built according to urban planning models typical of the period in which they were created, and continued to develop according to this tradition over the decades. They corresponded to the way people lived at the time and succeeded in responding to the needs of their inhabitants. However, a change has been underway for some time. It is necessary for the fixed system of buildings and infrastructure to adapt and to cope with new trends and challenges. Demolition, rethinking and rebuilding is not the solution here. What are the trends and challenges that the urban planners of today are facing, though?

For some years, a trend has been evident: increasing numbers of people are moving to cities. According to recent studies, more people will soon be living in cities than in the country. The impact of this trend towards re-urbanisation is already being felt by city dwellers in metropolitan areas, with housing becoming scarcer and more unaffordable for large numbers of people.

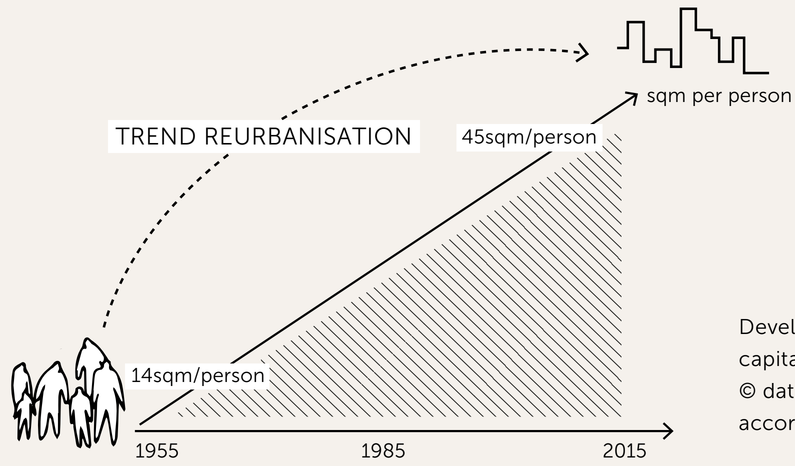
The first possible solution for the described problems could be the development of new areas and the creation of adapted neighbourhoods. This is not open for debate, however, as in recent years, urban sprawl and the associated sealing of land have exacerbated the effects of climate change. In addition, the resources required for construction are not unlimited, and are clearly becoming more expensive. The resources which have been tied up in existing buildings for several years or decades make working with the existing building stock unavoidable, and require planning which is aligned to the life of a building in order to conserve as many resources as possible in their pure state for future use.

The creation of living space through a targeted form of urban consolidation appears to represent a major opportunity and is more climate-friendly than new developments. Transformation, extensions/adding new storeys and closing gaps between buildings were therefore, the construction tasks which the SDE 21/22 addressed, but with a consistent focus on the improvement of the existing building stock and its energy supply, without resorting to the use of fossil fuels. In this context, it is necessary for the architectural and energy transformation to go hand in hand, as the existing building stock frequently fails to meet people's needs and personal requirements. Ageing apartment buildings usually have floor plans which were designed with the traditional family unit in mind and are often unmodernised. This makes it difficult to accommodate the significant number of single-person households consisting of people living alone for the long term and older people affected by this trend. The shift from traditional families to patchwork families as well as the large numbers of single parents are also making it increasingly difficult for people to find a suitable home on the housing market. Moreover, in recent decades, the expectations people living in cities have for their homes have also changed significantly. In 1950, people were expected to make do with approximately 14 m^2 of living space per person. This figure has increased exponentially. In 2010, the expectation for living space was approximately 43 m^2 per capita, which is equivalent to a tripling within half a century. In a European comparison, Germany is in the upper/middle tier. At the top of the pack are Denmark and Luxembourg, with approx. 51 m^2 and 66 m^2. Moreover, the gap to the lower field is considerable: People living in Poland and Romania respectively manage with just 24 m^2 and 15 m^2 of living space per capita. The higher expectations people have regarding living space is being driven by the desire to own a home, particularly in Germany. If the increased demand for individual housing and the urban-rural divide persist, the pressure on towns and cities and their residents will invariably increase. This is because nowadays the high costs of rent are being further driven up by the increased costs of utilities. The bulk of these costs are accounted for by the price of energy for the purposes of electricity and heating. The reduction in heating costs in particular, which can be expected from the increased rate of modernisation of the housing stock, is being cancelled out by a rebound effect due to user behaviour. Although the space heating requirement per square metre is falling all the time due to modernisation measures in buildings, the space heating requirement per capita has remained almost the same since 1970 because of the increase in living space in square metres per capita. On the one hand, this requires a radical rethink on the part of the general population, who should ask themselves how much living space they really individually need, and which rooms/spaces can be shared with other users under certain circumstances. On the other hand, urban planners should look at how housing can be made more flexible in the future. This means building for a specific target group as well as being able to respond to future demands with the current planning. Flexible floor plans, dispensing with load-bearing interior walls or the targeted use of outdoor space as living space are just a few of the ideas which should be implemented and that were addressed by the SDE 21/22. The development of new approaches to housing and a return to the city of short distances could make a further contribution to creating climate-neutral cities. For many challenges, looking beyond the boundaries of the individual plot can provide the answers. Certain concepts only make sense if they are planned and implemented as neighbourhood concepts. This is particularly true for mobility and energy concepts. This was also taken into account in the SDE 21/22.

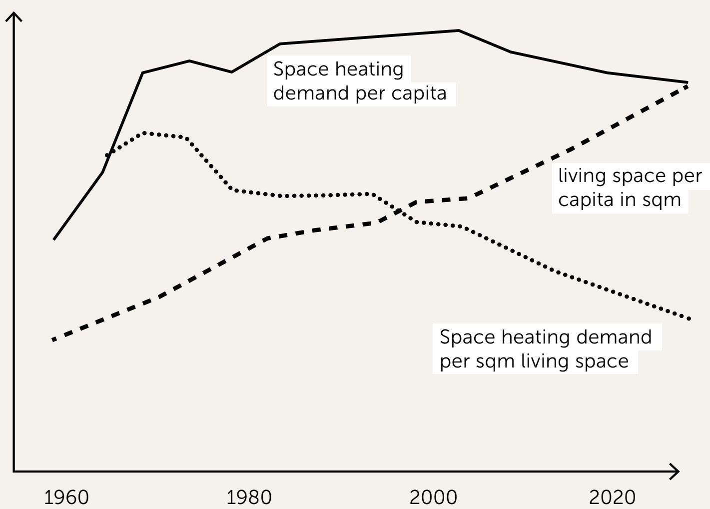
Architects, urban designers and urban planners are called upon to develop solutions for this heritage. This is where the first urban-oriented Solar Decathlon stepped in and responded to the current debates in the field of building culture, and therefore offered the international teams of students a platform where they could present their innovative ideas and put them to the test. The ten disciplines in which the international teams competed, addressed the new challenges surrounding further development in construction. The first German Solar Decathlon Europe was at the cutting edge.

«The event should be further developed towards a profile reflecting dense urban living, building renovation and life cycle cost - in order to fully satisfy human needs.»

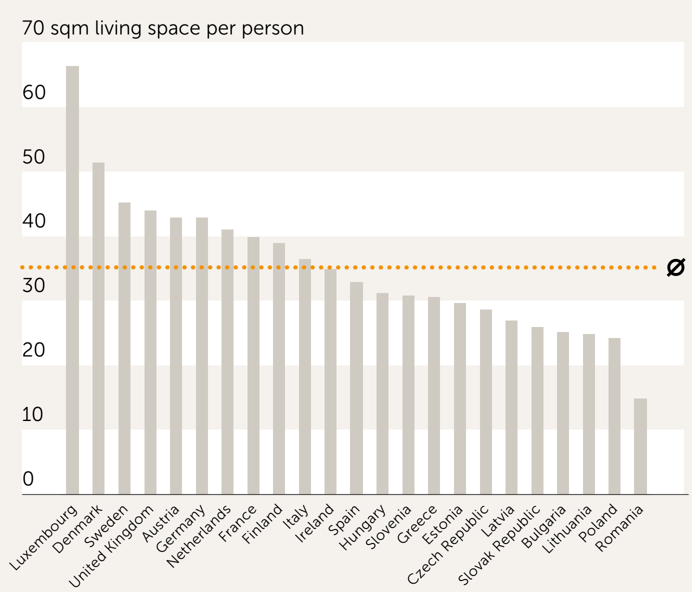
(Declaration of Madrid, SDE 2010)



Development of average living space per capita over the last 60 years in Germany
© data source: Federal Statistical Office according to gesis.org, illustration: K. Simon



Despite the implementation of measures to improve energy efficiency, the per capita demand for space heating in Germany has remained the same for years due to the increasing demand for living space
© data source: Wuppertal Institute 2015, illustration: K. Simon



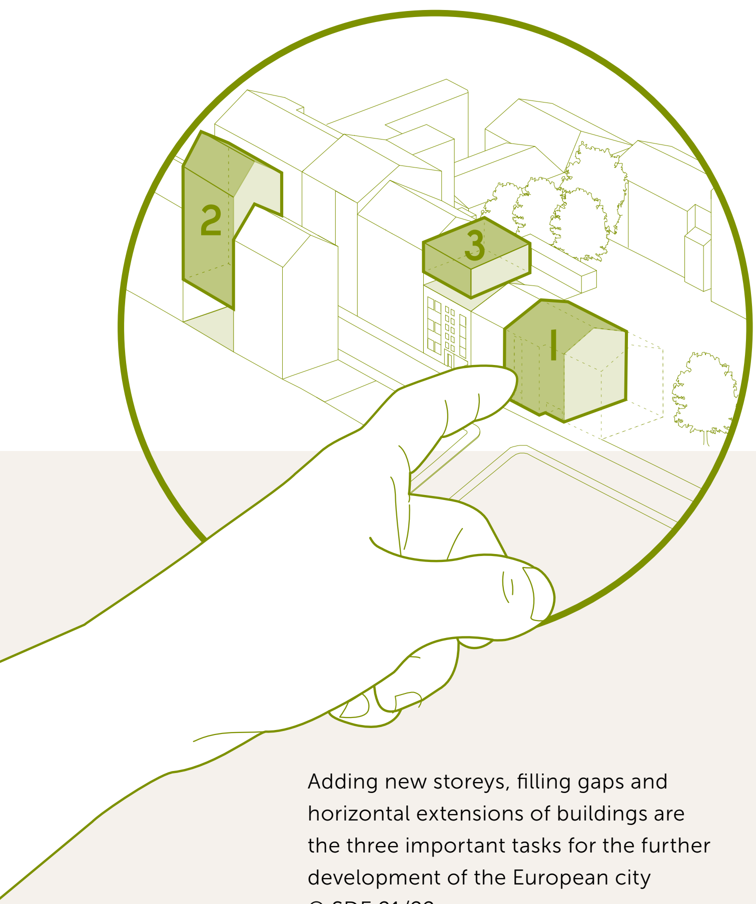
Comparison of living space in all European countries. The average living space per capita is approx. 35 m². Luxembourg comes first at 66 m², while Romania has the least living space per capita at 15 m². The data was collected between 2000 and 2009
© data source: Dol, Haffner-OTB Research Institute for the Built Environment, 2010, illustration: K. Simon

the competition goes urban

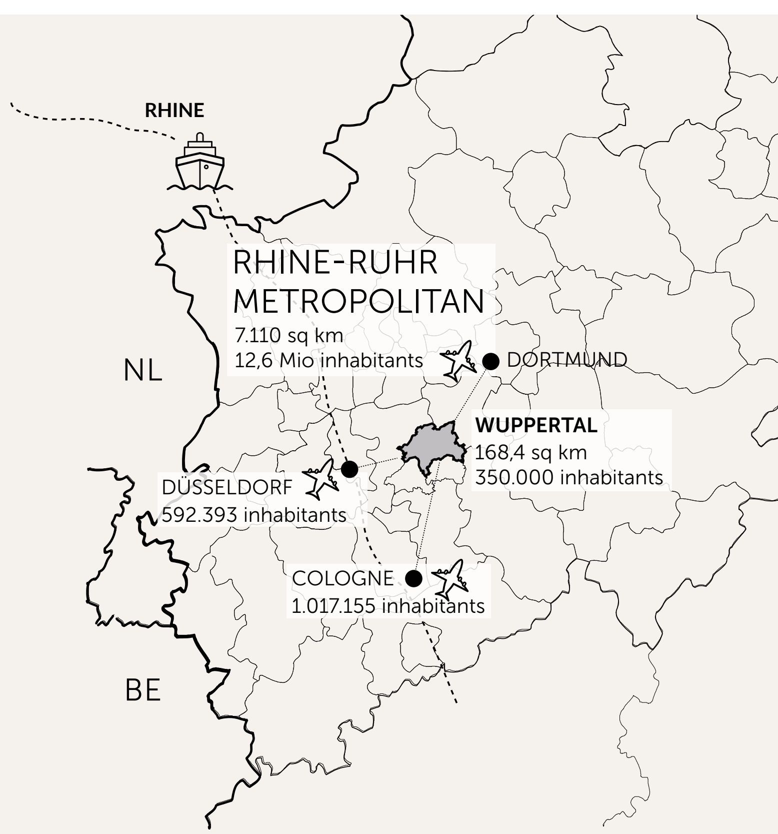
Katharina Simon
(University of Wuppertal)

In 2022, the SDE 21/22 was held in Germany for the first time – with a new urban profile. Its main topic was the further development of the European city, and specifically focused on the existing stock of residential buildings. Adding new storeys, closing the gaps between buildings and horizontal building extensions were the specific tasks in the field construction addressed by the SDE 21/22, consistently taking account of the architectural and technical improvement of existing buildings. Innovation, technical progress and structural excellence were assessed across ten disciplines. The urban profile of the competition, which found detailed reflection in the competition rules, was developed in its entirety by a team at the University of Wuppertal. Anchoring the competition at the neighbourhood level enabled the teams to plan precision drafts with actual social contexts and specific building tasks.

The concepts presented by the teams offered a current illustration of the possible implementation of climate-neutral buildings in cities. Holding the competition in Germany forms part of Germany's efforts to achieve a climate-neutral building stock by 2045. This was also the reason for the funding by the German Federal Ministry of Economic Affairs and Climate Action (BMWK).



Adding new storeys, filling gaps and horizontal extensions of buildings are the three important tasks for the further development of the European city
© SDE 21/22



Wuppertal - an exemplary city in Europe

Wuppertal wasn't just the venue for SDE 21/22, but also a source of inspiration for the ideas that were developed during the competition. Situated in the heart of North Rhine-Westphalia, Germany's most populous federal state, the proximity of Wuppertal to the Rhine-Ruhr metropolitan region made it an ideal location for hosting SDE 21/22 in terms of both its infrastructure and the topic. The city has been undergoing a transformation for several years. A declining population and an exodus of businesses, and with that, the loss of many jobs, have been the order of the day over the course of recent decades. But Wuppertal is a city that refuses to be defeated. Above all, its proximity to other major cities and its efforts at the civic level are particularly positive factors, and make the city into something special. Numerous projects have emerged as a result of this "bottom-up" movement. In this respect, the Nordbahntrasse should be mentioned first, a bicycle railway line, which connects several of the elevated parts of the city. A spirit of invention, courage and a flair for new things have always been firmly anchored in Wuppertal and the region, as evidenced by the invention of the electrically-operated suspension railway in 1900. This ingenuity – of world market-leading companies, numerous start-ups, public institutes, and last but not least the University of Wuppertal – is one of Wuppertal's key strengths, and also finds reflection in its urban development. The industrial success of the city has also left its mark on its urban development, especially between the years 1850 and 1920. Villa districts for merchants developed alongside large Wilhelmine workers' quarters, in which a variety of architectural styles such as Art Nouveau, Historicism and Neoclassicism can still be seen today. Despite the destruction caused by the two world wars, Wuppertal has an impressive stock of nineteenth century buildings to this day. With its post-war buildings, Wuppertal is certainly an exemplary city in Europe.

© SDE 21/22

The location of Wuppertal
in the metropolitan region
© bergisch.project,
Chair of Urban Design, BUW

The Mirke district

The Mirke district borders the north of Wuppertal city centre. It is a mixed quarter which has grown over the course of time. On the one hand, there are more people here with migrant origins and unemployment is higher than the average for the city as a whole, but on the other, the neighbourhood has a high density of students, societies and creative people who bring the neighbourhood to life and make it unique. Directly adjacent to the Solar Campus is the Mirker Bahnhof railway station, in which the Utopiastadt is located. It is a place for creative and engaged citizens, where a bottom-up development which is unique in Germany and attracting a lot of media attention is clearly underway.

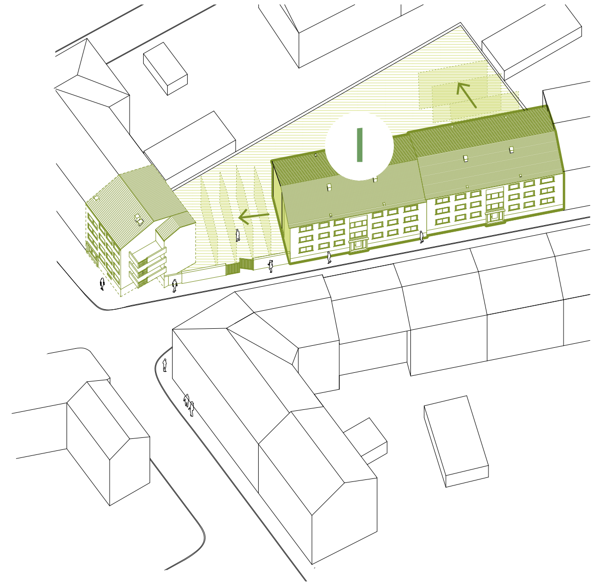
The building stock largely consists of typical buildings dating from the late 19th century, mixed with post-war buildings dating from the 1950s and 1960s. The rate of modernisation is quite low, which is due to the small-scale ownership structure and the owners' limited budgets. Buildings with historical character and a special atmosphere nestle in the immediate vicinity of the Solar Campus. Café Ada, for example, which is well known in Wuppertal and the surrounding area, represented a genuine task for adding new storeys. The gap in the Bandstraße, between two Wilhelmine residential buildings and a post-war residential building on the corner of Höchsten/ Ludwigstraße, was also within walking distance of the Solar Campus in the Mirke district. Even though the teams were free to choose a comparable building project in their country of origin, seven opted for a building project in the quarter Mirke. With its building-related and energy-related challenges and its social problems, this district is typical of many urban districts in Europe and therefore provided the ideal environment for the competition for this very reason.

Photos of the district Mirke
© SDE21/22

The three building tasks in the Mirke district.
© SDE 21/22

1. Renovation and extension

Renovation is an important step on the journey to urban transformation. In particular, buildings constructed after the Second World War are characterised by their cheap building materials, inadequate levels of thermal insulation and fixed floor plans. Redesigning these buildings not only makes them more visually attractive, but also allows them to become part of the urban energy transition.



2. Closing gaps

Undeveloped areas surrounded by two or more buildings in an urban environment are known as gaps between buildings. Filling in gaps between buildings is a good way to increase the urban density. At the same time, innovative architectural and energy solutions can rejuvenate the cityscape and bring inspiration to an entire district, including its energy supply.

3. Renovation and addition of storey

Adding one or more new storeys to a building, including its modernisation, is a great opportunity for creating new living space and increasing the urban density in a sustainable way. The variety of uses that are possible for new storeys enhances the urban environment. At the same time, opportunities become available for the intensive use of solar energy.

The Solar Campus

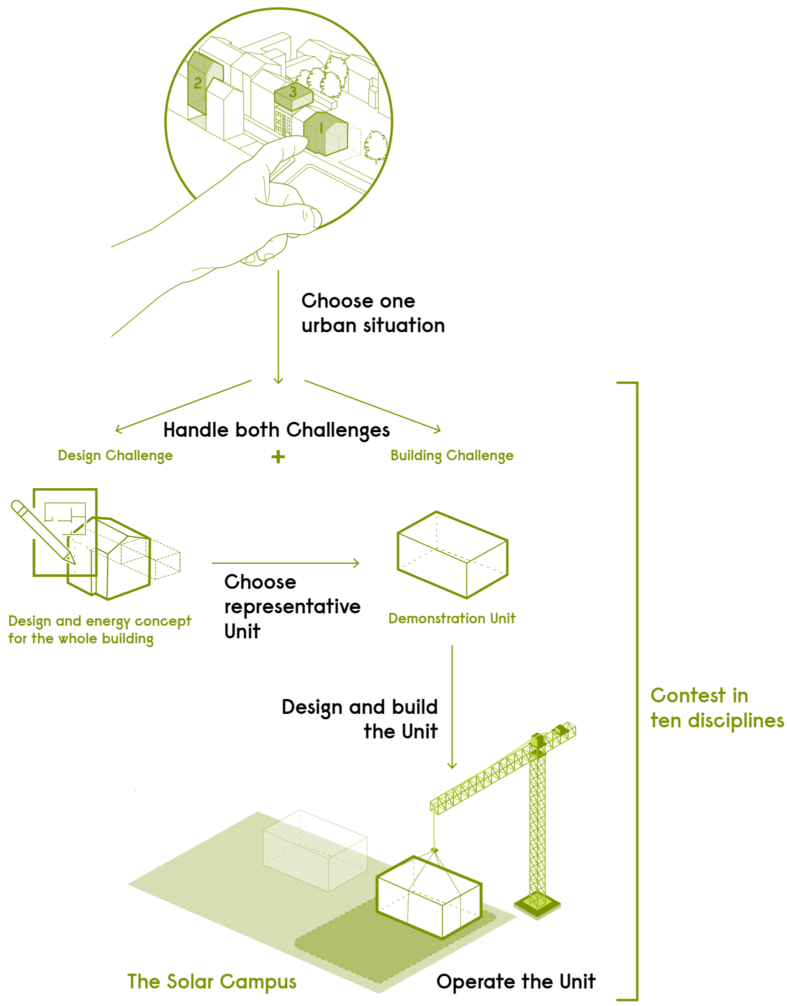
The Solar Campus, the venue of SDE 21/22, was situated in the northern part of the Mirke district. The site, which covered an area of approximately 50,000 m² along the Nordbahntrasse, offered the optimum conditions for the competition. The positioning of the sixteen Demonstration Units in a southeasterly orientation and the limited shading of the site offered a high degree of solar potential. The use of a shipping hall as a venue for several presentations connected with the urban profile of SDE 21/22. Overall, the easily-accessible inner-city location made the Solar Campus into a place of participation and discovery for the many visitors. Guided tours of the Demonstration Units raised awareness for the topic of sustainability in residential developments. The supporting programme with days focusing on culture and different countries, activities for schools and universities, conferences and symposia, created spaces for dialogue and inspiration for specialists and the general public.

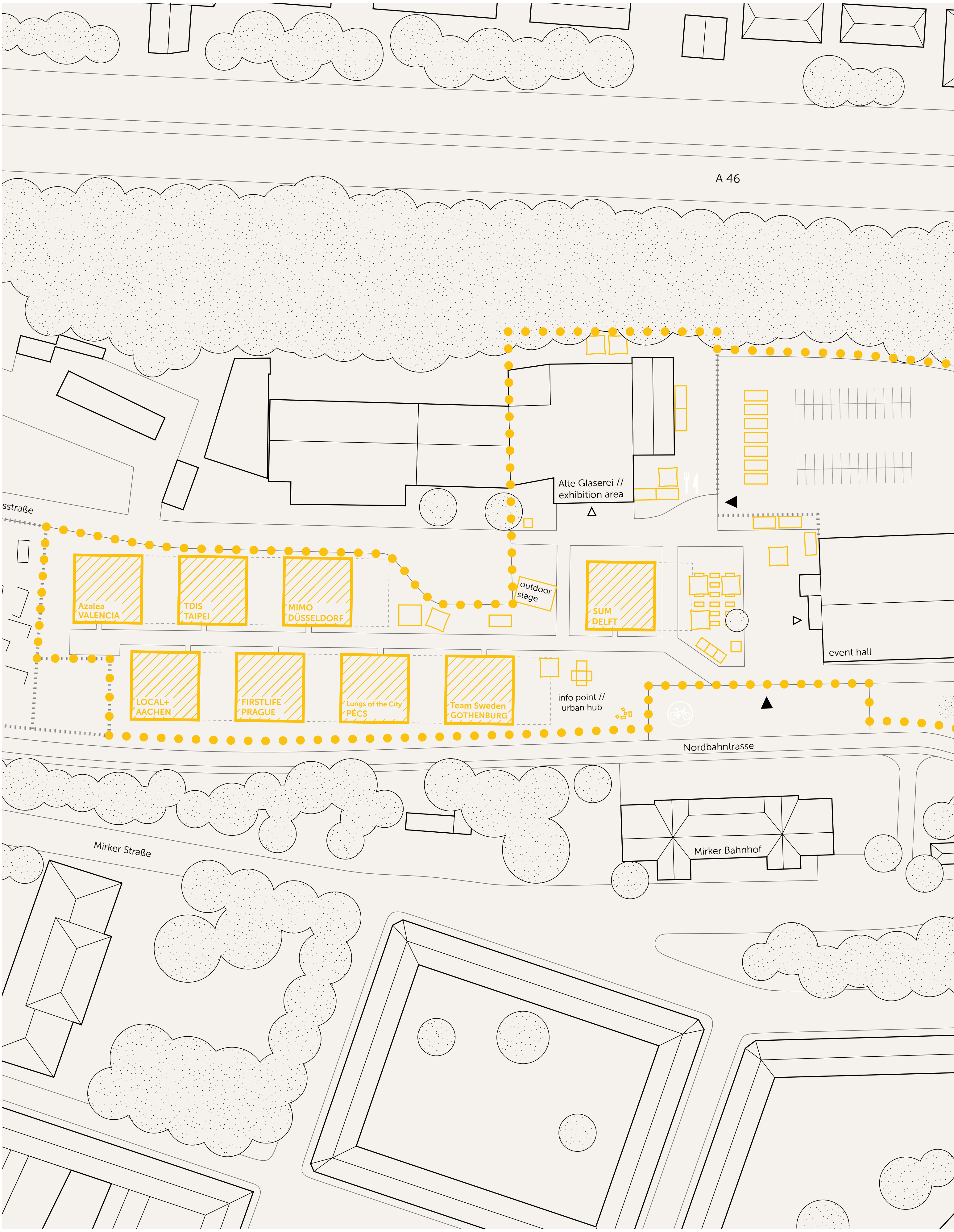
From design to building

“Design-build-operate” is both the principle and the unique characteristic of the Solar Decathlon Europe. The competition format in the SDE 21/22 edition involved two challenges:

In the Design Challenge, the teams created a design and energy concept for a complete building, including its urban context, putting principles of climate neutrality into practice.

In the Building Challenge, the teams constructed a representative full-scale Demonstration Unit (HDU) on the event site in Wuppertal. The results were fully functional one to two-storey Demonstration Units with apartments of up to 110 m² of living space that combined outstanding architecture with high-quality construction and building technology. While the teams were free to choose the most representative part of their building design, architecturally integrated solar systems had to be included.

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Team Sweden
GOTHENBURG
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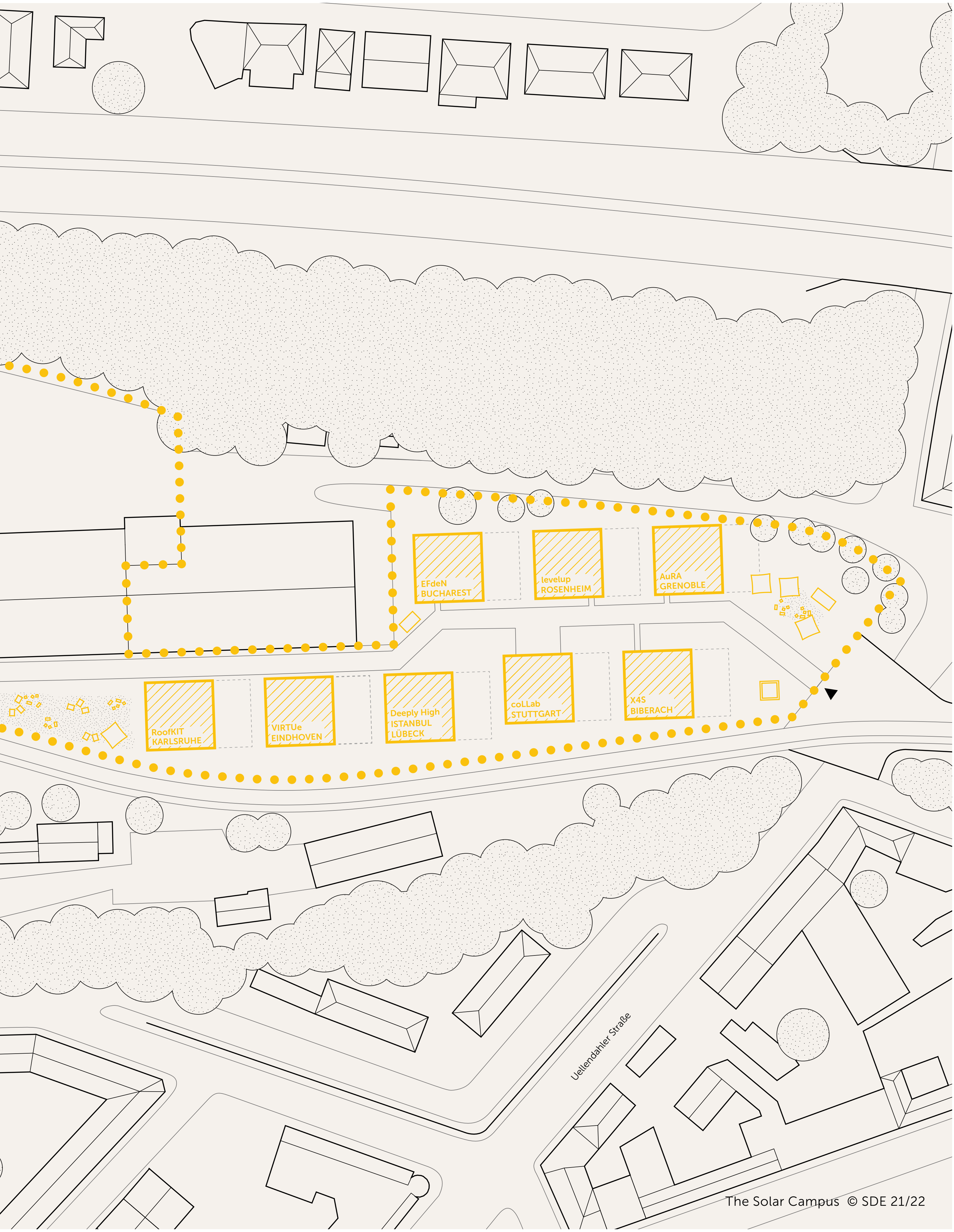
urban hub
Nordbahntrasse
Mirker Straße
Mirker Bahnhof


EFdeN
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RoofKIT
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EINDHOVEN
Deeply High
ISTANBUL
LÜBECK
coLLab
STUTTGART
X4S
BIBERACH
Uellendahler Straße
The Solar Campus © SDE 21/22

Solar Campus and Mirke district
© SDE 21/22

the competition in the district

Franziska Stelzer, Lea Kings,
Melina Freudenthal, Franziska Pennekamp
(Wuppertal Institute for Climate, Environment and Energy
and University of Wuppertal)

During SDE 21/22, seven of 18 teams worked on construction projects from the Mirke Neighbourhood in Wuppertal. The site of the competition, the Solar Campus, was situated at the northern edge of the district, which is home to about 8,600 people. Residents were not only visitors of the main event, but were also actively involved in regular surveys as part of the project. These focused on the question: What should a future – and post-Covid – neighbourhood look like to enable a good life for everyone?

Poster from the communication campaign “My Mirke, my opinion”.

“My Mirke Pass”. © SDE 21/22

The surveys

In April 2021, all households in the Mirke Neighbourhood received a postal invitation to the Neighbourhood Survey from the City of Wuppertal. Participation was voluntary and anonymous. The survey was accompanied by extensive video, poster, TV and print campaigns. Since some sections of the community proved difficult to recruit despite these efforts, they were targeted through on-site recruitment. In addition, there was intensive cooperation with local initiatives in the neighborhood in order to reach a cross-section of all of the community that was as representative as possible. Where this was not fully achieved, responses from some sections of the community were given more weight than others.

461 people took part in the first survey in September 2021, 390 took part in the second survey in April 2022. 376 people participated in the third survey in August 2022.

Key issues

The focus was on questions about everyday life in the Mirke Neighbourhood and ideas for a sustainable neighbourhood of the future. Participants were also able to suggest their own topics. In this way, they took part in designing subsequent questionnaires and research priorities. As a thank-you for taking part, they received the “My Mirke Pass” offering discounts, free drinks and other benefits in businesses in the neighbourhood.

The first survey asked about key factors such as current housing situation, the size of the flat/house, the number of living rooms, the type of housing, the length of residence, the number of vehicles owned by the household, and demographic variables such as gender, marital status, nationality, age, income group, level of education and employment situation. The preferred languages for completing the questionnaires were also recorded. In addition, participants were given an opportunity to suggest desired topics for subsequent surveys. The topics most frequently mentioned here were mobility and parking.

The contents of the first survey included place attachment, satisfaction with living conditions in the neighbourhood, key factors when choosing where to live, social cohesion, personal activities in the neighbourhood, changes in personal circumstances as a result of the coronavirus pandemic, the possibility and the practice of working from home, modes of transport used, housing situation and living space, environmental awareness and attitudes towards sufficiency. As mentioned above, the second survey focused first on mobility and parking, including various scenarios for the future and mobility solutions. Secondly, there were questions on aspects such as gentrification of the neighbourhood, the refurbishment status of the buildings and renovation measures carried out, volunteer work and information on the typology of the social milieu of participants. The third and final survey in August 2022 concentrated on an appraisal of the SDE 21/22 event in June 2022 and a resurvey of key indicators such as place attachment, environmental awareness, mobility behaviour, and work and housing preferences.

A brief overview of the results

Profile of survey participants

→ Male and female participants are roughly evenly balanced.
→ The ages of more than half of the sample are in the range from 16 to 44. Only just under 13 per cent stated that they were over 65.
→ 66 per cent are single, 21 per cent are married or live with a partner.
→ A large proportion of participants have a university education (44 per cent) or another higher education qualification (44 per cent).
→ 59 per cent of those surveyed are in employment, 16 per cent are in their vocational or further training.
→ For a majority of participants, their household's net monthly income is between €2,000 and €4,000 (39 per cent) or between €1,000 and €2,000 (23 per cent).
→ 21 per cent of participants have been living in Mirke Neighbourhood for over 20 years.

Mirke Station on the Nordbahntrasse is a well-known landmark in the neighbourhood. © Wolf Sondermann

Life in the neighbourhood

Associations with the Mirke Neighbourhood most frequently mentioned included well-known places, buildings and people, the streetscape, the mixed and diverse population, and positive descriptions of the neighbourhood as friendly, inexpensive and alternative.

There were a generally high level of satisfaction with the neighbourhood and strong sense of connectedness with it. The intercultural community and social cohesion in the neighbourhood were perceived as positive. Neighbourly relations tended to be close. Public transport in the neighbourhood was well regarded. However, there was great dissatisfaction with the availability of car parking spaces.

Experience of the COVID-19 pandemic

Overall, no major changes to personal circumstances as a result of Covid were reported. Changes perceived in the areas of life concerning neighbourhood, housing and work even tended to be on the positive side. Only 31 per cent of participants were able to work from home (to some extent).

Living in the Mirke Neighbourhood

The average housing space per capita was 47 m², with most living alone or with one other person. There was a high level of satisfaction with the housing situation in flats that were generally regarded as "just right" or "slightly too small". Most had no plans to move. The most important considerations in choosing a home were a flat of suitable size, having a balcony and good relations with others in the building.

Environmental awareness, desire for refurbishment and attitudes to sufficiency

Those surveyed in the Mirke Neighbourhood generally showed a (very) high level of environmental awareness. About half (56 per cent) would welcome a refurbishment of their living space. A majority of survey participants (66 per cent) also agreed with the statement that a carbon-neutral housing stock is important for meeting national climate targets. However, most considered a reduction in the size of their housing as less important for combating climate change.

Mobility, energy-efficient refurbishment and civic engagement

The idea of a mobility station was judged to be good to very good by 80 per cent of those surveyed. A mobility station is a space where people can change between various modes of transport, such as e-bikes, buses, rail, taxis, car sharing or hire scooters. More than half of those surveyed (58 per cent) also said that they could well imagine using a mobility station. Most participants also rated as good to very good the ideas of a neighbourhood hub (84 per cent) and a neighbourhood garage (82 per cent). A neighbourhood hub is an extension of a mobility station according to the "compact city" principle by including e.g. parcel stations, opportunities to shop for groceries, swap boxes, hire shops, a café or a bike repair shop. A neighbourhood car park concentrates parking spaces at an easily accessible location in the neighbourhood. It thus reduces on-street parking and provides opportunities for making public spaces more attractive.

The energy efficiency of the housing stock was rated very poorly. 38 per cent of participants said they were rather dissatisfied or very dissatisfied with energy efficiency. 28 per cent were partly satisfied, partly dissatisfied. Energy-efficient refurbishment had taken place only in rare cases since 2000.

Just over a quarter of participants said they were involved in some form of civic engagement at least once a week. More than a third of respondents were passive members of a sports club. At 15 per cent of participants, churches and other religious communities had the largest number of active members.

Participation in and views on SDE 21/22

63 per cent of participants in the neighbourhood surveys had visited SDE 21/22. They had liked or very much liked the exhibition space. Participants rated the information given on the individual buildings as easy to understand. More than half of those surveyed said that SDE 21/22 had a positive effect on the Mirke Neighbourhood and that the Solar Campus would, in their opinion, remain exciting in the future. Just under 60 per cent of those surveyed agreed with the statement that SDE 21/22 was a good thing for the Mirke Neighbourhood and would bring about positive change in the long run. Another welcome development was apparent in people's desire to live in renovated housing. Among those surveyed, this rose from an initial 56 per cent to 64 per cent.

Due to the high participation of the neighborhood residents in the neighborhood survey, the Mirke Neighborhood was given a voice within the competition. It also became apparent that the residents in the Mirke Neighborhood perceived the Solar Decathlon as a positive impulse for their neighborhood and also discovered solar construction and living as an opportunity for themselves.

The parking situation in
the Mirke Neighbourhood.
© SDE 21/22

assembly logistics

Katharina Simon
(University of Wuppertal)

Logistics in the construction phase

Organising a large student building competition such as the SDE 21/22, with 16 individual buildings in the heart of the city, is certainly challenging. It requires both professional logistics planning in the run-up phase as well as professional support during the construction and disassembly phase.

Planning – the name of the game

The building logistics planning began together with the partner company at a very early stage in the project. Due to the central, inner city location of the Solar Campus, bordering a residential area with narrow roads, all of the heavy goods traffic came and went exclusively via the adjoining premises of a freight-forwarding company. This was also the site for a waiting area for the heavy goods vehicle (HGVs). The traffic on the Solar Campus was managed via a one-way system. Adjoining the individual construction area of 18 x 18 m, the assembly zone, with 18 x 10 m, was available to each team as parking space for the crane or an intermediate storage area for components.

In addition to the areas of the operational building logistics, construction electricity and construction water, the logistic partner provided on-site support by renting machines and equipment out to the teams; the city waste management provided a recycling and collection point.

The evening before the construction: The Solar Campus is prepared. Here you can see the future Living Lab NRW area, with in-situ infrastructure and cast foundations. The construction areas are marked. © SDE 21/22

The non living lab teams used paving slabs for the load transfer work. © SDE 21/22

Constructional preparations for the Solar Campus

It was necessary to prepare the Solar Campus for the competition. When it was handed over, the site was of a very varied nature. The site had former railway tracks, the remnants of a scrap yard, potholes and in some area the surface could not support heavy loads. After dumping numerous truckloads of gravel and hours spent rolling, it was possible to create a sufficiently stable surface for the demonstration buildings and the construction site traffic. In the eastern section of the site, the infrastructure for eight temporary structures was built. In the western area, it was necessary to make additional preparations for the Living Lab NRW follow-up project. For this purpose, in-situ power, water and wastewater pipelines, the local heating network and mains connections were laid, and cast foundations were created to enable the long-term use of the demonstration buildings for research purposes (see chapter post competition living lab). This was a first for a Solar Decathlon.

The cranes: ready on the first day of the construction work ...

... and the teams are ready to go © SDE 21/22

Construction of the house demonstration units © SDE 21/22

Operational construction logistics

The starting signal for the construction was given at 10:00 am on 20th May 2022. All teams started the competition at the same time. The first HGVs, with girders, modules and partition walls were already queuing up early in the morning. Cranes moved to the location designated in the working plan and began to unload the first components. The coordination work determining which HGV was allowed to drive onto the site and when was huge, as the unloading HGVs weren't allowed to obstruct the general traffic on the campus. With each HGV, the demonstration buildings grew in height; it was only after the fourth day of the construction work that the deliveries began to peter out. Some minor delays in the construction work set in after a thunderstorm on the first day of construction. Coordination and flexibility, especially by the cranes and their drivers, was necessary to complete the buildings on time. The teams notified their neighbouring teams about any available crane capacity or their own requirements, which generally helped to accelerate the progress.

From the construction site to the event site

After a two-week construction period, six teams were ready with their demonstration buildings and were able to win special points in the competition. The remaining teams continued working on their demonstration buildings while the gardening and landscaping work started. A water-bound path surface was created for the visitors, bark mulch was laid on the construction area, bucket trees were distributed, and seating was installed. The Solar Campus was completed in five days, right on time for its opening on 10th June 2022.

Preparations for the garden landscaping
and the finished site
© SDE 21/22


LOCAL
MIMO

health & safety

Marina Bier, Florian Hafner
(University of Wuppertal)

At the Solar Decathlon Europe 21/22, the safety of everyone involved was of high importance and a top priority. During planning, assembly and disassembly, the 16 teams were continually supported by safety engineers from the chair of Safety Engineering/Occupational Safety of the University of Wuppertal, performing the function of health and safety officers (HS officers). Furthermore, during the assembly phase, a health and safety coordinator took on overall responsibility. Observers in the form of safety engineering students were out and about on the campus as the eyes and ears of the above-named functions.

Due to the character of the student competition, the personnel on the construction site was more heterogeneous than usual. Work was predominantly carried out by students, in addition to skilled tradespeople. This led to challenges but also opened up new perspectives in the area of occupational safety. On one hand, the skilled workers were already affected by routine and by actual practice and were sometimes amazed at the high level of safety. On the other hand, the students needed set guidelines in order to avoid getting into dangerous situations due to inexperience and time pressure. However, it was the practice of the skilled workers that led to unsafe behaviour. In particular, the behaviour of one or two contracted companies caused a few headaches for the teams and the HS actors. Because the teams were responsible for the contracted companies used by them and for their adherence to the SDE occupational safety regulations. For example, situations often arose in which the less experienced students had to remind the experienced employees of contracted companies about some regulations. The students were often more familiar with the occupational safety regulations

on the Solar Campus. Their awareness of occupational safety had been raised by the intensive preliminary planning of their safety concepts in close cooperation with the HS officers.

Contrary to what is often the case on normal construction sites, the HS actors were also thanked for their advice, because unsafe situations were not noticed during concentrated work and external advice was welcome. At all times during the assembly phase, the event was monitored by five safety engineering students; the observers. This was at first a challenging situation for many teams, but they quickly learnt that these observers were also pursuing the aim of expanding their theoretical knowledge through practical experience. Overall, there was respectful interaction between the teams and the HS actors. Nevertheless, in the heat of the moment and in stressful situations, the tone was sometimes also consistent with the normal conditions on a construction site.

It was striking that the teams supported each other intensively despite the competitive situation. For example, now and then HS officers had to stop creative but unsafe attempts at securing, but other teams soon provided a safe solution, such as lifeline systems.

Another positive aspect was the good technological standard of the individual working appliances. Because many tools and machines were newly acquired or borrowed for the competition, they were optimally adapted to the necessary work processes. There were, for example, mobile work platforms that could be extended over the entire length of the House Demonstration Unit, suction removal close to the source, and automatic protective devices on circular saws.

The morning daily meetings between the teams and the SDE officials also contributed to safety. These represented an important instrument for passing on information and experiences from safety observations and incidents. The recommendations there were always accepted and largely implemented. Occasionally, however, the SDE rules had to be broadly interpreted and the HS actors had to turn a blind eye, for example regarding the wearing of personal protective equipment outside the lots. It must be mentioned at this point, that the SDE regulations were to some extent stricter than the legal regulations. In conclusion, it can be stated that only a few accidents occurred and not a single serious accident, despite the time pressure and high workload. Also, penalties for unsafe working, in the form of time penalties, hardly had to be applied at all. Instead, the HS actors warned the teams, and it was explained to them, what has to be improved. The focus of the interaction between the HS actors and the teams existed on equal terms in the form of communication and advice. The detailed preliminary planning of the teams and the indefatigable support from the SDE officials thus led to a successful assembly phase with regard to occupational safety.

Decathletes take part in
the health & safety briefing
© SDE 21/22

the event

Kirstin Schreiber, Daniel Lorberg
(University of Wuppertal)

The public event phase of SDE 21/22 took place from 10th until 26th June. On 19th May, a taster event took place, however: that morning, all the teams met in Wuppertal for the first time. They gathered in their team outfits on a central square in Wuppertal city centre, where they were welcomed by the public and registered for the event phase. In good spirits and cheered on by the people of Wuppertal, they then walked together to the Solar Campus, where the first symbolic ground-breaking ceremony was held, heralding the start of the construction phase.

On 10th June, the event phase of SDE 21/22 began as scheduled. In addition to evaluating the contributions to the competition, the primary goal of the public event was to reach a large and broadly-based public audience and to raise awareness for the responsible management of energy and the technologies available for the reduction of energy use. The target groups of the SDE 21/22 were, in particular, politicians and stakeholders from civil society, private attendees, professional attendees from a wide range of industries and disciplines, as well as potential newcomers – i.e. school pupils, students and apprentices. The integration of the various groups played a central role in the overall concept behind the SDE 21/22. For the wider general public, the SDE 21/22 should be an attractive experience-based space, and with the backdrop of an open-air sustainability festival, give attendees the opportunity to immerse themselves in topics surrounding sustainable building, perhaps for the first time. In this respect, offerings for school pupils also played a key role, which are addressed in a separate chapter in this book. As regards the professional attendees, a double-incentive strategy was

in place: the Co-Host-Days, organised by institutions and associations from the practice, created a positive incentive for professional attendees to make the journey to the SDE 21/22.

On the basis of the wide-ranging target group, the offering available to the attendees during the event phase was conceptualised with various elements. In addition to tours of the demonstration buildings, guided tours and information offerings, there was an almost continuous programme of events. This included ceremonial events, such as the opening ceremony and prize-giving ceremonies, as well as specialist events and cultural offerings as a supporting programme.

Advice on digitalisation and sustainability in the building trade at the information stand of DigIT_Campus, a joint project between the University of Wuppertal and the not-for-profit companies Neue Effizienz gGmbH and Utopiastadt gGmbH.
© SDE 21/22

The demonstration buildings were open for twelve days – 10th until 12th June, 16th until 19th June and 22nd until 26th June 2022. During these periods, the teams offered guided public tours of their buildings – in German and English, depending on the possibilities. During the guided tours, the students explained their ideas and the specifics of their concept and answered questions. It was possible to partake in the guided tours without advance registration. The attendees were able to join a guided tour of the demonstration building of their choice at any time.

Guided tours of the external area of the Solar Campus were also offered to groups of experts and groups from universities. The attendees were provided with a general introduction to the concept and history of the Solar Decathlon as well as information on the Wuppertal profile of the competition. The private attendees were able to take advantage of a similar programme of guided tours which took place in collaboration with Wuppertal Marketing GmbH.

The walk through the city centre to the Solar Campus. Pictured in the first row is the team from Valencia.
© SDE 21/22

Wide-ranging information and advice on associated topics was also available at the Solar Campus, including related training and study opportunities as well as information on the possibilities surrounding the provision of financial support to homeowners for energy-related refurbishment measures. This offering was provided by partners such as NRW Consumer Advice Centre, the Ministry for Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia, the University of Wuppertal and others at their information stands on the Solar Campus.

The above-mentioned elements formed the core offering throughout the event phase. This offering was supplemented by a changing programme entailing the use of several exhibition areas on the Solar Campus. In particular, these included an outdoor stage, an events hall with space for 1,000 people, as well as several areas for exhibitions and smaller-scale performances. The ceremonial events began with the opening ceremony on 10th June 2022, which was attended by 1,000 invited guests from the worlds of politics, science, business and culture and was also streamed live. The opening ceremony took place in the events hall and came to a close with the official opening of the demonstration buildings.

After some brief VIP tours, the Solar Campus and demonstration buildings were subsequently opened to the public.

The second VIP event was the final award ceremony, which took place on 24th June 2022. Following the evaluation of all the disciplines, the overall winners of the SDE 21/22 were then chosen. For the final award ceremony, the events hall was also reserved for invited guests, key stakeholders from the worlds of politics, civil society, science and business, and, of course, the teams and their guests. Like all the prize-giving ceremonies, the ceremony was streamed and broadcast live on the outdoor screen at the Solar Campus.

District Mayor Thomas Kring presents the Mirke Choice Award.

Live music on the outdoor stage during the Spanish Country & Culture Day.

As previously mentioned, a co-host concept was used for the specialist events. Different partners each day configured the daily programme with their expertise and their coverage. They held symposia, conferences and presentations in the events hall, to which other attendees were invited in addition to the associations' members. The changing daily offering resulted in a wide-ranging but consistently high-quality overall programme. For their part, the professional associations benefited from the high profile of the SDE 21/22 and the supporting programme at the Solar Campus. The partners involved included:

- European Platform of Transport Sciences – EPTS Foundation e.V.
- Chamber of Crafts Düsseldorf and the Local Council of Skilled Crafts Solingen-Wuppertal
- Federal Association of German Housing and Real Estate Companies (GdW)
- Association of German Engineers (VDI), together with buildingSMART Germany and the BIM-Institute of the University of Wuppertal
- Association of German Interior Architects (bdia)
- Association for Air-Conditioning and Ventilation in Buildings (FGK)
- International Solar Energy Society (ISES) and the Solar Heating and Cooling Programme within the International Energy Agency (IEA SHC)
- The German Lighting Society (LiTG)
- Cooperation of Timber Construction Associations
- Chamber of Architects in North Rhine-Westphalia

The strategy of the co-hosts served the generation of reach and attendee-quality in terms of a wide-ranging professional community. The range of topics and professions covered was of instrumental importance to the selection process. The role of co-host was generally associated with the awarding of a special prize. This allowed the teams to prove themselves in additional categories outside the general competition as part of the Out of Competition awards. In this respect, prizes were awarded e.g. for the best craftsmanship, especially innovative living and energy concepts with wood, as well as the most convincing lighting concepts. These prize-giving ceremonies also took place before a public audience in the events hall and were streamed live. In addition to professional associations, the city of Wuppertal also took the role of co-host for one day, bringing politicians as well as stakeholders and initiatives from the region together at the Solar Campus. Two Out of Competition awards weren't awarded by the expert juries, but by the attendees. Through the two audience awards, and with the Mirke Choice Award in particular, local residents in the Mirke district of Wuppertal were actively included and encouraged to participate in the SDE 21/22.

The prize-giving ceremonies generally took place in the early evening. They brought the day's programme to a close, provided opportunities for discussions and networking at the subsequent reception and led into the evening programme. All the ceremonies were consistently configured with music and video clips and accompanied by the host, Wilma Werner.

Another mainstay of the events programme was the Country & Culture Days. Similar to the concept of the co-hosts, a different participating nation co-hosted the day's programme on each opening day. This took the international dimension of the competition into account and gave each team the opportunity to communicate selected aspects of their national culture. In this respect, exhibitions combined with catering and musical performances proved popular.

The programme of the co-hosts, the Country & Culture Days and the competition were coordinated in such a way that prize-giving ceremonies, presentations and specialist events intertwined during the day – especially in the events hall – while musical and performance-based items on the programme following the prize-giving ceremonies invited the attendees to linger and celebrate. The exhibitions, catering and workshops ran all day simultaneously to the day's programme.

Due to the central location of the Solar Campus in inner-city Wuppertal, the traffic concept was designed to ensure that the attendees were able to arrive by public transport, on foot or by bike. It was also possible to arrive by coach. The relatively limited amount of parking was reserved for specific groups, such as attendees with limited mobility. Bearing this in mind, several bicycle parking spaces were provided on the Solar Campus and the frequency of specific bus routes was increased in coordination with the Wuppertal public transport service. In the city as a whole and the neighbouring district in particular, signposting and stewards were provided to direct the flow of attendees. As a result of this and effective communication on how to find the Solar Campus in the run-up to the event, this concept was welcomed by the attendees. Despite the considerable numbers of people entering and leaving inner-city Wuppertal, there were no traffic congestion or similar problems at any time.

Including all the supporting and specialist events, the SDE 21/22 was offered free-of-charge to the attendees in the interests of achieving the broadest possible participation and to avoid setting any hurdles. Despite that, an online ticketing system to control the number of visitors was developed for reasons of security and in accordance with the traffic concept. Groups of attendees, such as school and university groups, were able to register separately. Approximately 115,000 people attended the SDE 21/22 via this registration system. The size of the Solar Campus meant that at certain times it proved possible to admit additional, unregistered walk-in attendees to the event. During these periods, the security personnel simply ensured compliance with the maximum number of attendees permitted on the premises. Accordingly, it can be assumed that the actual number people who attended the SDE 21/22 significantly exceeded the official number of 115,000.

educational offers

Jutta Bedehäsing,
Christopher Koslowski,
Nicolas Meintz
(University of Wuppertal)

In light of the political, ecological and social challenges of our time, it is particularly important to raise the awareness of children, adolescents and young adults for topics such as “energy (revolution)”, “future housing”, “energy renovation” and “sustainable urban development” as early as possible. With its ten disciplines, the SDE is a complex event for the aforementioned target group and requires different strategies and collaboration with different education providers for the teaching

One first obvious target group for the SDE 21/22 educational work was children and young people from the Mirke district. In cooperation with the “Alte Feuerwache Wuppertal” multicultural youth and meeting centre, which is active in the district and whose vegetable garden is located right next to the Solar Campus, a video series was developed in which children pass on their local knowledge. During the “SDE 21/22 Walking Tours”, seven children act as guides through the Mirke district to show viewers their favourite places. At the same time, the videos gave the SDE 21/22 teams and the interested public a first impression of the neighbourhood from the specific perspective of children.

Participants of the Junior Uni presenting their models to the public.
© SDE 21/22

The “Biparcours” digital learning tool was used to create a themed scavenger hunt on the Mirke district for school classes. Children and young people can explore the Mirke district interactively on their own during the scavenger hunt, which takes about two hours. This offer will also be available after the end of the project.

Another cooperation partner was the “VRD Foundation for Renewable Energies”, whose educational materials on renewable energies were used for the SDE 21/22. Parts of a modular teaching concept created by the foundation were incorporated into the development of workshops for children at the Alte Feuerwache and into school classes from Wuppertal. Almost all workshops took place on the Solar Campus grounds.

The first three workshops for children from the neighbourhood were held in February 2022. These gave children the opportunity to learn about photovoltaics, solar thermal energy, and the principle of thermal insulation through play.

Two-hour workshops for school classes followed from March, which included an introduction to the competition as well as seven stations on selected SDE 21/22 topics: solar thermal energy, photovoltaics, heat & insulation, energy sources, design for a sustainable building, collection of ideas for more sustainable cities and measures for climate-friendly buildings. A total of nine classes with about 230 pupils took part in the workshops.

Older pupils (from year 10) were given the chance to participate in the “Renewable Energies” course offered by the “GeoIT school lab of the Department of Geography” at the University of Wuppertal. The six-hour course was developed on the occasion of the SDE 21/22 at the Institute of Geography and will still be available to pupils after the end of the project.

The “Junior Uni”, a teaching and research institution for young people from Wuppertal, was collaborated with as part of an “Architects’ Challenge”. From February to June 2022, for example, a course was offered at the Junior Uni for seven pupils (7-10 years old), in which the children planned and built a model of an extension to the Junior Uni building – along the lines of a construction task for the SDE 21/22. The models were presented during the SDE 21/22, judged by a jury and awarded prizes by the Mayor of Wuppertal, Uwe Schneidewind.

Another cooperation was with the University of Wuppertal's SommerUni, an offer for pupils from year 10 upwards to learn more about science and technology centred topics. An excursion was organised with 20 people in the Mirke district under the motto "Architecture meets climate protection". In addition, a mobility concept for the district and selected house demonstration units were explained to the pupils during the assembly period.

To be able to supervise a larger number of pupils, the SDE 21/22 was prepared in cooperation with teacher training students from different Institute of Geography and Social and Science Education seminars at the University of Wuppertal. The students were introduced to the competition and the event site, and materials were provided to help them prepare. The students were able to work on their own small research projects for the SDE 21/22 or were involved in the workshops with school classes, in the urban research working group and in the planning for the SDE 21/22 event.

With the help of 60 teacher training students, about 40 school classes with about 850 pupils and several groups from the Alte Feuerwache were supervised on four “Education Days” during the event. The students introduced the school classes to the competition and assisted them in finding their way around the grounds. The classes were assigned to different house demonstration units to avoid longer waiting times. The guided tours through the house demonstration units were taken over by the SDE 21/22 teams, who had prepared offers specific to the target groups according to the competition. This not only included age-appropriate tours through the houses, but also smaller games or search tasks.

In total, about 1,000 children, adolescents and young adults as well as about 50 teachers could be reached as multipliers for the SDE 21/22 topics through the different educational offers.

Award ceremony for the Junior Uni Architects’ Challenge during the SDE 21/22.
© SDE 21/22

the competition

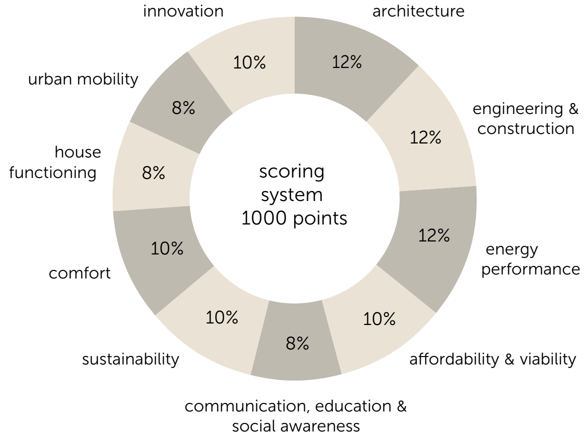
Karsten Voss
(University of Wuppertal)

16 house demonstration units competed as free-standing houses on the Solar Campus. What at first glance appeared to be an exhibition of detached family houses became a tangible experience of the dawn of the urban energy and resource transition through the teams' presentations on site and supplementary materials such as posters, architectural models and brochures. All the house demonstration units were "purely electric houses" due to the rules of fair competition. Their remaining energy demand was covered by solar power systems connected to the grid with the aim of achieving a positive energy balance between import and export.

Explanation of the task from Building in Context during a presentation as part of the Communication, Education and Social Awareness discipline, in this case the extension of Café ADA presented by the team RoofKIT from Karlsruhe.
© SDE 21/22

Disciplines

Energy performance is just one of the criteria in the competition, as the teams are judged in ten disciplines at each Solar Decathlon. The content of the disciplines varies depending on the venue and the focus around the core challenges of Architecture, Communication, Function, Comfort and Energy. In Wuppertal, the disciplines were also divided into sub-categories and awarded points. The aim was to formulate special focus areas more clearly and to increase the transparency of the jury evaluations.
Due to the competition's new profile, the designs of the overall buildings, including their energy and mobility concepts, were also judged as context of the house demonstration units for the first time at a Solar Decathlon. Therefore, the number of points through jury evaluations also increased to 70 percent compared to 30 percent for the monitoring evaluations. The juries had to do more preparatory work by reviewing the documents on the buildings as a whole. A data collection system was developed for the monitoring disciplines, which, in addition to the evaluation in the competition, also allows the data to be used for downstream analyses. Standardised and newly developed simulation tools were made available to the teams for some disciplines to facilitate the planning work and improve the comparability of the results (UMI: circularity , SimRoom: performance gap).



Weighting of the ten disciplines.
© SDE 21/22

no.	contest	innovation	total points	sub contest	points	sub contest	assigned by	design challenge	building challenge
1	**Architecture**	•	**120**						
				site integration	20		jury	•	
				building design	60		jury	•	•
				interior & lighting design	20		jury		•
				solar system integration	20		jury	•	•
2	**Engineering & Construction**	•	**120**						
				energy concept	60		jury	•	•
				performance analysis	30		jury	•	•
				life cycle carbon footprint	30		jury		•
3	**Energy Performance**		**120**						
				energy consumption	30		monitoring		•
				energy balance	30		monitoring		•
				self consumption	20		monitoring		•
				pv system performance	20		monitoring		•
				grid interaction	20		task		•
4	**Affordability & Viability**	•	**100**						
				affordability	50		jury	•	•
				viability	50		jury	•	•
5	**Communication, Education & Social Awareness**		**80**						
				communication	40		jury	•	•
				education	20		jury	•	
				social awareness	20		jury	•	•
6	**Sustainability**	•	**100**						
				circularity	60		jury		•
				sufficiency, flexibility & environmental performance	40		jury	•	
7	**Comfort**		**100**						
				temperature	25		monitoring		•
				humidity	5		monitoring		•
				air quality (CO_2)	20		monitoring		•
				lighting	10		monitoring		•
				sound insulation	10		test		•
				air tightness	10		test		•
				performance gap	20		task		•
8	**House Functioning**		**80**						
				appliances	40				•
				refrigeration		5	monitoring		•
				freezing		5	monitoring		•
				washing		5	task		•
				drying		5	task		•
				dish washing		5	task		•
				oven		5	task		•
				cooking		5	task		•
				home electronics		5	task		•
				water	10				•
				hot water		5	task		•
				water balance		5	monitoring		•
				dinner	15		guest evaluation		•
				user friedliness	15		guest evaluation		•
9	**Urban Mobility**	•	**80**						
				mobility concept	60		jury	•	
				beverages, dinner food, food retrieval	20		task		•
10	**Innovation**		**100**	5 x 20 points	100		jury	•	•
			1000		1000				

Structure of the ten disciplines and their subcategories © SDE 21/22

Rules, submissions, inspections and monitoring

The rules for the SDE 21/22 comprised 100 pages and another 50 pages for the structural design rules with reference to German building law. The competition rules form the basis for fair competition. The design rules are intended to ensure that the buildings can be visited by the public without any safety risks. The rules were supplemented and fine-tuned several times during the course of the competition until the release of the final version.

The teams submitted six deliverables over the planning period. These were checked by the team from the University of Wuppertal for completeness and consistency with the rules and regulations. The real building on site was checked for compliance with the rules by inspections during the construction process. For example, it had to be ensured that the cubic volume built fitted into the "solar envelope", that the static planning was implemented from the foundation to the rooftop and that the electrical installations guaranteed the safe running of the building. At the end there was a final inspection for participation in the competition. If the team stayed on schedule, the first ten bonus points were in the bag.

"Inspectors" were also present on all competition days. Specially trained students from the University of Wuppertal contributed more than 1,500 hours of work to ensure that tasks such as drawing hot water, cooking or washing clothes were carried out in the individual houses fairly in accordance with the rules.

Inspectors at work © SDE 21/22

A crucial moment is celebrated: the Grenoble team's inspection is completed, giving it the green light to participate in the competition. © SDE 21/22

Jury

An international jury was assembled with three members for each of the six jury disciplines. They include renowned representatives from practice and research. Their decisions were based on a preliminary review of the teams' submissions and three days of on-site work, including presentations on the respective topic by the teams in their houses. In addition to the points in the respective discipline, each jury was also allowed to award further points for innovations in their topic area. The sum of the points in five of the six jury disciplines made up the result in the Innovation discipline.

The jury members received explanations from the teams during their tour. Dietmar Eberle and Jette Cathrin Hopp talking to the team from Valencia. © SDE 21/22

Jury members gave presentations on the discipline's theme and their related work, here Anne Lacaton. © SDE 21/22

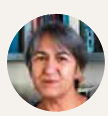
Architecture

Prof. Dietmar Eberle
Baumschlager Eberle Architekten
Austria

Jette Cathrin Hopp
Snøhetta
Norway

Fuensanta Nieto
Nieto Sobejano Arquitectos
Spain
(cancelation due to pandemic)

Affordability & Viability



Anne Lacaton
Lacaton & Vassal
France

DI Bahanur Nasya
Eutropian
Austria

Prof. Dr Guido Spars
Bundesstiftung Bauakademie
Germany

Communication, Education & Social Awareness

Richard King
Founder of the Solar Decathlon
United States

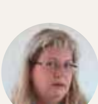
Jakob Schoof
DETAIL
Germany

Asst. Prof. DI Dr Karin Stieldorf
TU Wien
Austria

Engineering & Construction

Dr-Ing. Markus Lichtmess
Institute for Building Energy Research
Germany

Prof. Dr-Ing. Nathan Van Den Bossche
Ghent University
Belgium

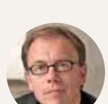


Prof. Dr-Ing. Maria Wall
Lund University
Sweden

Sustainability

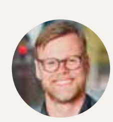
Dr Anna Braune
German Sustainable Building Council (DGNB)
Germany

Prof. Andrea Klinge,
Dipl.-Ing. Architecture,
University of Applied Sciences Northwestern Switzerland



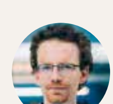
Søren Nielsen
Vandkunsten Architects
Denmark

Urban Mobility



Dr Jörg Beckmann
Mobility Academy
Switzerland

Prof. Dr-Ing. Heather Kaths
University of Wuppertal
Germany



Nicolas Saunier, ing. DrSc / Ph.D.
Polytechnique Montréal
Canada

Competition calendar, guided tours and award ceremonies

For the first time, there was a clear separation in the competition calendar between days for the public with guided tours and those for monitoring. The aim was to be able to derive clearer statements from the monitoring data.

The guided tours in the houses were the main element of the social awareness work. Only the students themselves were allowed to explain the projects, which was done partly in English and partly in German. Up to 20 people were allowed in the houses at the same time. As a result of the large number of visitors, queues often formed in front of the houses. For all those who were not on site: the houses can also be visited as 3D scans on the “digital campus” at the event web site. What this lacks though is the young people’s enthusiasm for their work, which can only be experienced on site. This was what really inspired the visitors. Facts and pictures alone do not achieve this.

The public award ceremonies were the highlights of the competition. The topics were introduced through presentations by the jury members in front of a large audience in the event hall. Hosted by the professional moderator Wilma Werner, the tension and excitement heightened and peaked whenever the awards were presented to the winners of the respective discipline.

The oak wood awards in different size, designed by Jan Müller from the University of Wuppertal team. © SDE 21/22

The two teams from the Netherlands beam happily about their placement in front of the ranking table on the Solar Campus. © SDE 21/22

The team from Rosenheim proudly displays its First Prize in the Energy Performance discipline. © SDE 21/22

3D scans of the buildings make a virtual tour of the digital campus possible after the competition on the event web site. © SDE 21/22

Visitors queuing in front of a building to take part in a guided tour. © SDE 21/22

the competition results

Karsten Voss
(University of Wuppertal)

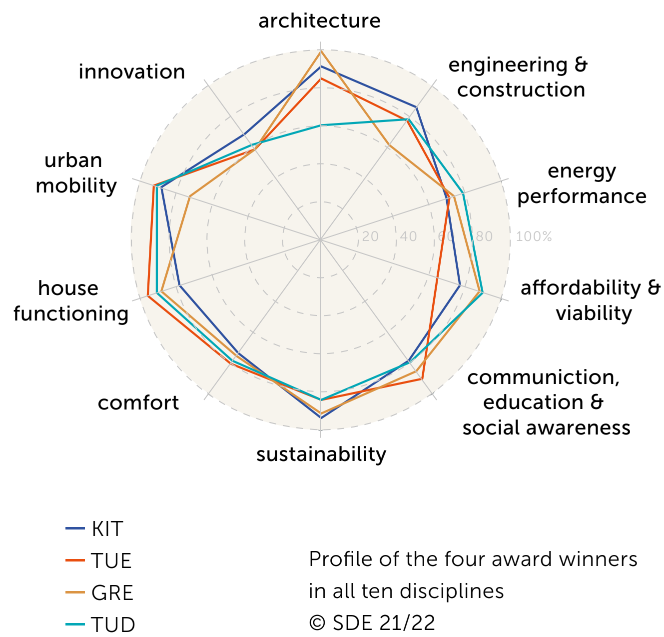
After an intense period with two weeks of assembly, one week of experimentation (co-heating test) and two weeks of competition, it was finally decision day on Friday 24 June. The event hall was packed with around 1,000 visitors. The award ceremonies in the Architecture and Innovation jury disciplines took place in the morning, with a few surprises. Since the placings were announced here, but not the points, the tension remained high until the final. In the end, the overall scores are based 70 percent on jury evaluations and 30 percent on monitoring results. For the first time at the Solar Decathlon, the jury evaluations not only included the house demonstration units on site in their rating for many disciplines, but also the overall designs and concepts (design challenge).

The proud winning team RoofKIT from Karlsruhe. © SDE 21/22

Score and ranking of the teams in all disciplines at the end of the competition. Further details are available on the event website and in the online international competition database (https://building-competition.org/) © SDE 21/22

Rank	Team Identity	University
1	KIT	Karlsruhe Institute of Technology
2	TUE	Eindhoven University of Technology
3	GRE	Grenoble National School of Architecture
3	TUD	Delft University of Technology
4	HSD	University of Applied Science Düsseldorf
5	FHA	Aachen University of Applied Sciences
6	ROS	Technical University of Applied Sciences Rosenheim
7	UPV	Polytechnic University of Valencia
8	HFT	Stuttgart University of Applied Sciences
9	ION	Ion Mincu University of Architecture and Urbanism
10	NCT	National Chiao-Tung University,
11	HBC	Biberach University of Applied Sciences
12	CTU	Czech Technical University in Prague
13	ITU	Technical University of Applied Sciences Lübeck, Istanbul Technical University
14	UPH	University of Pécs
15	CHA	Chalmers University of Technology

Following speeches by the Rector of the University, the Mayor of Wuppertal and the organisers of the SDE, the prizes were presented to four teams. First place went to the RoofKIT team from the Karlsruhe Institute of Technology (DE), and second place went to the VIRTUe team from Eindhoven University of Technology (NL). Third place was shared equally by the AURA team from the National School of Architecture in Grenoble (F) and SUM from Delft University of Technology (NL). It was the first time in the history of the Solar Decathlon that two third places were awarded. Even if there were minimal differences in the decimal places of the total score, this would not justify a different ranking. Neither the jury evaluations nor monitoring results produce such precision – so the organisers' decision was clear in the end.



Profile of the four award winners
in all ten disciplines
© SDE 21/22

Team Name	Country	1 | Architecture	2 | Engineering & Construction	3 | Energy Performance	4 | Affordability & Viability	5 | Communiction, Education, Social Awareness	6 | Sustainability	7 | Comfort	8 | House Functioning	9 | Urban Mobility	10 | Innovation	Penalties/Bonus	**Total**
	max.	120	120	120	100	80	100	100	80	80	100	0	**1.000**
RoofKIT	Germany	109	103	84	77	63	94	74	63	71	68	8	**814**
VIRTUe	The Netherlands	102	93	86	65	73	85	81	77	74	59	7	**801**
AuRA	France	119	74	89	88	69	92	76	71	58	59	0	**795**
SUM	The Netherlands	72	94	95	90	64	85	79	73	73	62	8	**795**
MIMO	Germany	110	101	64	89	76	73	60	67	67	58	9	**775**
LOCAL+	Germany	78	106	81	60	74	79	76	63	74	54	0	**745**
levelup	Germany	98	92	99	53	67	63	88	74	64	31	10	**739**
Azalea	Spain	115	103	40	68	65	77	51	67	65	79	0	**728**
coLLab	Germany	106	108	70	52	70	82	65	71	54	34	0	**711**
EFdeN	Rumania	76	81	80	75	63	73	89	74	52	35	-2	**695**
TDIS	Taiwan	120	75	71	75	59	52	43	64	64	63	-1	**685**
X4S	Germany	76	75	83	65	56	65	80	68	40	27	-1	**634**
FIRSTLIFE	Czech Republik	74	90	43	59	61	50	88	72	58	25	2	**622**
Deeply High	Germany/ Turkey	74	41	76	51	50	65	41	69	28	25	-5	**515**
Lungs of the City	Hungary	79	38	38	54	0	73	32	44	47	18	-10	**413**
Team Sweden	Sweden	110	0	0	0	0	0	0	4	0	20	-7	**127**

Out of competition awards

In addition to the ten disciplines in the competition, twelve special awards were also presented. Partnerships were entered into with national and international associations and institutions for this, which ensured that the SDE's profile was also raised within these circles. Their juries selected the award winners. Votes were also submitted by the population and the district through online portals.

One particularly impressive moment was the presentation of the "Team's Choice Award". This award was not originally planned and was created on the initiative of all the teams on location. The reason behind this? The entire competition period was characterised by the teams mutually helping and supporting each other. Every day the shared news portal was full of "looking for this, need that, have this, got the following problem, be right over...". The teams created an intensive neighbourhood network among themselves. The house by the team from Sweden became a symbol of this culture. A university project with a far too small team and many challenges turned into an international competition entry in the end. Every team and the organisers on site actively contributed to the completion of the house in the end. The "Team's Choice Award" for Team Sweden became a symbol for all of us of what collective action can achieve, despite all the comparing and counting. The award ceremony became one of the most emotional moments of the Solar Decathlon Europe 21/22 in Wuppertal.

The "Team's Choice Award" in the hands of the proud team from Sweden.
© SDE 21/22

Team Identity	University
KIT	Karlsruhe Institute of Technology
TUE	Eindhoven University of Technology
TUD	Delft University of Technology
HSD	University of Applied Science Düsseldorf
FHA	Aachen University of Applied Sciences
ROS	Technical University of Applied Sciences Rosenheim
UPV	Polytechnic University of Valencia
HFT	Stuttgart University of Applied Sciences
ION	Ion Mincu University of Architecture and Urbanism
UPH	University of Pécs
CHA	Chalmers University of Technology

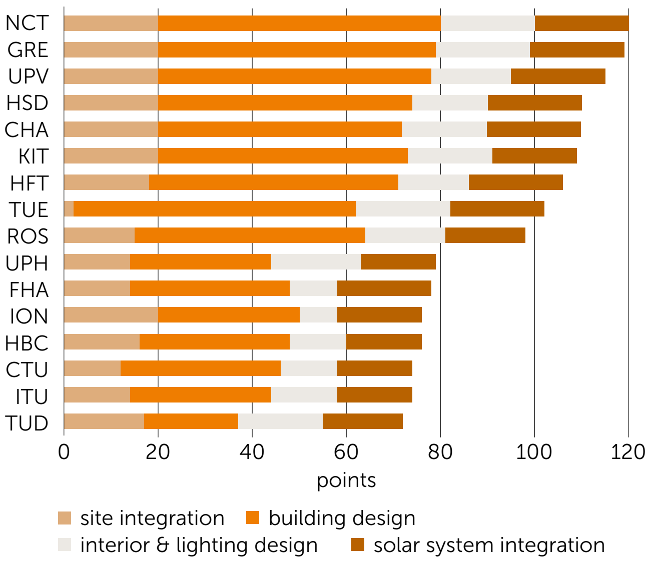
Special awards for the teams © SDE 21/22

Competition live:
The dinner in the house of team SUM
(sub contest 8.11).
© SDE 21/22

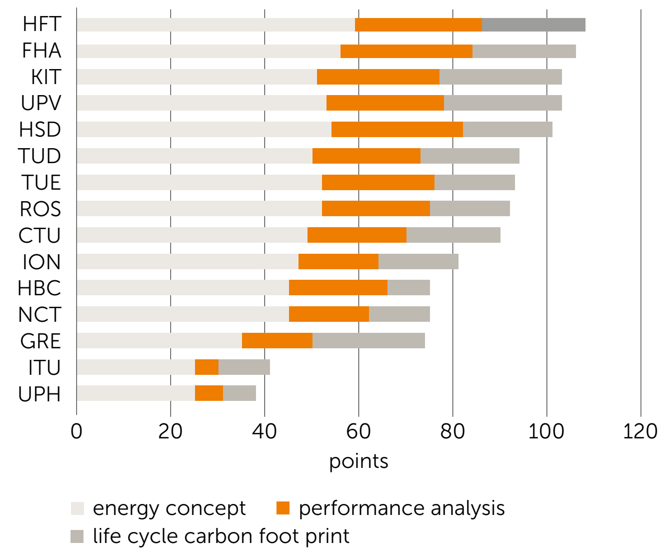
Team Name	Country	Solar Award	Indoor Air Quality Award	Timber Construction Award	Building for Future Award	German Sustainable Housing Award	Green BIM Award	Applied Mobility Science Award	Human Centered Interior Architecture Award	Sustainable Architectural Lighting Award	People's Choice Award	Mirke Choice Award	Team's Choice Award
RoofKIT	Germany		3	1		2	3			1		2	
VIRTUe	The Netherlands	1				1	2		2			1	
SUM	The Netherlands			2	1	3	1						
MIMO	Germany				2			1					
LOCAL+	Germany	2									2	3	
levelup	Germany		1							3			
Azalea	Spain							2					
coLLab	Germany		2	2	3			3	3	2	3		
EFdeN	Rumania			*							1		
Lungs of the City	Hungary								1				
Team Sweden	Sweden												1

* Honourable mention

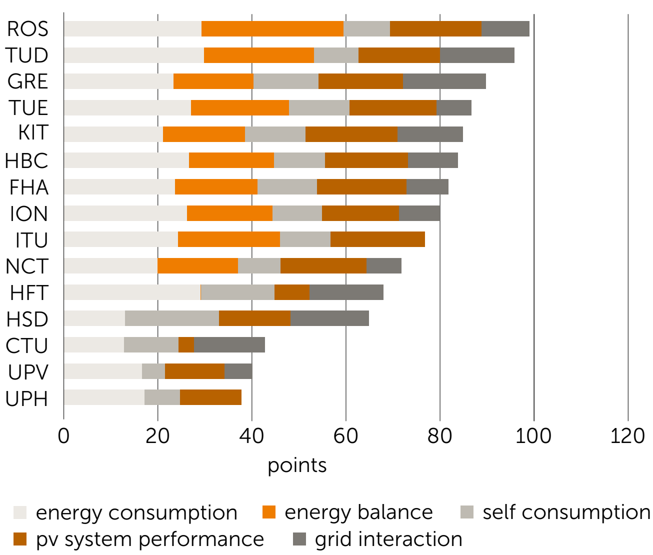
Contest 1: **architecture**



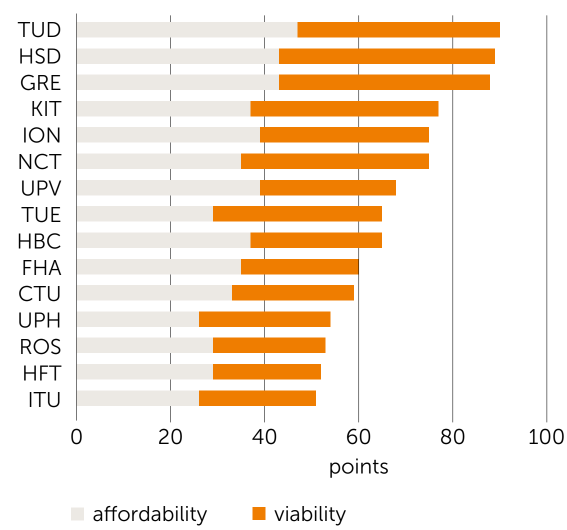
Contest 2: **engineering & construction**



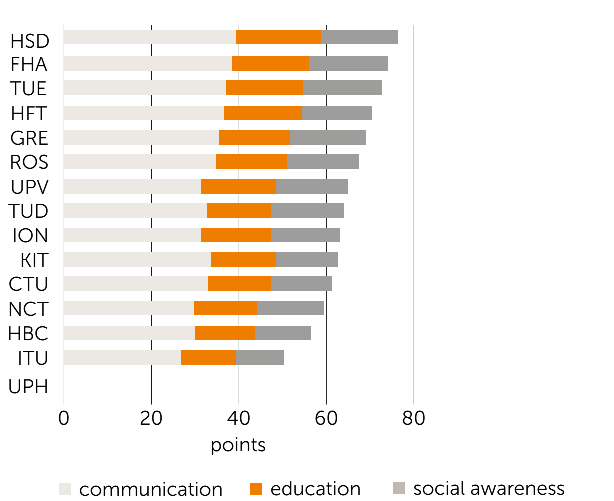
Contest 3: **energy performance**



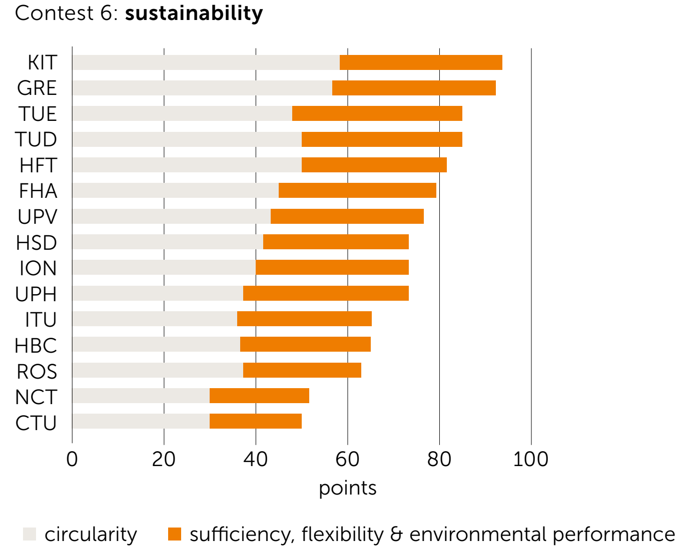
Contest 4: **affordability & viability**



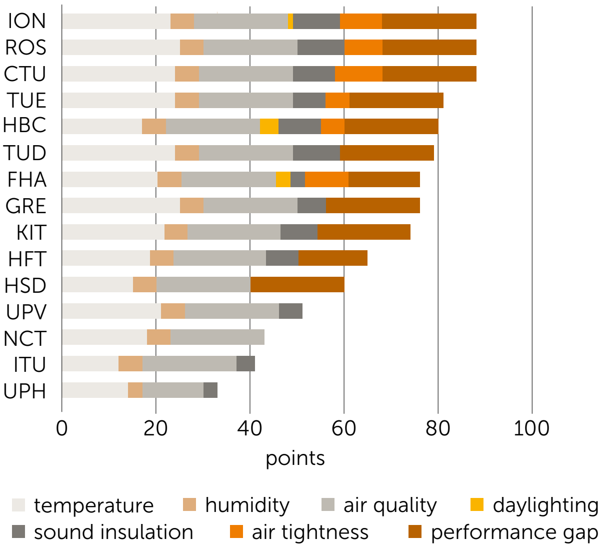
Contest 5: **communication, education & social awareness**



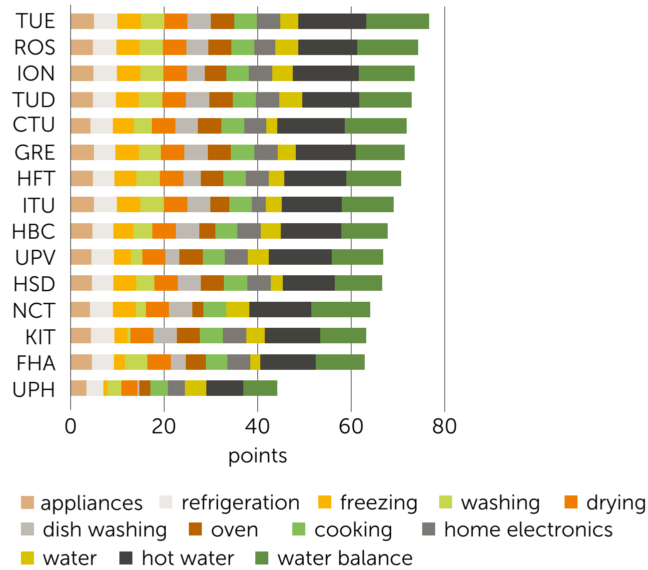
Contest 6: **sustainability**



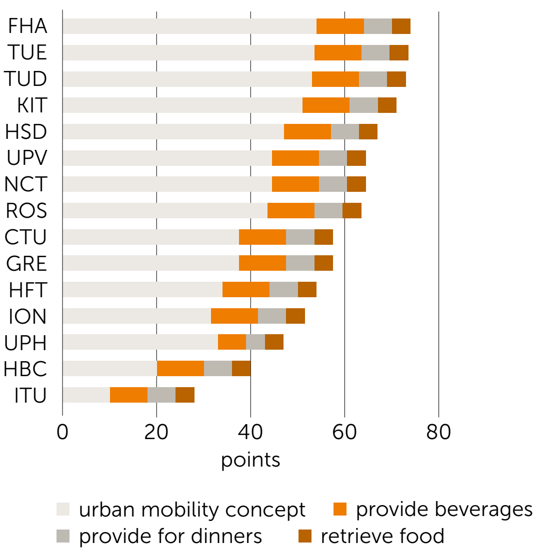
Contest 7: **comfort**



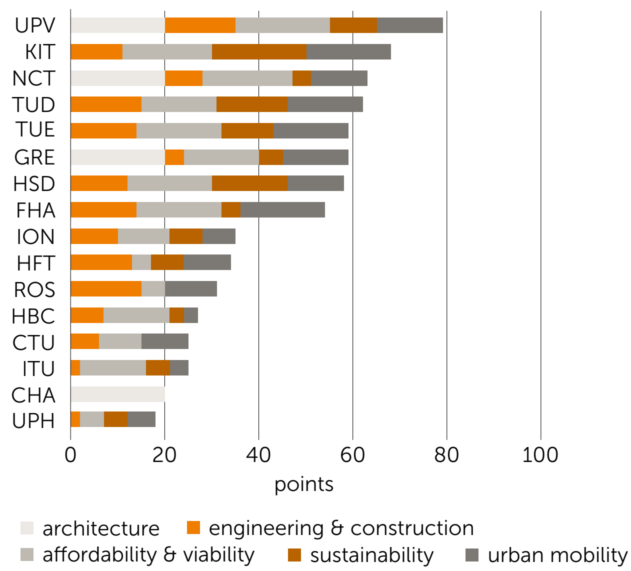
Contest 8: **house functioning**



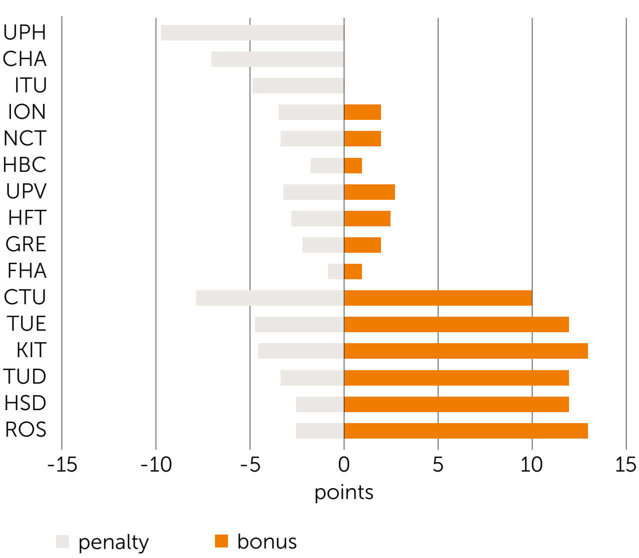
Contest 9: **urban mobility**



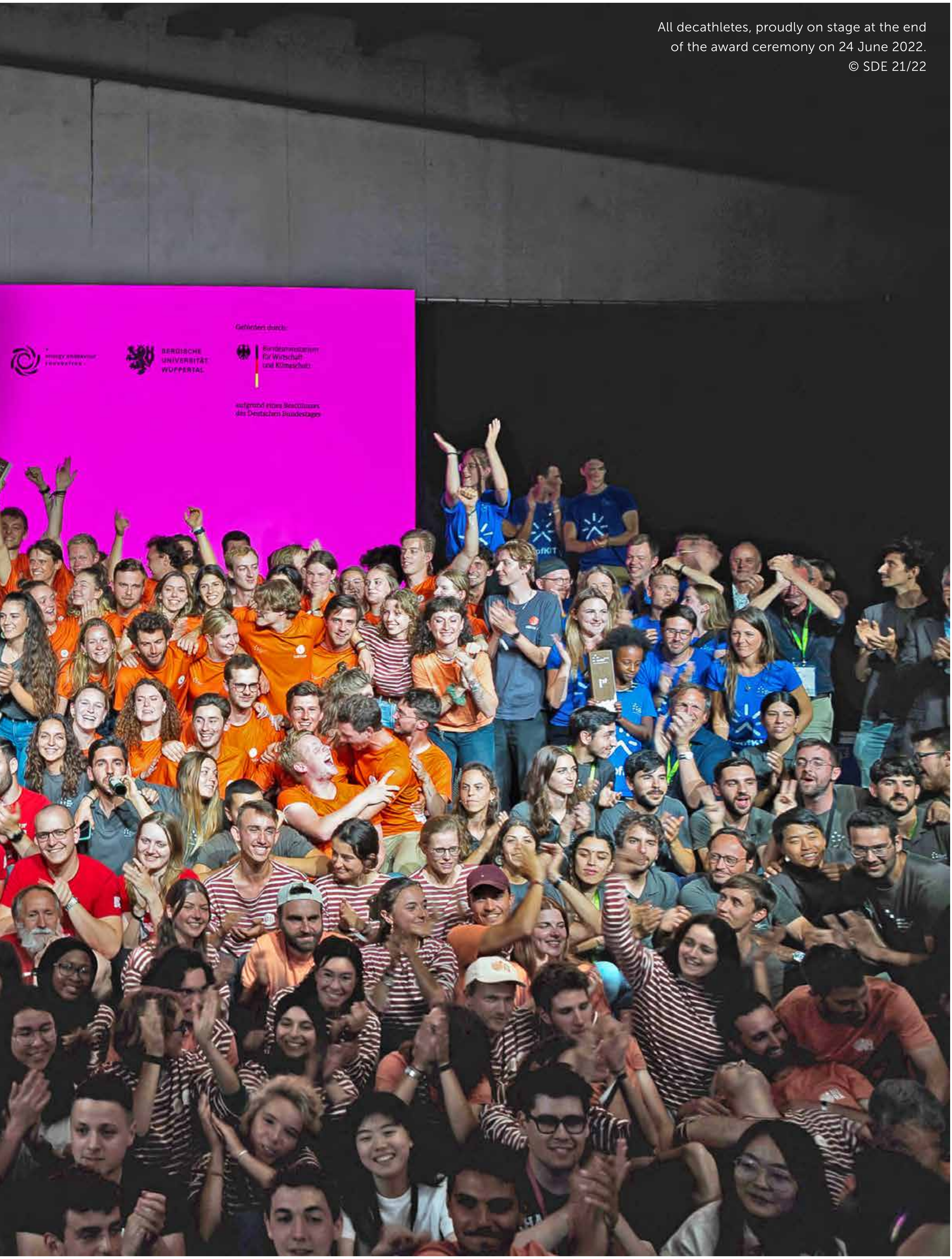
Contest 10: **innovation**



Penalty & bonus points




solar
decathlon
europe
21•22
WUPPERTAL GERMANY
goes urban!



All decathletes, proudly on stage at the end of the award ceremony on 24 June 2022.
© SDE 21/22

monitoring & climate

Karsten Voss
(University of Wuppertal)

In the competition, the three disciplines

→ Energy Performance
→ Comfort and
→ House Functioning

were evaluated entirely from measurement data and evaluation rules. The monitoring system developed for this purpose was based on data loggers in each house that record the signals from electricity meters, irradiation sensors, room climate sensors and appliance temperatures, store them locally and forward them via the Internet to a central data storage and processing system.

All the data was collected every minute and aggregated into 15-minute totals or median data as a basis for the evaluation in the competition. The software for the evaluation was further developed with the partner TÜV Rheinland out of the established platform from the Solar Decathlon held twice in Dubai. Many teams also operated their own monitoring systems for further evaluations.

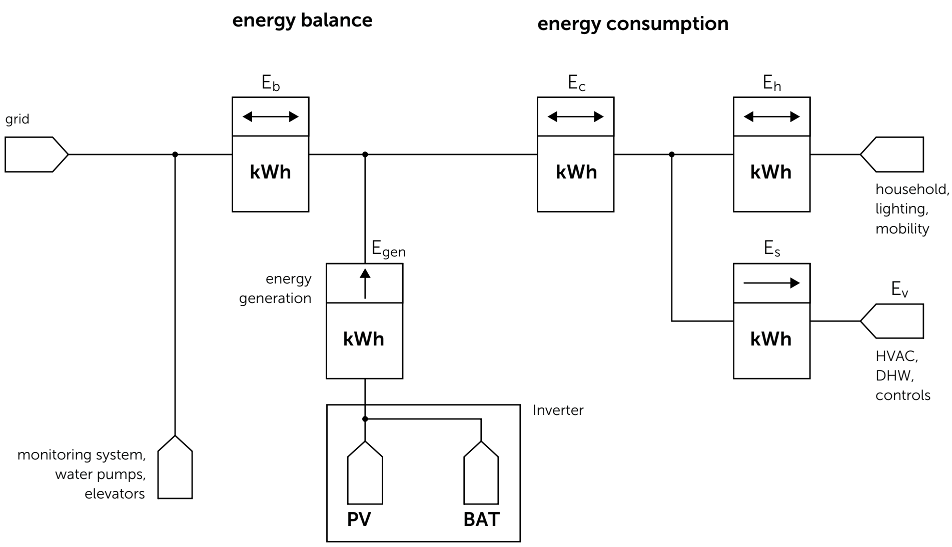
The indoor climate measurements were only taken on seven selected days when no visitors were allowed in the houses, while the energy and equipment measurements were taken continuously over ten days. The respective energy storage units' states of charge were recorded at the beginning and end of the competition by reading thermometers and charge level indicators. Water consumption data was derived from meter readings at the beginning and end of the competition. In total, over half a million pieces of data were collected during the competition. The monitoring system was even used before the actual competition days for the co-heating tests.

Decathletes from each team learn about the monitoring technology during the assembly period.
© SDE 21/22

Inside the central monitoring panel in each house
© SDE 21/22

Irradiation measurement at module level with calibrated solar cells. Buildings with PV systems facing different directions were equipped with multiple sensors
© SDE 21/22

Some of the buildings' properties were determined as part of special test measurements. For example, an airtightness test was carried out for each HDU and the sound insulation was determined. In addition, the illumination of the artificial lighting indoors and outdoors was checked by spot measurements at different times and compared with the requirements.



The standard was three digital electricity meters to determine five energy consumptions. The variables that were not measured were calculated from the energy balance. The amount of energy generated by solar was measured on the AC side and taking the battery storage into account.
© TÜV Rheinland

Temperatures in household appliances such as refrigerators, freezers, ovens, dishwashers and washing machines were continuously recorded using thermocouples.
© Claudio Montero,
Energy Endeavour Foundation

Room climate sensors on a tripod in the living area in the Rosenheim house record the air temperature and humidity as well as the CO_2 content at a height of 90 cm. Temperature and humidity were also measured in the bedroom. © SDE 21/22

Climate

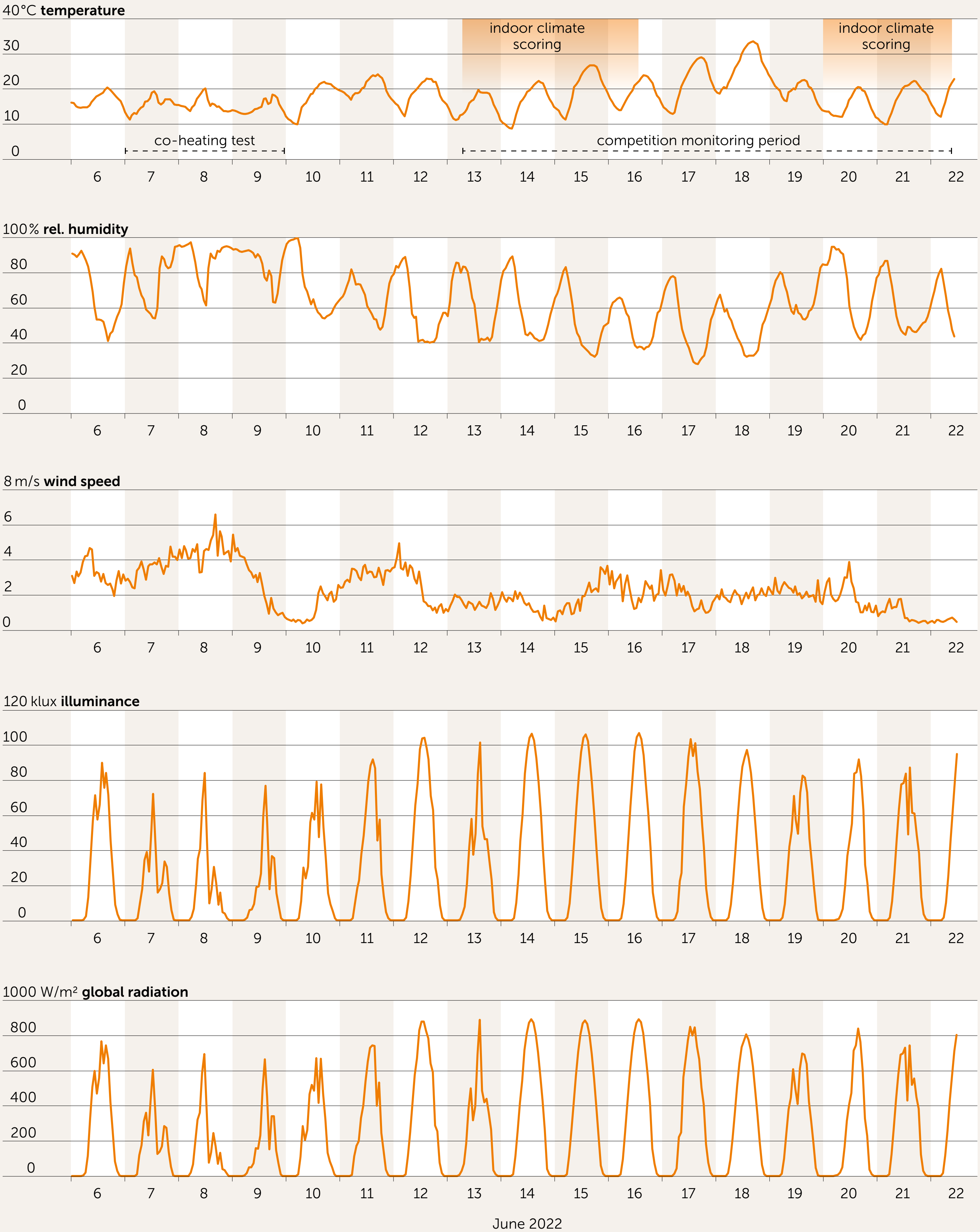
Local outdoor climate measurements directly on the solar campus were part of the monitoring. The basis for the teams' energy planning in the competition was the weather data set from the nearest meteorological station at Düsseldorf Airport. Moderate winters as well as summers are typical of the weather in Wuppertal. Wuppertal is neither a cold nor a sunny location by German standards. The long-term annual average temperature is 10.5°C, the total global radiation is 942 kWh/m²a. One special feature is the comparatively high rainfall, distributed over the entire year (1,170 mm). In light of the above, the energy planning for buildings focuses on winter thermal insulation, although winter temperatures are slightly rising due to climate change.

The conditions during the assembly period were typical for the season, with moderate temperatures between 10°C and 23°C; combined with intermittent heavy rain and windy spells. The moderate weather also continued during the co-heating tests. During the actual competition days it got much warmer and sunnier with up to 33°C (18 June) and no precipitation. Consequently, the indoor climate measurements refer to really summery conditions. The teams had live access to weather data from the measuring station on the Solar Campus to optimise the building operation.

Bad weather front at the start of the assembly period. © SDE 21/22

Compact weather station located on a building on the competition site under a bright blue sky. © SDE 21/22

Representation of the climate data during the competition period. From top to bottom: outdoor temperature, relative humidity, wind speed, illuminance and global radiation. The representation is based on hourly averages. Measurements on building level were taken in the buildings from 13 June, 8.00 a.m., to 22 June, 12 noon. © SDE 21/22


40°C temperature
30
20
10
0
indoor climate scoring
indoor climate scoring
co-heating test
competition monitoring period
100% rel. humidity
80
60
40
20
0
8 m/s wind speed
6
4
2
0
120 klux illuminance
100
80
60
40
20
0
1000 W/m² global radiation
800
600
400
200
0
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
June 2022

post competition living lab

Katharina Simon
(University of Wuppertal)

After the Solar Decathlon Europe 21/22 has ended, half of the buildings remained standing on the Solar Campus and were not dismantled. From autumn 2022 onwards, the Living Lab NRW became a research and educational facility for North Rhine-Westphalia (NRW), i.e. a real-world laboratory, including eight of the Demonstration Units constructed for the Solar Decathlon Europe. The House Demonstration Units were selected by a jury of experts already at the beginning of 2021. Not all of the teams that were interested in becoming part of the Living Lab NRW actually made it through, however. The number of places was limited to eight, as it was necessary to hand some of the Solar Campus back to the owners after the competition.

It wasn't easy for the expert jury to select the participating teams, as the standard of the concepts and ideas was exceptionally high throughout. The architectural approach, innovation in the area of the technical and structural implementation and a high degree of research potential were just some of the criteria that went into the decision-making process. The teams from Delft, Valencia, Taipei, Pécs, Prague and Biberach as well as the teams from Aachen and Düsseldorf in NRW succeeded in impressing the jury. They are research and cooperation partners for about three years.

The Living Lab NRW creates a network for research and education both throughout Germany and at the international level. The subject matter of this research is innovative concepts for climate-friendly, and in particular, energy-efficient buildings in the urban environment. Before the backdrop of the considerable importance of the building sector and the transformation of the urban building stock in particular, the Living Lab NRW is an exemplary demonstration and application project for the achievement of climate protection goals, for energy efficiency as well as

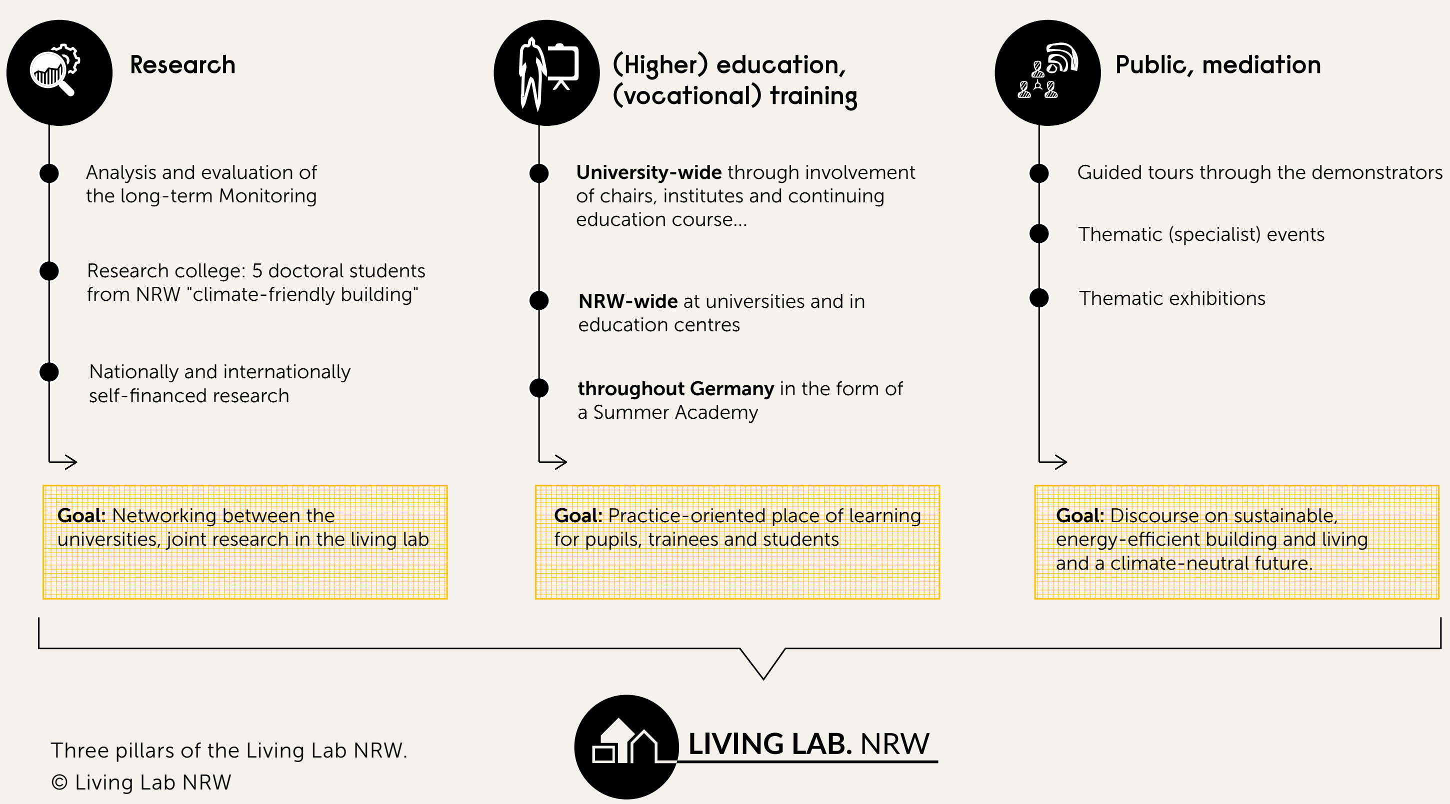
Site map of the
Living Lab NRW Campus
© Living Lab NRW

for the reduction of greenhouse gas emissions. It demonstrates new approaches to space sufficiency and a sustainable circular economy for building in the area of architecture and building design.

Five doctoral students from different universities in North Rhine-Westphalia work intensively on the demonstration buildings. The long research period over three years allows for a variety of topics to be investigated and – in contrast to the two-week SDE 21/22 competition phase – for the collection and analysis of seasonally-based measurement data. The doctoral theses address the optimisation of the local heating supply and operation of the buildings with the use of artificial intelligence; the circularity of electrical building energy systems; the impact of non-physical factors on residential health, as well as the development of teaching approaches. All universities participating in the Living Lab NRW are invited to become part of these research colleges and to further maintain the networks previously established during SDE 21/22. The goal of this research initiative is the networking and internationalisation of the universities as well as joint research in and at this functioning laboratory.

In addition to the research itself, another goal of the Living Lab NRW is the transfer into teaching and education. Specifically, the universities in NRW are to be encouraged to offer joint courses which are based on the Living Lab NRW. The participating students are also offered the opportunity to write their bachelor's and master's theses in the framework of the Living Lab NRW. Additional offerings for school pupils and young people undergoing vocational training are to be created so that a practice-oriented place of learning can be created for both these groups and students.
Public awareness is also to be strengthened and a public discourse on sustainable building and living in the city is to be encouraged. Regular events on specific topics are held for this purpose. The Demonstration Units remain open to the public through bookable guided tours.

After three years, the extent to which this real-world laboratory at this inner-city location in Wuppertal was able to contribute to the debate or even to a rethinking of climate-friendly living will become clear.



Three pillars of the Living Lab NRW.
© Living Lab NRW

reflections

SDE 21/22 Organisers
(University of Wuppertal)

When it comes to major events, the same rules apply as for architecture: not everything can be planned. In spite of, or perhaps because of, the almost one-year postponement during the coronavirus pandemic, SDE 21/22 came around just at the right time. At a time where there is maximum uncertainty about our future energy supply, the event and the university teams gave us food for thought about how we in architecture can build our way out of the current crises with energy, resources and the cost of living. Here, there are three strategies which form the focus, and these have always been part of basic practice in the sustainable economy: sufficiency, efficiency and consistency. In other words, reducing the amount of living space per person, frugality regarding the use of energy and resources, and consistent recirculation of the materials and products used.

The new profile

At SDE 21/22 in Wuppertal we saw that the focus of the Solar Decathlon Europe was more diverse than it had been previously. The competition has developed into a sustainability assessment for all aspects of construction. On the Solar Campus, we saw many ecological and sustainable structures, where the designers made use of contemporary technologies and production methods. This aspect should be followed up on in order to meet the demand of the competition for comprehensive sustainability in all areas examined. This also includes urban mobility with considerably fewer, or even completely without, private cars. The teams involved exemplified their concepts – they mainly travelled on foot, by bike or using public transport. They had their provisions delivered by cargo bike.

For the first time, the focus on further construction onto the existing urban building stock made the (urban) structural context important for each of the contributions. Against this backdrop, we saw renovation and adding new storeys or extensions or developing structures to fill in gaps between buildings and in demonstration buildings on site. The building stock and infrastructure context became an important inspiration.
In Europe, the clear focus on building in existing structures is precisely what is required to solve the pressing tasks relating to preventing climate change and changing the way we think about resources. Building new is the exception; further developing existing buildings is the reality.
For visitors of SDE 21/22 without previous information, this focus was not easy to recognise. At first glance, they saw the Solar Campus as an exhibition space for single-family dwellings. The cubic volume, proportion and façade design perplexed some visitors at first. Guides then explained the connection between the demonstration buildings which were built and the chosen construction task. The more complex the profile of a competition, the more it requires specific and purposeful communication. A Solar Decathlon is not necessarily an easy communication task. In non-English-speaking countries, the name does not provoke associations with construction, students, an exhibition or a competition. In the end, intensive networking and cooperation with local players, associations, craft, press work, social media activities and various presentations in advance brought more than 115,000 visitors to Wuppertal.
At the same time, the aim was to be more than just a one-off event for the Mirke neighbourhood, where the Solar Campus was located. More than half of the teams address the district with their project. Through the accompanying social science research, which took place in this form for the first time in the context of an SDE, the neighbourhood residents were actively involved

in the SDE 21/22 and its topics. This increased local acceptance and interest and created impulses for long-term neighbourhood development.

Solar energy meets architecture

One of the key tasks of each Solar Decathlon is to showcase the possibilities of utilising solar energy on buildings. We can certainly say that today's situation is completely new. The costs of fossil energy are increasing substantially. The costs of solar power generation have decreased so much that it has become the most affordable form of energy production, along with wind energy. The impressive technical and architectural integration of this possibility is a pressing issue, particularly in the case of existing buildings. For a long time, this was considered a purely theoretical option; now it's practically mandatory. At the SDE 21/22, hybrid collectors used in conjunction with heat pumps became a central topic in order to best utilise the potential offered by the small amount of roof area in urban construction. Sophisticated solar systems in façades were added to the catalogue of possibilities. In this regard, the SDE 21/22 lived up to its role as trailblazer for the building practices of the future.

Student builders

Building your first house is a very special experience for budding architects and engineers. Firstly, students from different faculties draw up their plans together in an interdisciplinary way. This is the concrete preparation for their later professional lives and encourages mutual understanding. At the SDE 21/22, several hundred students gained this experience – but not only that: they presented their visions of post-fossil construction and living to the public, and at a time where the world needs visions like these with more urgency than ever. They learned that future-proof architecture requires interdisciplinary teamwork and that in most cases, your first house is rarely just "yours" alone. They learned how to coordinate site processes under time pressure to ensure that their prototype houses were actually operational on opening day. They negotiated with sponsors, calculated budgets, read environmental product declarations and grappled with the operation of power stores which provide power to the network. They learned that architecture is a public art form which wants to be communicated and that it may provoke different reactions from different people. They allowed thousands of interested visitors – professionals as well as members of the public – to take a tour of their houses and attempted to explain the principles of sustainable construction to them.

The entire time, the participating universities had the task of integrating the competition into the curriculum of the various study programmes in the best way possible, and recognising the achievements of the students within their studies. After the competition, their task is to add further value to the experience. This includes the impulse to have more of an interdisciplinary approach in the faculties and study programmes, and the subsequent use of the competition results and the buildings for teaching and research at the respective university location.

In practice, architects do not build; they design something to be built by tradespeople. The cooperation between the universities and the trades was also implemented at this SDE with a broad range: some teams did all the trades work themselves, and others learned how to build professionally from trades partners in their workshops. The strategies produced very different learning successes. It's part of the SDE tradition to allow this openness. There is even further potential to be found in the participation of training centres for trades apprenticeships.

Competition meets building science

This SDE sought out a closer relationship with building science at an early stage. This had a clear effect on the regulations, the procedure and the monitoring of performance. In the planning phase, standardised tools and documentation platforms were used in order to encourage comparability of the results. BIM models were to be created for the first time. The teams on site faced new tasks in terms of room climate management and interactions between the building and the power grid. The monitoring programme was expanded and additional experiments, such as the co-heating test, were carried out. In selected areas, this book shows a first cross-application documentation and forms the basis for later analysis. Initial academic publications were submitted at this early stage and will be published during subsequent years. All data and documents are accessible on the "competition knowledge platform" where they can be further used for research and teaching purposes. It remains to be seen how intensively the vast number of associated possibilities are used. The national follow-up project "Living Lab NRW" also offers a great deal of academic potential, see below.

Universities as organisers

At an SDE, the local university is normally the main organiser. The high level of motivation among staff forms an almost perfect basis for success. This is especially the case when the university management supports the project emphatically. In Wuppertal, we had both. The successful SDE 21/22 became the highlight of the University of Wuppertal's 50-year anniversary celebrations. On the other hand, experience shows that the necessary resources are not always assessed correctly. A university is not a professional events agency and for a university, SDE is a one-off event where they have no prior knowledge of how to pull it off. The greater the success, the more spontaneous adjustments have to be made. This pushes many staff members to the limits of their skills and beyond. At the end, they can feel proud that they have achieved something really great together.

Spaces, costs and funding

Planning and holding a competition like the Solar Decathlon requires an available site and secure funding from an early point in time. This applies in particular if, in the case that the teams' own expenses are greater, they need to be sure that the final can also take place and be carried out to a professional standard at the end. A suitable competition space of around 40,000 m² must be available and rented on a long-term basis. Due to urbanisation and the associated high demand for urban living spaces, it is becoming increasingly more difficult to hold a Solar Decathlon on an attractive city-centre space in a European metropolis. The situation in Wuppertal was ideal. Experiences of competitions outside of the city have shown that these events are less attractive to the public and that there is significantly less success in terms of communication.

The University of Wuppertal budget for holding the 2022 Solar Decathlon was around 12 million euros. The German Federal Ministry for Economic Affairs and Climate Action agreed to the funding at an early stage, including start-up money of 100,000 euros for each team. The respective project volume was very different for the participating teams. On average, the costs were 1.2 million euros with a 30% funding proportion from business and industry. As a consequence, a Solar Decathlon Europe with 18 teams covers a total volume of a little over 30 million euros. The funding is successful against the backdrop of the great synergy between the aims of the competition and the European and national objectives for construction, mobility and climate change mitigation. The focus on renovation and further construction on existing buildings in an urban setting meant that this synergy was especially high at the SDE 21/22.

From competition to living lab

The follow-up project, "Living Lab NRW", is based directly on the SDE 21/22 with 8 out of 16 houses from the competition final. Its aim is to achieve a greater added value from the investments in the competition on site, as well as from the expenditure of the teams. The synergy is clear. The target group work started during the competition with school pupils, apprentices and students can be continued, and more time-intensive formats than with the SDE can be implemented. However, initial experiences also show how different the requirements are when working with a house which must remain stable and functional at the competition site for 3 to 5 years, and the requirements for a successful function during the two weeks of the competition. To achieve this, the teams must make early decisions, have preliminary structural consultations, make compromises and sometimes make construction changes and improvements, even after the competition. An example of this is ensuring that the building can operate through the winter without succumbing to frost, and maintaining the secure function of house automation. There would be numerous other requirements based on the respective construction law if the houses were to be lived in as normal. This is not the case in Wuppertal, as the focus here is on research and education.

Central, decentralised, hybrid

Weeks spent together in one place characterised the event and kept the SDE in the minds of the public. Experiences, networks and friendships emerged. In Wuppertal, the positive energy of the students produced a fantastic radiance everywhere, which filled the visitors with enthusiasm. Everywhere you looked, you could sense the feeling of overcoming obstacles and achieving something together.

On the other hand, the search for a central location is a limiting factor, it makes up the biggest part of the competition costs and the transportability of the houses and tight time window for assembling and disassembling create tough framework conditions. With complex construction tasks and building technology, the tight time window of two weeks to assemble the houses frequently causes the teams to be overburdened, or leads to less experimental solutions so that it can definitely be achieved.

In the USA, the costs mean that a decentralised competition is preferred since 2022. A thought experiment for Europe: houses are built at each university site at home as a joint competition task and are not transported. The tight time window for construction and commissioning is extended. Students travel to joint events at the university sites and for networking. The houses don't travel, they stay fixed in one place. This means that participants have significantly lower costs. In all, it increases the opportunity for universities from all over Europe to take on event coordination individually or as a group. The hurdles are smaller. Use of each university's site is clearly defined from the very beginning. There does not need to be a compromise between the function of the native climate and the climate at a centralised competition location. This was always an additional obstacle for teams from remote regions with different climates – in the case of Wuppertal, the teams from Spain and Taiwan.

The next European Solar Decathlons will show us what has changed and what has remained the same. Let's proceed!

Signboard at the lot of team RoofKIT
© SDE 21/22

House Demonstraion Unit
of the team from Delft
© Steinprinz / University of Wuppertal

Facts and Analysis

While the project portraits in the forth part of the book present the contributions of the teams in detail, the following part shows a cross-sectional analysis of selected topics. A core team from the School of Architecture & Civil Engineering of the University of Wuppertal did the compilation and evaluation.

architecture as a discipline

Frauke Rottschy
(University of Wuppertal)
and Jakob Schoof
(DETAIL)

"Everything is architecture" was the title of a programmatic text written by Hans Hollein in 1967. According to Hollein, "Our efforts are aimed at the environment as a whole and all the media which shape it". "Whether it is television or air conditioning, transportation or clothing, the telephone or housing." Even if students today would certainly set other priorities, the Solar Decathlon pursues a similarly all-embracing aspiration. Accordingly, the ten disciplines represent the entire spectrum of sustainability. The recyclability of the building materials, the choice of structural design and the cost-effectiveness of the overall concept are assessed by separate expert juries. Architecture is just one of ten assessment categories in the Solar Decathlon, which is certainly due to the fact that the competition does not have its origins in the world of architecture. To architects, this is equivalent to renaming the pole vault in the Olympic decathlon, for example, as "track and field" and thereby implicitly excluding all the other disciplines – the javelin, the 110-metre hurdles, or the shot put – from this designation.

To classify architecture as a discipline in this way is due to the nature of this competition format, as without the sub-disciplines, a decathlon is not possible. However, it is certainly the most integrative and generalist. In the following, to do justice to the wealth of architectural and design solutions on display at the Solar Decathlon Europe 21/22 in Wuppertal, we look at the cross-cutting themes which had a particularly strong impact on the designs in this year's SDE 21/22 and make reference to detailed contributions at the appropriate points.

Tours on the Solar Campus: architecture is a public art which needs to be explained and understood. © SDE 21/22

The task: further building

In the early years, the Solar Decathlon essentially designed and built buildings without an (urban) architectural context. The only restrictions and guidelines were in the form of construction limits, referred to as the Solar Envelope, which the teams were and are required to comply with in order to avoid shading the houses of the other teams and ensure comparability in terms of the size of the demonstration buildings. At the SDE in Wuppertal, by contrast, the designs were specifically related to a single location, and the focus was on retrofitting existing buildings and a sustainable further development of the city. Before designing the demonstration building, the teams focused on an overall building in an actual urban environment, and developed ideas for bringing about a transformation of urban neighbourhoods. A core idea behind this task is that in the years to come, the renovation of existing buildings will determine whether the climate goals in the building industry can be achieved.

Designs should always take the renovation of the existing building into account. Overall, the teams placed a strong focus on the topic of adding new storeys to buildings, with some 50 percent of the projects addressing this topic. Half of the participating teams also addressed construction projects from their home cities and regions. In addition to projects for the Mirke district of Wuppertal, for example, the designs on show included adding new storeys to a post-war building in Prague to provide accommodation for students, an in-fill development in a historic district of Bangkok, and the transformation of a former hotel building near Grenoble in the Alps. In this way, the SDE 21/22 shows that building in existing buildings is relevant in many cities and that – with all due respect for specific climate and cultural factors – numerous solutions can also apply throughout Europe, if not worldwide.

A genuine urban context was selected by the team from Taiwan – an in-fill development in Taipei. © SDE 21/22

Comparison of existing building...

...and design visualisation by the team from Grenoble © AuRA / SDE 21/22

The Solar Decathlon as a reflection of architectural diversity

Through the contextualisation of the task and the different cultural backgrounds of the teams, the students' designs at the SDE 21/22 took on a greater degree of depth. Cultural peculiarities, such as the use of natural ventilation and insulation material by the teams from Valencia and Taiwan, who come from warmer climates, weren't just visible but also tangible through the choice of materials and the spatial geometry. Embedding the projects in the urban and cultural context has therefore been beneficial for the importance of the SDE in terms of the architectural dialogue. It gave the designs a natural authenticity which extends beyond what an exhibition display without any reference to a particular location is capable of achieving.

It is ultimately of consequence that the first three places in the architecture category went to teams which pursued exceptionally independent design approaches adapted to their urban building situation. The variety of topics and concepts was correspondingly large: the team from Taiwan worked on an extremely narrow, elongated in-fill building project in Taipei, and used cedar wood from the region for the supporting structure. The team from Grenoble designed the transformation of a former hotel in the Alps, making use of traditional materials such as straw and clay, and the team from Valencia dealt with the careful redevelopment of the historic district of El Cabanyal, designing a façade made using local ceramic. In terms of the assessment by the jury, weak points in the detailing, technical implementation or building integration of solar systems tended to play a secondary role to the design, the spatial and the typological attributes of the projects.

Historical building in the El Cabanyal district and modern interpretation in the façade by the team from Valencia.
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& Steinprinz / University of Wuppertal

Interestingly, having recourse to the tasks in the Mirke district prepared by the organisers for teams that weren't from the local area – which initially seemed straightforward – did not necessarily prove beneficial. This is because, from a distance, the task was more difficult for these teams to assess and to complete, such as for the team from Bangkok, which dealt with the in-fill project in the Mirke district. This may be because although an understanding of the regional specifics without on-site presence is theoretically possible, it cannot be of a comprehensive nature in practice. This was partly noticeable in the contributions, as some of the designs involved cultural blending and something of a collaged form of implementation.

The contribution by the team from Gothenburg was also an experimental collage, which was recognised and appreciated by the architectural jury for its process-relevance and contradictory nature. The team began with the idea of the 3D printing of key parts of its demonstration building, but failed to implement it due to a lack of materials, equipment and people. The team nevertheless had the ambition to be included in the competition, and confidently proclaimed: "We are making use of the experimental freedom and aware that we won't deliver a perfect product". The example shows collaboration, the joy of experimentation and that failure in terms of the formal criteria can nevertheless lead to (learning) success.

The team from Gothenburg used 3D printed elements for its demonstration building. The jury praised the experimental and process-relevant approach of the project. © Steinprinz / University of Wuppertal / SDE 21/22

Showing the big in condensed form – from the overall building to the demonstration building

At the SDE 21/22, the teams started by addressing the urban integration and design of the overall building, which was also reflected in the assessment criteria. Due to the varied nature of the urban contexts, emphasis was placed on a systematic investigation into the surrounding area. Therefore, the jury was also concerned with the urban building qualities and the selected building typologies. For example, in the case of the six teams which planned adding new storeys to the Café Ada building, there was some discussion about the proportionality of the new storeys as regards the surrounding development, as the designs differed greatly in terms of their height. The height of the newly added storeys varies between two and four storeys, whereby the teams with three additional storeys and an overall building height of about 20 metres aligned their work with the height of the neighbouring buildings.

A special attribute of the demonstration buildings is that the intersections, which result from the choice of the section from the overall building, remain visible. For example, in the case of the in-fill development, the side façades are closed, as these consist of the fire walls to the neighbouring buildings. With the addition of new storeys, the façades are closed at the corner or only have one door, which represents the entrance door to the apartment. The majority of the teams used the closed façade areas to explain their concept and the constructed buildings to the visitors on large canvases or with the use of printed façade elements.

Communal and with the minimal use of space: the housing typologies

The teams developed sufficiency-based, space-saving housing concepts primarily for single people and couples, including accessible solutions for older residents. They do not consist of classic one- and two-bedroom apartments, however, but a combination of small individual spaces with generous communal areas both indoors and outdoors. Accordingly, the teams seek to demonstrate that privacy and communal living are not mutually exclusive. The living space per capita in the projects is consistently well below 40 m^2, and in many cases less than 30 m^2, which is also shown in the section on Sufficiency. Larger family dwellings were most likely to be envisioned by those teams that had looked at larger existing buildings in their home regions. It would also have been interesting to see more intelligent, space-saving solutions from this area at the SDE 21/22, especially since demand for family housing is currently on the rise, at least in the major German cities.

Height comparison of three designs involving the adding of new storeys to Café Ada

© VIRTUe

© RoofKIT

Convertible interior elements for space-saving building

Space-saving building doesn't stop at the room shell, but is required to continue with an appropriate furnishing concept to elicit the maximum utility from every square metre. Almost all of the teams therefore explored the space-saving potential of reconfigurable, multifunctional furnishing elements. In the house demonstration units, fold-out beds and pull-out tables are standard equipment. More unconventional solutions, for example, include rotatable storage elements in the Stuttgart house, or a completely movable wall of cabinets, as realised by the team from Delft in their demonstration building.

Thinking differently about land use – minimalist sleeping and living cubes in the Aachen house.
© Steinprinz / University of Wuppertal

Storage and dual use solutions: movable table and bed by the team from Eindhoven and rotating cabinets by the team from Stuttgart.
© Steinprinz / University of Wuppertal

© MIMO

Roof terraces, conservatories, outdoor kitchens: offerings for outdoor living

The contributions to the SDE 21/22 demonstrate that the roof areas of our cities are too valuable to be left as unused expanses of tarmac or gravel. The teams made these available for a variety of uses as rooftop gardens or terraces which are generally available to those who live in the apartment building. In this respect, pergolas and canopies don’t just provide shade, but also serve the purpose of harnessing solar energy and are often used for urban gardening. In private apartments, balconies and conservatories also extend the living space to the outside. In other cases, outdoor circulation areas which are of the appropriate size serve as communal outdoor areas.

The teams from Rosenheim and Bucharest, for example, present green conservatories which are available for communal use. The furnishing of these areas is not always particularly differentiated, and in most cases, they can’t be used all year round in the Central European climate. Exceptions, such as that of the team from Grenoble, which set up a full outdoor kitchen on the roof of its house demonstration unit, confirm this rule. Making rooftop space available for community use rather than high-priced penthouses may be a luxury which profit-minded developers are quick to rule out. The designs show what is possible when commercial pressures on urban spaces play a less dominant role, however.

Conservatories and roof terraces with urban gardening by the teams from Pécs and Rosenheim. © Steinprinz / University of Wuppertal

Solar systems as part of the architecture

In this area, the SDE 21/22 shows an impressive range of solutions with a high degree of sophistication from the technical and design perspectives. A more detailed description is provided in the section on Solar System Integration. Some systems are located more inconspicuously on rooftops, with little or no impact on the appearance of the house. In these cases, the teams are able to dispense with expensive stand-alone solutions. In the case of the visible systems, both the skilful handling of the design-related integration and technological progress are clearly evident. As a combination between thermal and electric collectors, hybrid systems are widely represented, and are particularly striking on the façade of the house from Biberach. The enthusiasm for design with respect to PV was particularly evident in the Dutch teams from Delft and Eindhoven, with ceramic printing processes, and the team from Stuttgart, with trapezoidal, organic solar cells.

Architecture becomes green – façade greening and trellises

In their projects, the teams looked at various forms of building greening in the interests of counteracting urban heat islands. In the case of the team from Aachen, the extensive greening of the façade encourages biodiversity. It is equipped with automated irrigation. The team from Pécs integrated nesting boxes for various native bird species in their greened façade. In the case of the house from Stuttgart, the steel cables for the PV elements in the lower area serve as a trellis for plants. Façades and roofs can lower the local temperature through evaporative cooling, or absorb and buffer rainwater during heavy rainfall, see the Building Envelope section.

Coloured PV cells manufactured with a ceramic printing process by the team from Eindhoven and trapezoidal organic solar cells on the house from Stuttgart show considerable enthusiasm for design.
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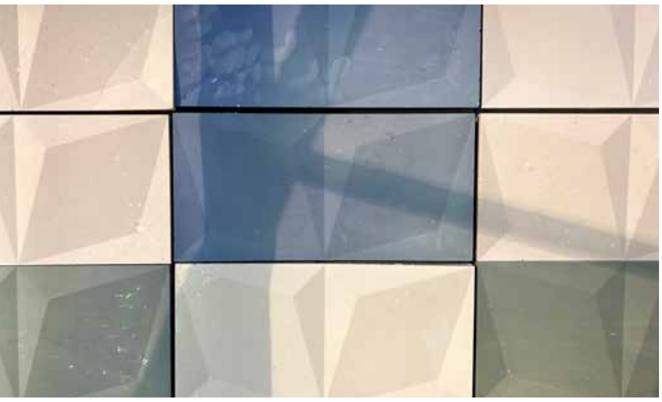
Façade greening with automated irrigation on the house from Aachen
© Steinprinz / University of Wuppertal

The construction: room module construction from wood

Prefabricated buildings are almost inevitable at the Solar Decathlon, as the demonstration buildings are built at their home sites before being transported to the respective venues and constructed there in a very short time – in Wuppertal, within two weeks. The competition entries therefore follow the trend which is currently underway in the construction industry towards prefabricated room modules made from wood, as shown in the section on Modular and Elemental Construction. Some of the advantages are obvious: speed on the construction site by relocating the manufacturing to the production hall, the building material of wood as a sustainable and renewable raw material which acts as a reservoir of CO_2, and a resource-conserving lightweight construction method with a low weight. The additional potentials of prefabricated timber construction consist of the reduction of waste and a high quality of execution. Prefabricated timber construction, either from planar elements or from prefabricated room modules in timber frame or solid timber construction, was therefore an obvious choice for the teams. The Solar Campus therefore showcased timber construction at its finest, with a precision and speed that the people of Wuppertal were able to marvel at from the Nordbahntrasse cycling path and walkway during the construction phase.

Design for disassembly – recycling loop capability through clever designs

In the contributions to the SDE 21/22, approaches for innovation in terms of recycling-loop-capable constructions abound. The teams demonstrate possibilities for the further use and reuse of building materials, and with their designs, contribute to closing material loops as well as to construction methods that minimise waste. They practice what is known as design for disassembly, in which the dismantling of buildings at the end of their life is considered in the design and the construction from the outset. One principle here is to rely on mono-materials rather than mixtures of materials. The teams from Düsseldorf, Rosenheim and Karlsruhe have therefore completely dispensed with glued wood products in their demonstration buildings. The thought of the subsequent dismantling shapes the designs, right down to the smallest details of the interior. Some teams build silicone-free bathrooms and kitchens, for example. Interior wall and ceiling panels can be seen to have been fastened with screws in the demonstration buildings from Istanbul/Lübeck and Karlsruhe. Two teams also developed "dry" constructions without tile adhesives for ceramic materials. These constructions consciously show the fastening materials and joints, and are therefore also effective in terms of design. The fact that this effect can be made use of for architecture on a beneficial basis was demonstrated by the demonstration buildings at the SDE 21/22 in a wide variety and to a high design standard.



Dry constructions:
ceramic façade without mortar
and adhesive by the Taipei team
© SDE 21/22

Design concepts for the loop economy

The contributions to the SDE 21/22 show that the students have taken the cradle-to-cradle idea into full consideration, and that they know how to use it creatively. The winning project by the team from Karlsruhe underlines this with its façade cladding made from reclaimed wood, the borrowed steel staircase to the upper floor, and the second-hand windows in the entrance façade. The windows had been made in the wrong size or colour or had been left unused at the window manufacturer for other reasons. At the HDU, they complement each other to create a patchwork-like façade image which illustrates how building with reused materials is a little like “dumpster diving” – the menu is based on what is available, and not what is on the shopping list. Those who build with “classic” recycled materials, in contrast, are subject to comparatively few restrictions. Here, above all else, it is the interior design of the houses that demonstrates what is possible: the teams use glass ceramics or board materials made from recycled yogurt pots for kitchen units and wet room cladding, they make tables from old door leaves, and for the wall cladding and seating they use boards made from recycled Tetra Pak cartons, on some of which the calorie information remains legible. In general, the students give preference to large-format cladding over small-format tile and slab coverings. Equally ubiquitous in the HDUs, although at times less obvious, are building materials from the biological materials cycle. Wall cladding made of clay building panels conceals insulation made from seaweed, straw bales, recycled cotton or rice husks – mostly, but not always, from the agriculture and forestry of the teams’ home regions. The attentive observer encountered wood and wood-based materials at every turn in the SDE 21/22 – not only as a load-bearing structure, but also as a surface material.

Reused windows and façade woods on the house from Karlsruhe
© Steinprinz / University of Wuppertal

modular and element-based construction

Frauke Rottschy
(University of Wuppertal)

View into the production hall of the assembled room modules by the team from Karlsruhe. © RoofKIT / SDE 21/22

Glue-free wood-wood connections for wall elements for the house demonstration unit by the team from Düsseldorf. © MIMO / SDE 21/22

At each Solar Decathlon, the teams face the challenge of designing and constructing their buildings in such a way that they can be transported to the venue and erected within a tight time frame before the event. Therefore, the buildings usually have a medium to high degree of prefabrication. Specifications for maximum transport dimensions were set out in the SDE 21/22 regulations. The maximum transport dimensions were 4.0 m x 3.0 m x 22.0 m. (L x W x H). The teams had exactly two weeks to set up their house demonstration units on the Solar Campus. The teams had to go through a structural inspection of the foundations as part of the construction phase before they could start assembling their prefabricated elements and modules.

Initial set-up at the home location

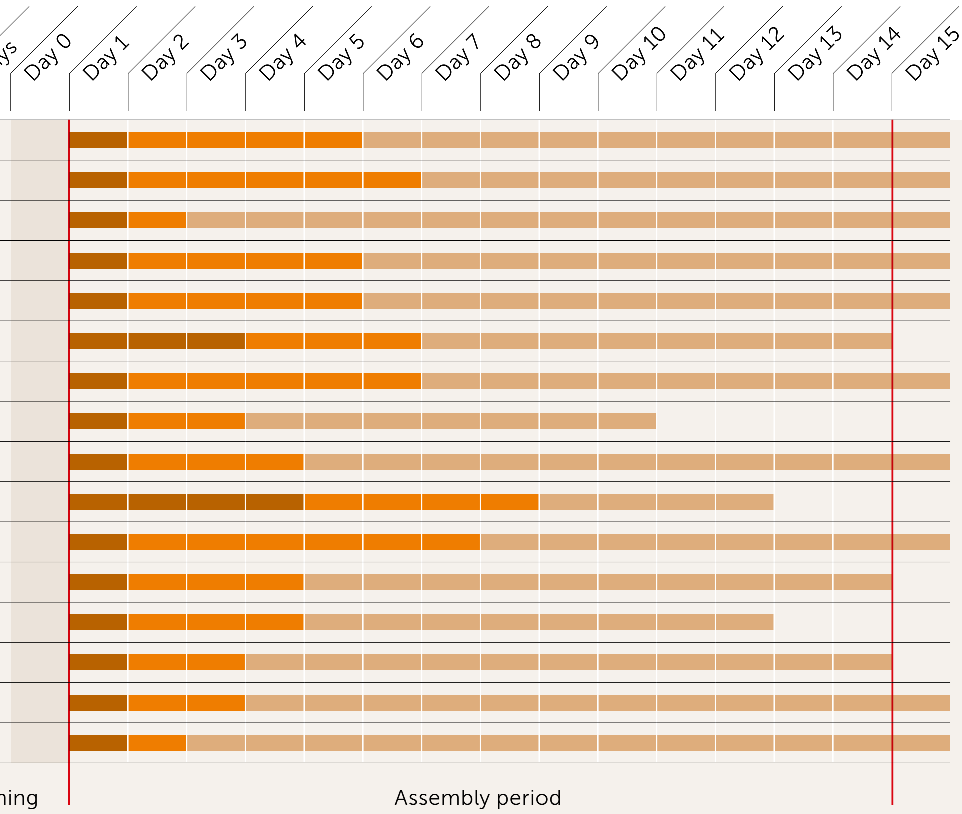
The SDE teams usually build their houses at their home sites and then transport them to the venue. However, there are also some teams that produce the components for their house demonstration units just in time and then assemble them for the first time on the competition site. The degree of prefabrication and the teams' own construction share differ from each other depending on the teams' concept and performance. At the SDE 21/22, for example, some teams had their building constructed by timber construction companies. In these cases, the students were involved in production on site with the industrial partners and learned their trade there. In contrast, other teams built their house demonstration units completely by themselves. Both strategies have advantages and disadvantages. In the case of professional production, the teams learn about the coordination process with the companies and therefore a great deal about the technological possibilities that exist in the companies' production lines. For the teams that construct their buildings on their own, the learning experience is more in learning by doing. They have the opportunity to live through their project themselves from the very first sketch to the last screw and thus get direct feedback between the planning and implementation.

In the case of the Grenoble team, the project was carried out through an affiliated institute of the university called “Les Grands Ateliers”. The old SDE house demonstration units from 2010 and 2012 were completely dismantled into their individual parts and, for example, 80 percent of their timber construction was reused from the recovered material. The team is therefore a good example of “design to disassembly”. As part of the competition, the team from Düsseldorf involved all the university’s departments in the project and achieved a high level of knowledge and technology transfer between the stakeholders. The university’s timber construction workshop acted as the key institution in this case. For example, the team here has dealt with glue-free constructions, from shell construction to furniture construction.

The team from Grenoble is experimenting with straw and clay at "Les Grands Ateliers".
© AuRA / SDE 21/22

The teams’ planned set-up and assembly times, divided into foundation, primary construction and finishing.
Source: SDE 21/22

Team Identity	City	Team Name	Days
CHA	Gothenburg	Team Sweden	15
CTU	Prague	FIRSTLIFE	15
FHA	Aachen	LOCAL+	15
GRE	Grenoble	AuRA	15
HBC	Biberach	X4S	15
HFT	Stuttgart	coLLab	14
HSD	Düsseldorf	MIMO	15
ION	Bucharest	EFdeN	10
ITU	Istanbul/Lübeck	Deeply high	15
KIT	Karlsruhe	RoofKIT	12
NCT	Taipeh	TDIS	15
ROS	Rosenheim	levelup	14
TUD	Delft	SUM	12
TUE	Eindhoven	VIRTUe	14
UPH	Pécs	Lungs of the City	15
UPV	Valencia	Azalea	15



Foundation   Primary construction   Finishing

Module assembly by the team from Aachen: The second of six room modules in total is assembled. © LOCAL+ / SDE 21/22

Assembly period in Wuppertal

In preparation for the event phase, all teams have prepared a construction schedule for the assembly period. The majority of the teams (just under 80 percent) used the entire assembly period of 14 days in their planning. Only four teams indicated shorter assembly times between ten and twelve days. The planned completion of the shell was on the second day in the shortest case and on day eight in the longest case. The actual assembly time for the primary construction using the two fastest teams' prefabricated room modules was just one to one and a half days. The longer duration for the foundation and erection of the primary construction for the team from Karlsruhe was due to the fact that the residential floor is one storey above ground level and is elevated. Overall, it was easy to observe that for some teams there was a considerable difference between the planned construction time and the reality of construction. Due to the teams starting their construction at the same time, the differences in the construction progress were very easy to observe.

			Type			Technical				Prefabrication				
Team Identity	City	Team Name	Modules	Hybrid	Elements	Technical core	Façade premounted	Roof-PV premounted	Visible joints	Very high level	High level	Medium level	Low level	Very low level
CHA	Gothenburg	Team Sweden			•	•							•	
CTU	Prague	FIRSTLIFE		•		•						•		
FHA	Aachen	LOCAL+	•			•			•		•			
GRE	Grenoble	AuRA		•					•		•			
HBC	Biberach	X4S			•	•						•		
HFT	Stuttgart	coLLab			•	•	•					•		
HSD	Düsseldorf	MIMO		•		•		•			•			
ION	Bucharest	EFdeN	•						•		•			
ITU	Istanbul/Lübeck	Deeply high	•			•			•			•		
KIT	Karlsruhe	RoofKIT	•			•	•	•	•	•				
NCT	Taipei	TDIS			•								•	
ROS	Rosenheim	levelup	•			•		•			•			
TUD	Delft	SUM	•			•	•				•			
TUE	Eindhoven	VIRTUe		•		•		•	•			•		
UPH	Pecs	Lungs of the City		•				•				•		
UPV	Valencia	Azalea			•	•			•			•		

Overview of prefabrication strategies by the SDE 21/22 teams, sorted by the main categories type of prefabrication, preassembly of technical elements and degree of prefabrication. © SDE 21/22

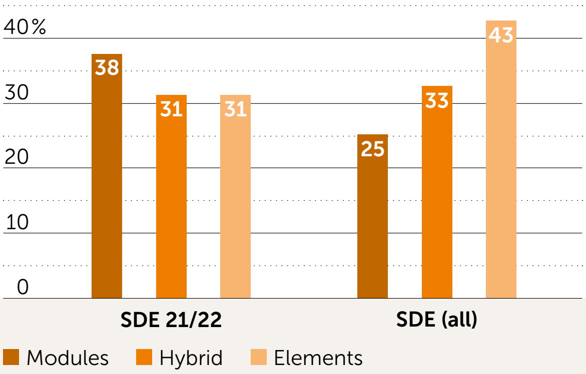
The degree of prefabrication

The degrees of prefabrication for the house demonstration units varied greatly at the SDE in Wuppertal. The majority of the teams used prefabricated room modules or hybrid constructions with prefabricated living, bathroom or technical modules for their house demonstration units. However, the strategies differed in different stages of the finishing. For example, the team from Karlsruhe delivered almost turnkey modules with the façades and roof cladding, as well as the interior panelling and furniture already pre-installed.

Although the team from Aachen also had a high degree of prefabrication due to the modular construction method, the curtain walls and roof sealing were only attached on site. The room modules from the Istanbul/Lübeck team were in a medium stage of construction. The team essentially delivered the primary construction

Timber frame made of cedar as the primary load-bearing structure. The Taipei team used small-scale elements.
© TDIS / SDE 21/22

The third and therefore last roof module is put into place. The team from Karlsruhe has a very high degree of prefabrication, as the façades and roof cladding are already assembled and the interior fittings are also delivered completely pre-assembled.
© RoofKIT / SDE 21/22



Comparison of the average share (in percent) of modular, hybrid and element-based buildings for all SDE competitions and the shares at the SDE 21/22. An evaluation on the prefabrication of SDE houses between 2010 and 2019 has been published in a scientific article entitled “Leichtes und nachhaltiges Bauen” (Lightweight and Sustainable Construction) in the Bauphysik-Kalender 2022.
© SDE 21/22

made of wood including the intermediate infill of straw insulation to the Solar Campus. The entire interior fittings, the technical installation and the façades were created on site.

About one third of the buildings were composed of wall panels or individual elements. But there were big differences. The team from Stuttgart was able to erect their element-based timber construction on site in just one working day. The building was tight from that moment on, only the joints still had to be connected and sealed. The Taipei team assembled each part of the cedar load-bearing framework individually on site. The interposed wall elements were also planned in very small parts. This division into many individual components was to optimise transport costs by being able to use standard containers.

Connections and constructions

The primary constructions of the house demonstration units at the SDE 21/22 were generally made of wood. Half of the houses were either timber frame or solid timber construction. The only exception was the team from Grenoble, which used prefabricated concrete elements as load-bearing components in their house demonstration unit, an unusual choice of material for the Solar Decathlon. In this house, the concrete core represented the existing construction. The house demonstration units in solid timber construction differ in their choice of materials in two subcategories. Most teams used glued cross-laminated timber elements for their load-bearing structure. The team from Düsseldorf, on the other hand, used glue-free wall, floor and ceiling elements made of plugged and wedged solid wood for their living modules. In the case of the team from Rosenheim, the load-bearing wall layer was dowelled without glue using wooden dowels. The transverse bracing was achieved by a diagonally mounted layer of boards.

Team Identity	City	Team Name	Solid wood construction	Wood frame construction	Timber panel construction	Cross-laminated timber	Solid wood	Solid construction timber	Wooden cross-piece beams	Laminated beams
CHA	Gothenburg	Team Sweden		•				•		
CTU	Prague	FIRSTLIFE			•			•		
FHA	Aachen	LOCAL+	•			•				
GRE	Grenoble	AuRA		•	•			•	•	
HBC	Biberach	X4S	•			•			•	
HFT	Stuttgart	coLLab			•			•		
HSD	Düsseldorf	MIMO	•	•		•	•	•		
ION	Bucharest	EFdeN		•	•			•	•	
ITU	Istanbul/Lübeck	Deeply high		•	•			•		
KIT	Karlsruhe	RoofKIT			•			•		
NCT	Taipei	TDIS	•	•		•				•
ROS	Rosenheim	levelup			•			•		
TUD	Delft	SUM			•			•		
TUE	Eindhoven	VIRTUe	•		•	•		•		
UPH	Pecs	Lungs of the City			•			•		
UPV	Valencia	Azalea	•	•		•		•		

Visible node of the load-bearing wooden frame construction with embedded steel strut by the team from Valencia. © SDE 21/22

Overview of the types of timber construction and the construction materials used in the SDE 21/22 houses. © SDE 21/22

For the teams that worked with large-format wall panels, different construction set-ups and materials were chosen. While the team from Prague used classic solid construction timber and OSB planking for their ceiling and floor elements, the team from Bucharest used wooden cross-piece beams to take the loads and create the necessary height for the straw infill. The team from Valencia first assembled large-format floor elements made of cross-laminated timber. For the rising components, the team then erected a basic construction of solid timber frames, which also remained visible in the building afterwards. The frame corners were connected and braced with recessed steel struts, which were locked in place with wooden dowels.

With the team from Delft, you could see the module connectors at the corners during assembly. A steel head plate was provided with a fitting hole. A protruding steel spike on the lower module, gripped into the fitting hole during assembly. The team from Aachen used a similar plug-in principle, but as a wood-wood connection. There was a tongue and groove on the modules that interlocked when they were placed on top of each other and also fixed the module in the correct position. With Stuttgart, a plug-in wooden connection was used for the wooden scaffolding that was built around the living modules. The plug connections were milled by machine and plugged into each other and locked on site.

Similar to the team from Stuttgart, the Rosenheim team also has an additive structure around their living module. This included a conservatory and the technical room on the roof and also offered the perfect orientation for the photovoltaics integrated into the roof. The building consists of three fully developed living modules. The room modules by the Istanbul/Lübeck team were deliberately planned with the standard transport dimensions of 2.55 m wide in order to save on transport costs and to be able to demonstrate simple feasibility for different building and property types. The team from Düsseldorf, on the other hand, used the maximum permitted transport dimensions for their living modules, i.e. they were each 3.00 m wide. In this respect, the team was able to make use of its location advantage with the very short transport route of just 40 km. The team chose a hybrid design for their house demonstration unit. It consists of two fully developed living modules, a smaller technical module and the all-encompassing climate envelope, which was erected in elements.

Façade element with preinstalled cladding and windows by the Team from Stuttgart.
© coLLab / SDE 21/22

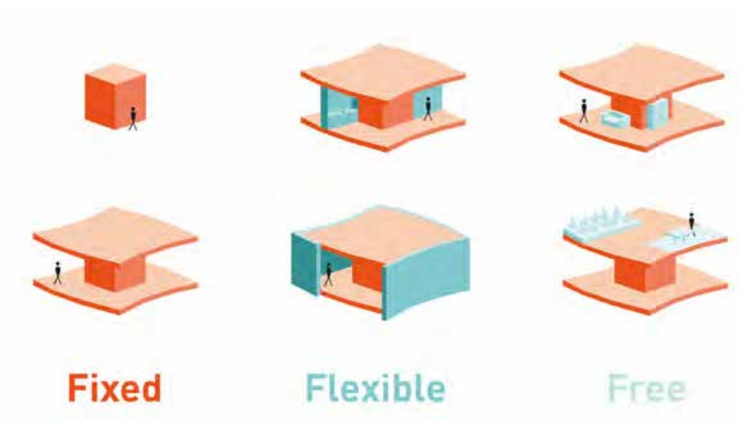
sufficiency

Jan Martin Müller,
Katharina Simon
(University of Wuppertal)

The sufficiency topic was part of the Sustainability discipline at the SDE 21/22. The required space per person, which has been increasing in many countries for years, makes it necessary to address this issue against the backdrop of the energy and resource transition. The reduction of individual living space, the flexibility of floor plans and new forms of housing are approaches to meet this challenge. The teams' concepts in four categories are explained below.

Individually adaptable floor plans

The frame construction method makes it possible to adapt the floor plans over a building's entire life cycle. The team from Eindhoven realised this concept in timber frame construction with interchangeable interior wall and façade modules in their house demonstration unit. The living spaces can be individually adapted in size and shape within the limits of a grid.



Flexible floor plan design concept by the team from Eindhoven.

Team Identity	City	Team Name	Individually adaptable floor plans	multifunctional use of space	Common rooms	Common buffer zones	Outdoor common areas	Private buffer zones	Private outdoor areas
CHA	Gothenburg	Team Sweden							
CTU	Prague	FIRSTLIFE			•		•		•
FHA	Aachen	LOCAL+		•	•		•		
GRE	Grenoble	AuRA			•		•		•
HBC	Biberach	X4S			•		•		
HFT	Stuttgart	coLLab		•			•		
HSD	Düsseldorf	MIMO			•	•			•
ION	Bucharest	EFdeN			•			•	
ITU	Istanbul/Lübeck	Deeply High				•	•	•	
KIT	Karlsruhe	RoofKIT		•	•		○		
NCT	Taipei	TDIS			•		•		
ROS	Rosenheim	levelup					•		○
TUD	Delft	SUM		•	•				•
TUE	Eindhoven	VIRTUe	•		•		•		
UPH	Pécs	Lungs of the City		•	•	○	•		•
UPV	Valencia	Azalea		•	•		•		

Strategies used for sufficiency

Reduction of individual living space through multifunctional use of space

The multifunctional use of space reduces the individual living space requirement. With a sliding wall, the team from Delft shows how the living space can be adapted to suit the time of day. The bedroom becomes smaller during the day in favour of the living room, and the other way round in the evening to make room for the fold-out bed.

Folding up, folding in and turning are the principles for keeping the space permanently taken up by furniture to a minimum, as the team from Stuttgart points out. Since only the piece of furniture that is actually needed at the time takes centre stage, the entire room does not look cramped. The team from Aachen developed lounge and sleeping cubes of only 4 m^2 that can be moved individually in a room. When all the cubes are put together, the communally usable area is maximised, making new uses possible.

The Delft team's sliding wall unit between the living and sleeping area.
© Steinprinz / University of Wuppertal

Flexibility of the built-in furniture in the house of the team from Stuttgart
© Steinprinz / University of Wuppertal

© coLLab / SDE 21/22

Expansion of individual living space through communal areas

What was particularly striking about the SDE 21/22 is the generous use of communal spaces. Almost all teams use this principle to reduce individual living space in favour of social meeting places. Communal spaces offer the residents a variety of uses: resulting in spaciously proportioned cooking and dining areas, as well as communal workshops, laundry and hobby rooms. This approach also counteracts the issue of loneliness as a result of the increase in the proportion of single households.

The teams from southern Europe in particular realised communal outdoor spaces to reduce individual living space. The buildings from Valencia and Grenoble, for example, each have an outdoor kitchen with a dining area covered by PV modules.

Even in the temperate climate of central Europe, living space can be supplemented and in some cases even replaced by outdoor space. The teams from Prague, Biberach and Eindhoven feature communal roof gardens.

A special feature are the climatic buffer zones by the teams from Düsseldorf and Istanbul/Lübeck. They surround the thermally fully conditioned areas, but can cope with temporary lower temperature requirements in winter.

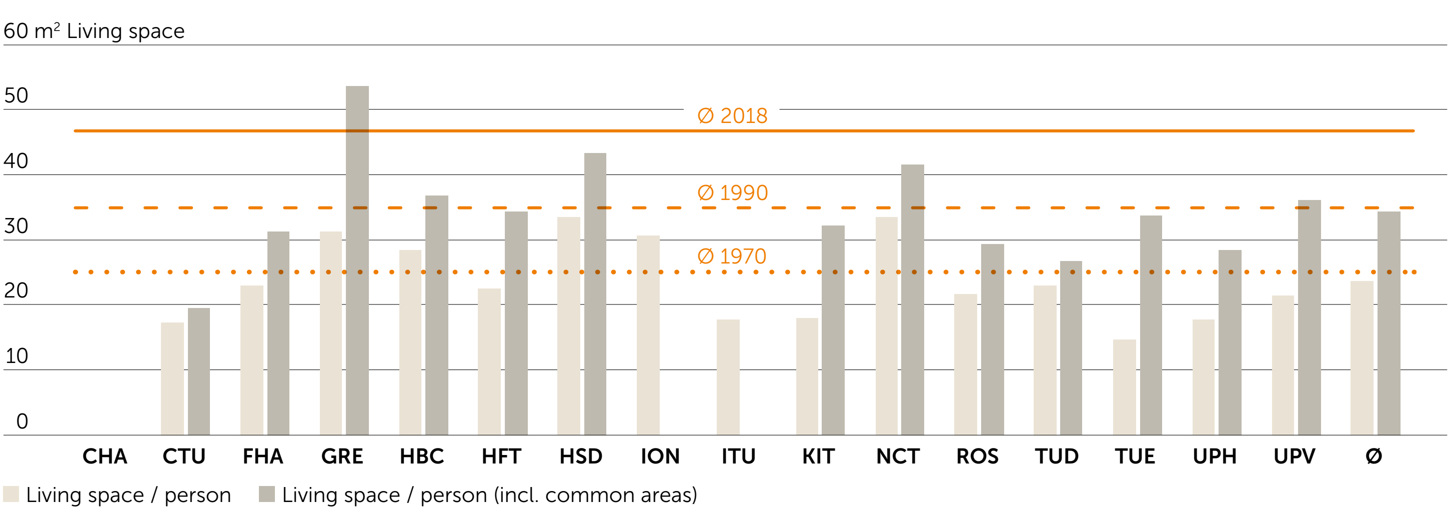
Private outdoor areas and conservatories

In addition to communal areas, private balconies, loggias and conservatories also contribute to reducing the heated volume. In the overall design by the team from Bucharest, for example, each dwelling unit has a conservatory. The teams from Prague, Grenoble and Pécs rely on classic balconies and loggias for their concepts.

Living space per person in comparison

Compared to the average German living space requirement from 2018, all teams reduce the living space per person by 25 to 50 percent with their overall building designs. Eleven teams' concepts are below the living space requirement of 1970. If you add the communal areas, most teams still manage to stay well below the current standard living space requirements in Germany while maintaining or enhancing the quality of living.

Living space per person for the Design Challenge excluding and including communal areas compared to average space requirements in Germany in 1970, 1990 and 2018.
© SDE 21/22



Shared laundry room on the Grenoble team's covered roof terrace.
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The Delft team's communal room with communal kitchen and tool lending.
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circular materials

Jan Martin Müller
(University of Wuppertal)

For the first time in the history of the SDE competition, there was a sustainability jury in the Wuppertal edition that evaluated the teams' concepts for consistency or the selection of circular materials, among other criteria, looking specifically at the circular economy in relation to biological and technical material cycles in the construction industry. The Buildings in particular feature a wide range of biological building materials.

Biological cycle

Plant-based building materials are kept in the biological cycle, which are ideally composted after multiple cascading use.

Timber construction

In sustainable forestry, wood has great recycling potential, especially if the wood products are downcycled several times after the use phase. All house demonstration units (HDU) at the SDE 21/22 are in timber construction. The European teams' constructions, either in skeleton or solid design, are made of European softwoods. The team from Taipei, on the other hand, chose locally available Japanese cedar wood as construction material, which creates an unusual appearance due to its dark colouring, setting it apart strongly from the other houses.

In addition to its use as a construction material, wood is often used as a façade material or in the form of wooden decking. The simple and quick processing of wood is a huge advantage, especially in the construction of the HDU terraces, as these were not prefabricated for most of the teams and therefore had to be built on site. The interiors all feature wood or wood-based panels. These include wall surfaces, flooring, ceilings or permanently installed built-in furniture. The experimental approaches to producing

Team Identity	City	Team Name	Primary construction	Facade	Interior wall surfaces	Floor	Ceiling	Terrace	Built-in furniture
CHA	Gothenburg	Team Sweden	•	•	•	•	•	•	•
CTU	Prague	FIRSTLIFE	•				•	•	•
FHA	Aachen	LOCAL+	•					•	•
GRE	Grenoble	AuRA	•			•		•	•
HBC	Biberach	X4S	•	•	•	•	•	•	•
HFT	Stuttgart	coLLab	•	•	•		•	•	•
HSD	Düsseldorf	MIMO	•		•	•	•	•	◦
ION	Bucharest	EFdeN	•	•			•	•	•
ITU	Istanbul/Lübeck	Deeply High	•	•		•		•	•
KIT	Karlsruhe	RoofKIT	•	•		•			◦
NCT	Taipei	TDIS	•		•		•		•
ROS	Rosenheim	levelup	•	•		•	•	•	•
TUD	Delft	SUM	•					•	•
TUE	Eindhoven	VIRTUe	•	•	•		•	•	•
UPH	Pécs	Lungs of the City	•	•	•			•	•
UPV	Valencia	Azalea	•				•	◦	•

Use of wood and wood building materials
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complete bathrooms, including showers, out of wood, featured in the HDUs by the teams from Biberach and Düsseldorf using acacia wood, are particularly noteworthy.

The Taipei team's living space with ceiling and laminated beams made of Japanese cedar wood.
© Steinprinz / University of Wuppertal

Biotic insulation materials

The biotic insulation materials chosen are incredibly diverse. The teams most frequently used wood fibre insulation materials. As an alternative to classic wood fibre boards, the team from Biberach blew wood fibres into the construction. The team from Stuttgart uses wood shavings accumulated by the cooperating timber prefab producer as insulation material.

In the case of the team from Düsseldorf, the living units facing the unheated communal space are insulated with cork, giving the interior a distinctive appearance.

Many of the biological insulations used are raw materials that are waste products. For example, five houses are insulated using cellulose fibres made from waste paper.

Team Identity	City	Team Name	Wood fibre	Wood fibre (blown in)	Wood shavings	Cork	Cellulose	Straw	Rice straw	Seaweed	Mycelium	Cotton	Non-biotic
CHA	Gothenburg	Team Sweden	•										
CTU	Prague	FIRSTLIFE	•				•						•
FHA	Aachen	LOCAL+	•										•
GRE	Grenoble	AuRA	•					•					
HBC	Biberach	X4S	•	•									
HFT	Stuttgart	coLLab	•		•								•
HSD	Düsseldorf	MIMO	•			•					○		•
ION	Bucharest	EFdeN					•	•					
ITU	Istanbul/Lübeck	Deeply High						•					
KIT	Karlsruhe	RoofKIT								•	○		
NCT	Taipei	TDIS											•
ROS	Rosenheim	levelup	•										
TUD	Delft	SUM					•					•	•
TUE	Eindhoven	VIRTUe	•										•
UPH	Pécs	Lungs of the City					•						•
UPV	Valencia	Azalea							•			•	

Biotic insulation materials used
© SDE 21/22

The teams from Grenoble, Bucharest and Istanbul / Lübeck use a waste product from agricultural wheat production – straw. This leads to insulation thicknesses that are approx. 50 percent thicker with a comparable insulating effect to mineral wool. The team from Valencia collected leftover rice plants from local rice farmers to make their own rice straw insulation.

The Düsseldorf team's communal space with cork insulation as surface material

The Karlsruhe team's interior with wall and ceiling covering made of felt

External steel staircase by the team from Stuttgart

The team from Karlsruhe chose washed-up seaweed, which is collected from coasts to clean up the beaches. The advantages of seaweed insulation are the good properties with regard to mould growth and combustibility, which are the result of it being in contact with the sea salt water for a long time.

The teams from Delft and Valencia use cotton insulation made from recycled clothing in some of their exterior walls.

The use of mycelium insulation panels, which are being used experimentally on small areas of the outer wall on the HDUs by the teams from Düsseldorf and Karlsruhe, is particularly innovative. Insulation panels made of mushrooms are still in the development and research phase.

Animal building materials

The interior walls and ceilings in the house by the team from Karlsruhe are covered with felt made from pure sheep's wool. This material gives the interior of the house a special feel and offers acoustic advantages as a sound-absorbent surface.

Technical cycle

The technical cycle describes industrial recycling after disassembly and the sorting of metallic and mineral materials in particular.

Metals

Metals can be recycled without any loss of quality. Corrosion-free metals are characterised by extremely good durability, which makes them an attractive material, especially for outdoor use. The pitched roofs of the HDUs by the teams from Rosenheim, Karlsruhe and Taipei are covered with metals. Purely metal façades are found exclusively by the teams from Düsseldorf and Taipei. An example of high-quality metal construction fabrication can be found in the outdoor area of the house by the team from Stuttgart. Its external staircase is made of folded steel, which manages with very low material thicknesses due to the effective design in terms of statics.

Metals were not only used for the exterior at the SDE 21/22. The staircase by the team from Pécs is an example of a metal construction design in the interior. The steel staircase above an interior garden has railing infills made of foamed aluminium panels. The teams from Karlsruhe and Grenoble have also used metals as an alternative to bonded tiles in bathroom and kitchen wet areas.

Clay building materials

As one of the few mineral building materials, clay has the advantage that it can be completely recycled at the same product level by adding water. Since clay is a natural raw material from the soil, it can be returned to the soil after several life cycles. In addition to these ecological aspects, clay has a high thermal mass, which can contribute to regulating the thermal indoor climate, especially in the lightweight timber constructions of the HDUs.

The team from Düsseldorf made special use of the thermal properties of clay building materials for their building concept. The communal area, which acts as a thermal buffer zone, has one wall made of clay blocks. In the modular living units, there are panel heating systems in the walls, whose pipes are routed in clay groove panels. This ensures that the heat is released slowly over the entire wall.

There are similar embedded panel heating systems in the houses of Aachen and Grenoble. In the case of Grenoble, clay plaster is also used as an exterior wall material. This very unusual choice of material is only possible because there is a protective layer of bevelled glass slats over the material that is susceptible to water.

Wall out of clay bricks by the team from Düsseldorf

The Grenoble team's exterior façade with glass slats in front of clay plaster

Internal steel staircase with foamed aluminium panels by the team from Pécs

© Steinprinz / University of Wuppertal

Recycling content – materials from the urban mine

The selection of materials is particularly effective in terms of waste reduction if you do not only use building materials that can be recycled after use, but also materials and components that have already been used elsewhere. The so-called "urban mine" is used by employing building materials with a high secondary material content or by reusing components.

Bathroom surfaces made from recycled yoghurt pot panels by the team from Stuttgart
© Steinprinz / University of Wuppertal

Team Identity	City	Team Name	Clay building boards	Clay plaster	Clay groove panels	Clay bricks
CHA	Gothenburg	Team Sweden	•	•		
CTU	Prague	FIRSTLIFE				
FHA	Aachen	LOCAL+	•	•	•	
GRE	Grenoble	AuRA	•	•	•	
HBC	Biberach	X4S				
HFT	Stuttgart	coLLab				
HSD	Düsseldorf	MIMO	•	•	•	•
ION	Bucharest	EFdeN				
ITU	Istanbul/Lübeck	Deeply High	•			
KIT	Karlsruhe	RoofKIT	•	•	•	
NCT	Taipei	TDIS				
ROS	Rosenheim	levelup	•	•		
TUD	Delft	SUM				
TUE	Eindhoven	VIRTUe				
UPH	Pécs	Lungs of the City		•		
UPV	Valencia	Azalea				

Secondary materials

The teams at the SDE 21/22 used some building materials whose aesthetics are strongly influenced by the high recycling content. For example, the teams from Karlsruhe and Stuttgart used panels made from recycled yoghurt pots for kitchens and bathrooms. The plastic panels have a slight marbling due to the aluminium lid particles, which gives the panels a distinctive appearance.

Glass ceramic panels with a high secondary material content are installed in the bathroom by the team from Karlsruhe and in the kitchen by the team from Rosenheim as another alternative material to bonded ceramic tiles in wet areas. Glass ceramics consist of glass shards that have been fused together and can still be seen after the melting process.

Tetra Paks pose a major challenge when it comes to recycling because they are a composite material made of cardboard, plastic and aluminium. It is almost impossible to separate the materials after use. However, the composite materials can be used to create panels whose appearance is strongly influenced by the source material. The teams from Pécs and Karlsruhe used the material to build furniture. Most of the interior walls of the Prague team's house are made out of Tetra Pak panels.

Cellulose panels are installed as planking for the interior walls of the Valencia team's house. The raw material is paper waste, whose cellulose fibres are pressed into large-format panels.

Clay products installed at the SDE 21/22.
© SDE 21/22

The team from Grenoble reused a lot of material from houses that the university had built in previous Solar Decathlon editions. Reused materials are wood fibre insulation, wooden cross-piece beams, photovoltaic panels and glass slats. The glass slats built into the façades have a particularly crucial influence on the new HDU's geometry and grid due to the specified dimensions.

Karlsruhe's HDU also features a large number of reused components. This starts with the entrance door, continues with parts of the floorboards and the visible supporting structure. All these elements show visual signs of ageing, which are used as a design tool. The windows are remaining stock from a window manufacturer that could not be installed due to incorrect orders or production. Therefore the dimensions, frame material and positioning of each window is completely different and unique. This shows that the reuse of building materials can have a major impact on architecture.

The team from Pécs uses wooden boards from a former terrace at the university as façade material. This avoided waste on the one hand and saved costs on the other.

Because of the tradition around the port city, the team from Valencia builds a lot with ceramics. Ceramic tiles cannot be recycled without large amounts of primary materials. Therefore, the team's approach of using carefully removed ceramic tiles vertically layered next to each other as outdoor flooring is valuable for reducing waste. The gaps between the ceramic tiles allow water to seep away, which benefits the microclimate.

The wooden façade by the team from Stuttgart is made out of wood scraps from the cooperating timber construction company. The profiled timbers, which vary greatly in colour due to different treatments and varnishes, are glued together to form large façade panels. This diversity gives the façades a very unique appearance.

Reused windows, timber construction and entrance door by the team from Karlsruhe © Steinprinz / University of Wuppertal

Terrace floor made of vertically arranged old ceramic tiles by the team from Valencia © SDE 21/22

Renting instead of buying

Renting components guarantees further use or correctly sorted recycling. At the SDE 21/22, the team from Karlsruhe rented most of the elements for the elevation of their HDU, as the building will not be elevated when it is assembled again in Karlsruhe. The outside lift and the water containers, which are no longer needed after the competition, were also taken away after the event phase. The Stuttgart team's outdoor platform made of raised anti-skid waterproof plywood boards from event construction was also rented for the event period.

All these examples illustrate that the SDE 21/22 teams have a good understanding of selecting circular materials and integrate them very consciously into their building concepts.

design for circularity

Jan Martin Müller
(University of Wuppertal)

In addition to the selection of circular materials, the separability of the constructions is essential in order to be able to reuse or recycle the materials after the use phase. The teams addressed this aspect with their house demonstration units (HDU) at the SDE 21/22, but also in the design of the structures for the whole buildings (design challenge).

Reversible connections

To dismantle the constructions at the end of the life cycle, materials have been layered, inlayed, hung in place, set, filled in, screwed, clamped, clipped, nailed and deformed.

In the case of the team from Karlsruhe, “Design for Circularity” goes so far as adhesives being entirely dispensed with in the construction. The timber construction is largely screwed together. All sealing foils are clamped along their entire length, especially at the joints. In order to avoid the use of adhesives or silicone sealants in details such as the joints of the large-format panels in the bathroom, elastomer sealing profiles are installed here. The strategy of installing panel materials with as large an area as possible in wet areas is used by many teams to reduce the material joints to be sealed to a minimum.

Team Identity	City	Team Name	Layering	Inlaying	Hanging	Setting	Infilling	Screwing	Clamping	Clipping	Nailing	Deformation of wires	Deformation of sheet metal
			Compose				**Filling**	**Pressing**				**Forming**	
HBC	Biberach	X4S	•	•			•	•					
HFT	Stuttgart	coLLab	•				•	•	•	•	•	•	
HSD	Düsseldorf	MIMO		•			•	•					•
ION	Bucharest	EFdeN			•			•	•	•			
KIT	Karlsruhe	RoofKIT		•		•	•	•	•		•		
TUD	Delft	SUM		•				•	•				

Reversible connection techniques,
presented for teams with sufficient data.

Due to the tradition in and around the port city, the team from Valencia uses a wide variety of ceramic tiles, which – in contrast to conventional construction methods – are not glued to the walls or floors, but have been fixed reversibly. Ceramic tiles in very different formats are used as the exterior façade. Large-format ceramic tiles are suspended on an aluminium substructure in the direction of the alignment, on the upper floor as well as on the ground floor. On the outer façade, ceramic profile panels in different colours are reversibly clamped in a wire mesh.

One particularly successful example of reversible connections can be found in the bathroom by the team from Rosenheim, which is equipped with waterproof panels that are hung in place. This has the advantage that the panels can not only be removed at the end of their life cycle, but maintenance work can also be carried out on the pipelines behind them very easily during the use phase.

Clamped foils by the team from Karlsruhe.
© RoofKIT / SDE 21/22

Ceramic profile panels clamped in a wire mesh as a façade by the team from Valencia.
© Steinprinz / University of Wuppertal

Removable wall panels allow access to pipes in the bathroom by the team from Rosenheim.
© Steinprinz / University of Wuppertal

The reused glass elements on the façades by the Grenoble team are reversibly inserted into a wooden batten. The timbers have angled cuts for this, in which the glass panes were set in overlapping.

The metal sheets of the three pitched roofs by the teams from Karlsruhe, Taipei and Rosenheim are joined by reshaping the metal using a standing seam. Compared to conventional flat roof waterproofing, this connection is more durable and does not require irreversible joints

Mono-materiality

A mono-material design simplifies the disassembly process and the separation of materials into the different waste fractions at the end of a building's life cycle. At the SDE 21/22, the teams partially managed without the use of metal screws or nails in the primary timber construction. The team from Rosenheim used wooden nails made of hardwood as an alternative to metal nails and inserted them using compressed air.

The Düsseldorf team's solid timber elements are made based on old carpentry tradition without any glue and metal using the dovetail technique. The absence of glue in particular distinguishes this building from conventional solid timber buildings, which are usually made using glued cross-laminated timber.

Glue was also dispensed by the teams from Karlsruhe and Rosenheim. In timber frame construction, wood-based panels are often used for bracing in the form of OSB or MDF panels, among others, which have wood glue content. These were replaced by diagonal formwork made of solid wooden boards.

Diagonal formwork made of solid wooden boards by the team from Karlsruhe.
© RoofKIT / SDE 21/22

Principle of the solid timber construction with mono-material dovetail joints by the team from Düsseldorf.
© SDE 21/22

Urban Mining Index

The “Urban Mining Index (UMI)” tool was used and further developed to quantitatively compare the circularity of the different house demonstration units for the first time for the SDE 21/22. In the process, the recycling content and potential of the construction during the building’s pre-use and post-use phases is mapped for each building component.

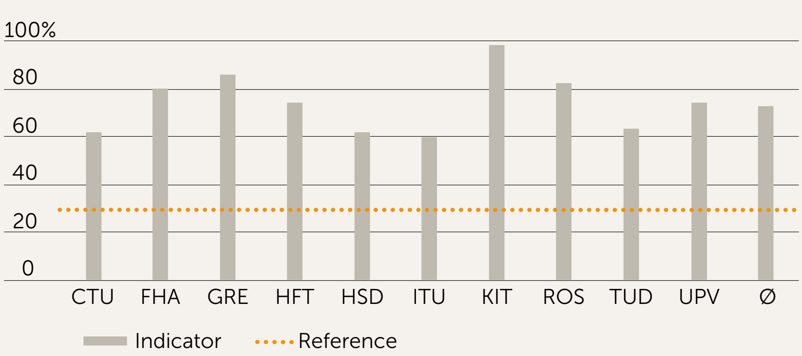
In addition to the circularity of the materials, the joining technique and effort required to separate the construction materials are also included in the evaluation. The easier it is to disassemble, the more likely it is that the materials will be separated by type, which is considered a prerequisite for high-quality recycling after a building’s use phase.

The result of the Urban Mining Index – the Urban Mining Indicator – is made up of the pre-use and post-use results of all components and indicates a building’s circularity with a maximum rating of 100 percent.

The Urban Mining Index results at the SDE 21/22 range from 60 to 98 percent. By comparison, a building constructed in conventional concrete only achieves around 30 percent. Therefore, the HDUs are all built in a more recycling-friendly way than most buildings in current construction practice. This is largely due to the timber construction, but also requires an understanding of separable constructions and the specific selection of recyclable materials.

The teams from Karlsruhe and Grenoble each have the highest UMI. This is mainly due to the high degree of reuse in the designs. For the French team, reuse refers to both the newly added materials and the continued use of the existing stock building’s concrete structure.

The teams from Rosenheim and Aachen also have UMI results of over 80 percent, which can be attributed to the material selection that is consistently circular. This applies to the biotic materials of the timber construction, insulation materials, façade materials and interior, but also refers to materials such as clay that are in the technical cycle.

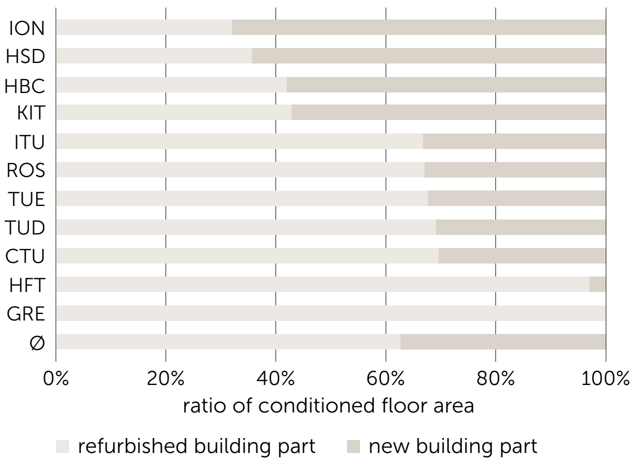


The teams’ Urban Mining Indicator in percent compared to a reference building in conventional concrete construction (line). © SDE 21/22

building envelope and energy efficiency

Helmut Krapmeier
(University of Wuppertal)

At the SDE 21/22, the topic of building energy efficiency wasn't merely significant when it came to the demonstration buildings (building challenge) – it was already vastly important when looking at the overall building energy concept (design challenge).



Proportion of floor area of the renovated building and new storeys added to the building © SDE 21/22

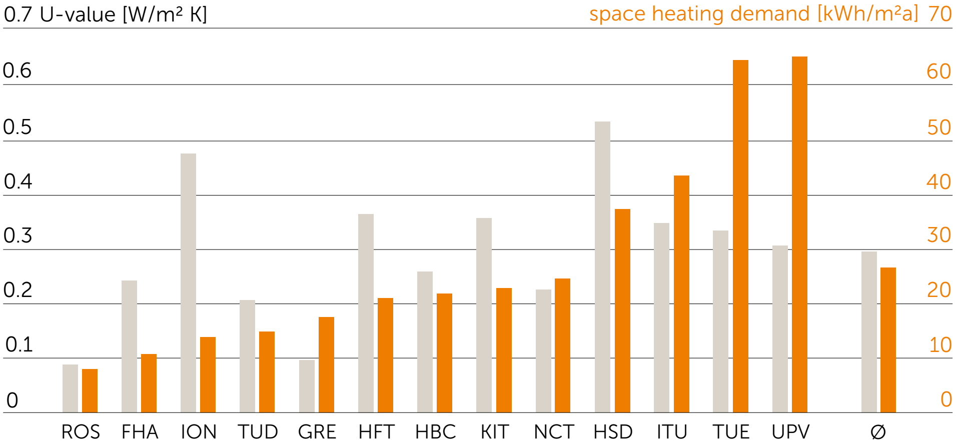
Design challenge

The proportion of renovation in the entire project

Some teams, such as Stuttgart, Rosenheim, Delft, selected a large, tall, old building and added just one and a half or two storeys. Other teams, such as Biberach and Düsseldorf, took a low building, in this case Café Ada in Wuppertal, and put several storeys above it, thus reaching a height corresponding to the development of the adjacent buildings. The Grenoble team had the greatest proportion of renovation, as they only added a communal "rooftop" onto a five-storey structure which was neither heated nor cooled.

Thermal insulation and space heating demand

In most cases, the planned thermal insulation of the building envelope for renovating the existing buildings as well as the added storeys was very high quality, and yet planned in different ways. The thermal insulation level (U-value) has a significant influence on the heating demand. As the evaluation below shows, there is no clear connection between the average U-value of the entire building envelope (renovation of existing structure and added storeys) and the heating demand calculated. Differences in window orientation, occupation density, ventilation types, heat given off by electrical devices, etc. are the cause of this.



Design challenge: Average U-value (opaqe and windows) of the envelope and calculated space heating demand (climate Wuppertal) © SDE 21/22

Ø average U-value
space heating demand

Energy efficient windows

On one hand, the windows are the weak point in terms of thermal losses of the building envelope. On the other hand, they permit a passive use of solar energy. When oriented correctly, the balance of this in Wuppertal's climate is positive. For the windows in the renovated parts of the building, the U_W-value of team Rosenheim (ROS) ranked the lowest with 0.45 W/m^{2}K. This is the only building with triple pane vacuum glazing. The U_W-value of team Biberach was the highest hear at 1.6 W/m^{2}K (existing building with thermal renovation). In the case of the windows of the added storeys, the team from Rosenheim also made use of vacuum glazing, and the Istanbul/Lübeck (ITU) team used double pane thermal glazing only (U_W=1.3 W/m^{2}K). The average thermal insulation level of all windows is very good with a U_W-value of 0.9 W/m^{2}K.

Energy efficient ventilation

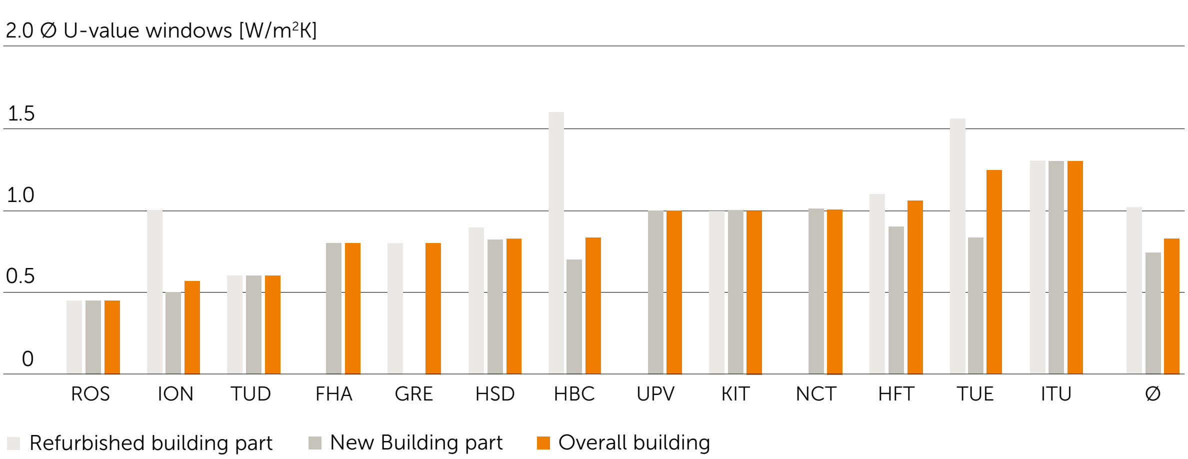
Mechanical ventilation systems with efficient heat recovery offer great potential for reducing heat losses in winter, while at the same time maintaining good air quality. However, the heat recovery system has to be highly effective, yet have a low demand for electrical energy.

The electrical energy demand of mechanical ventilation systems with heat recovery ranged from 0.18 W with team Eindhoven (TUE) to 0.52 W with team Delft (TUD) per m^3/h required air flow (SFP value). Efficient systems are labelled with their SFP value and listed in the European standard 1253/2014/EC (energy-related products).

Team Identity	Window ventilation only	Mechanical ventilation with heat recovery	Specific fan power [W/m³h]	Degree of heat recovery [%]
BKU	•			
CTU		•	0.20	88
FHA		•	0.23	92
GRE			0.14	0
HBC		•	0.24	87
HFT	•			
HSD			0.40	85
ION			0.02	90
ITU		•	0.50	80
KIT		•	0.35	80
NCT		•	0.33	69
ROS		•	0.38	79
TUD		•	0.52	91
TUE		•	0.18	95
UPH		•	n/a	n/a
UPV			0.49	86
Ø			0.31	79

Characteristics of the ventilation systems
© SDE 21/22

U_W-value of the windows
© SDE 21/22



Building challenge

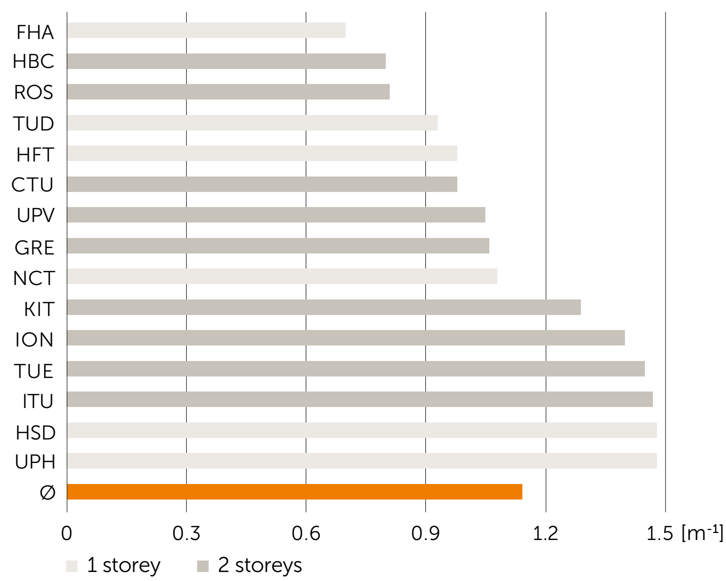
Thermal insulation

The house demonstration units (HDUs) may have a maximum of two storeys. Eight teams build one-storey demonstration buildings, the team from Sweden built a one-and-a-half storey building, and nine teams built, or planned (team Bangkok KMU), two-storey buildings. All the buildings are relatively compact. The most compact structure was created by team Aachen (FHA) with a form factor of 0.70 m^{-1}. The average value is 1.14 m^{-1}

Energy efficient windows

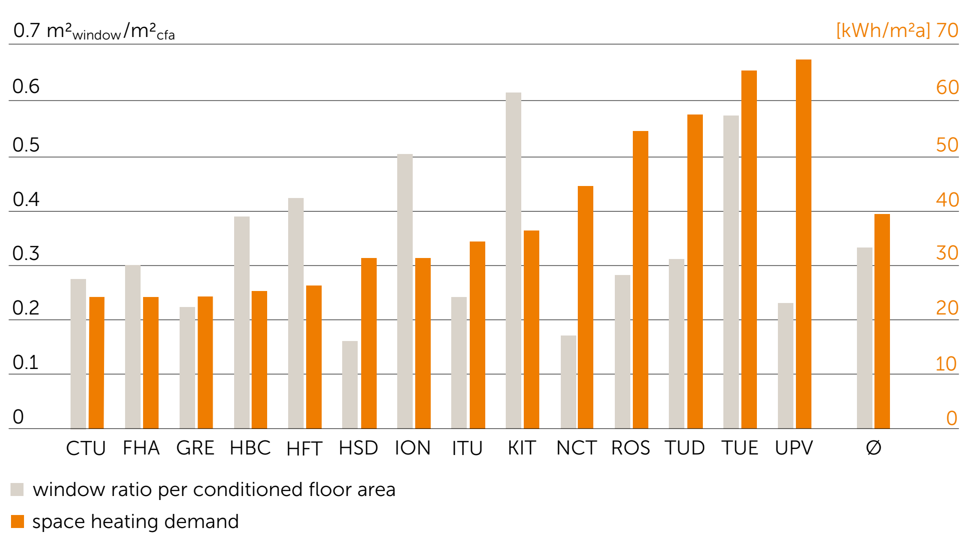
The proportion of window areas and their orientation are very important for the passive use of solar energy in winter, as well as for the cooling load in summer. Here, the window area of the conditioned building envelope per m^2 of conditioned floor area (cfa) was examined.

A relation between the selected window area and the heating demand cannot be found.



Surface to volume ratio (formfactor) of the demonstration units
© SDE 21/22

Window area per m^2 of conditioned floor area (cfa) and space heating demand (climate Wuppertal)
© SDE 21/22



Energy efficient ventilation

The energy consumption for domestic ventilation is mainly determined by the respiration of the occupants. The standard is an hourly exchange of fresh air of 30 m^3 per person, and the energy consumption for this is determined. The indicator for good quality air in a room is the proportion of CO_2 in the air. The limit value for this in the living area is about 1,000 ppm. To prevent unnecessary ventilation, methods such as CO_2 level controls are used. A reduction of the thermal energy demand for the hygienically necessary minimum air change is only possible using a mechanical ventilation system with heat recovery.

Example of thermal insulation made from renewable raw materials, team Grenoble
© Steinprinz / University of Wuppertal

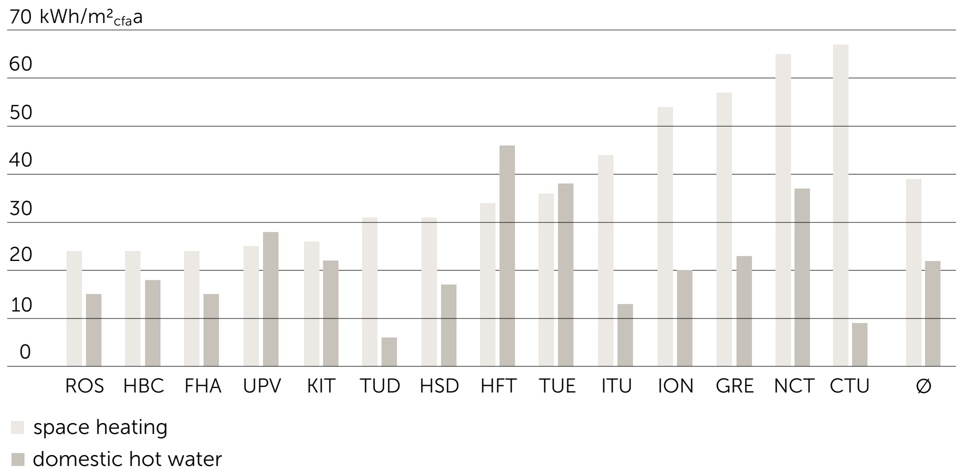
Ventilation Systems in the House Demonstration Units
© SDE 21/22

Team Identity	City	Team Name	Window ventilation only	Mechanical ventilation	Heat recovery	Humidity recovery (Enthalpy exchanger)	Control	Efficiency of heat recovery	Specific fan power [W/(m^3/h)]
CHA	Gothenburg	Team Sweden	•						
CTU	Prague	FIRSTLIFE		•	•	/	CO_2	82%	0,72
FHA	Aachen	LOCAL+		•	•	/	CO_2	92%	0,59
GRE	Grenoble	AuRA		•	•	•	CO_2	90%	0,12
HBC	Biberach	X4S		•	•	•	CO_2	93%	0,17
HFT	Stuttgart	coLLab	•						
HSD	Düsseldorf	MIMO		•	•	/	humidity	84%	0,38
ION	Bucharest	EFdeN		•	•	/	CO_2, temperature	90%	0,11
ITU	Istanbul/Lübeck	Deeply High		•	•	/	CO_2	85%	0,67
KIT	Karlsruhe	RoofKIT		•	•	/	CO_2	83%	0,06
NCT	Taipei	TDIS		•	•	•	CO_2	84%	0,33
ROS	Rosenheim	levelup		•	•	•	CO_2, presence control	79%	0,33
TUD	Delft	SUM		•	•	•	CO_2	86%	0,22
TUE	Eindhoven	VIRTUe		•	•	•	CO_2, humidity, weather	95%	0,11
UPH	Pecs	Lungs of the City		•	•	•	*	*	*
UPV	Valencia	Azalea		•	•	/	CO_2	86%	0,41
							Ø average	**87%**	**0,32**

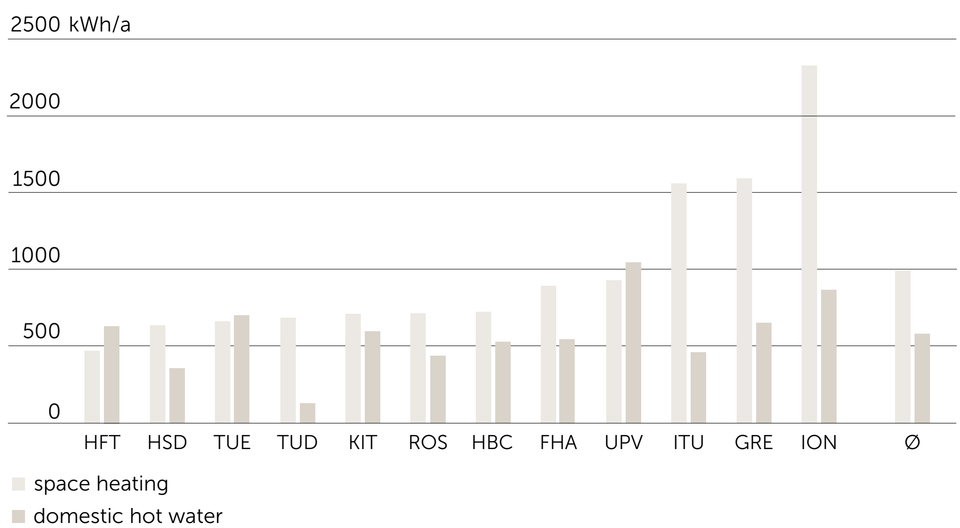
Heat Demand

On average, the calculated energy requirement for domestic hot water is 40% lower than for space heating. The Delft team (TUD) included the heat recovery for the hot water heating demand in the calculation. The teams from Aachen (FHA), Rosenheim (ROS) and Stuttgart (HFT) did not factor in the heat recovery.

However, there were vast differences between the individual projects. On one hand, the causes for this were the different assumptions made in terms of the hot water demand per person and, on the other hand, the occupation density per in m² floor area per person. In practice, the hot water consumption depends above all on the occupants and whether they are inclined to be economical with water or waste water. The same applies to room heating. The energy efficiency for covering the respective heat demand is a planning task in terms of home technology.



Useful energy demand for space heating (climate Wuppertal) and hot water per m² conditioned floor area and per year
© SDE 21/22



Useful energy demand space heating (climate Wuppertal) and domestic hot water per person and per year
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House Demonstration Unit of the team from Pécs
© Steinprinz / University of Wuppertal

air tightness and sound insulation of the building envelope

Heiko Hansen
(Hansen + Partner Ingenieure GmbH)

A subcategory in the "Comfort" discipline concerns the air tightness or air permeability of the building envelope. This building property results from the basic building design with regard to the arrangement and execution of penetrations of the heated building envelope as well as the quality of the construction work. In the competition phase, the air tightness of the building envelope had an effect on the course of the room temperature in relation to the external climate, as well as on the function of mechanical ventilation systems. Building envelope here means the envelope of the heated building volume or partial volume which was also defined for the co-heating tests and the room climate measurements.

The airtightness of the building envelope was checked for each house using a “blower door”. © SDE 21/22

The test was performed after closing all closable openings and sealing all existing systems and equipment for ventilation. The focus was thus on the building envelope. The air exchange rate was measured at a test pressure of 50 Pascal. The team with the lowest air exchange rate achieved the full score of 10 points. No points were awarded for an air exchange rate above 2 h^{-1}, the intermediate results were interpolated linearly. The measurement results of the air tightness measurements were between 0.89 h^{-1} and 27.15 h^{-1}. Six buildings achieve remarkable good results (Prag, Bukarest, Aachen, Rosenheim, Eindhoven, Biberach), nine demonstration buildings were measured with values above 2 h^{-1} and thus received no points.

The leakage detection during the measurement of the buildings led to a basic differentiation into leakages due to the construction and leakages due to the building concept. All results have to be considered against the background that the construction phase was very short (14 days) and for the most part not carried out by skilled workers. It is particularly noteworthy that the majority of the buildings with good air tightness were built entirely by students.

The air tightness measurements carried out on the various demonstration buildings lead to findings that can be transferred to building practice:

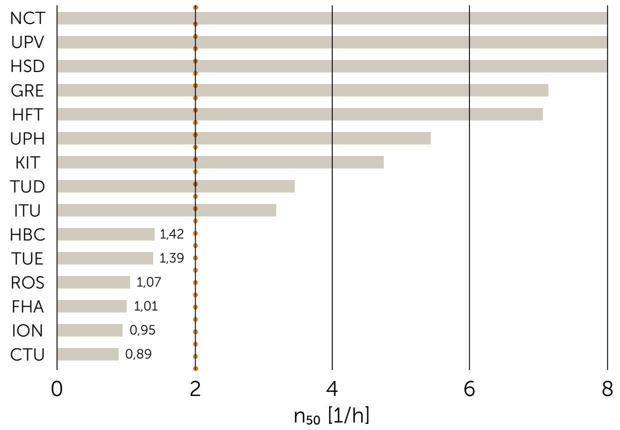
- Leaks in the areas of windows, doors and system components are comparatively easy to detect and quickly rectify. The contact pressure and joint tightness must be checked.
- Locating the mechanical rooms within the heated envelope area results in significantly lower air infiltration rates.
- Concepts with a separable and adhesive-free construction and connection design still need to be further developed with regard to the requirement of an airtight building envelope.

A further subcategory in the competition discipline "Comfort" related to the facade sound insulation of the demonstration buildings. Against the background of urban construction tasks and the predominance of lightweight construction, facade sound insulation represents an important requirement for the buildings. The point distribution in the competition was based on the achieved standard sound level difference for the worst façade, with a maximum of 10 points ≥ 42 dB and 0 points for <30 dB. Intermediate values were then linearly interpolated. For the determination of the facade sound insulation by means of measurements, a loudspeaker was positioned outside the building in front of the facade being tested and a microphone in the receiving room behind it.

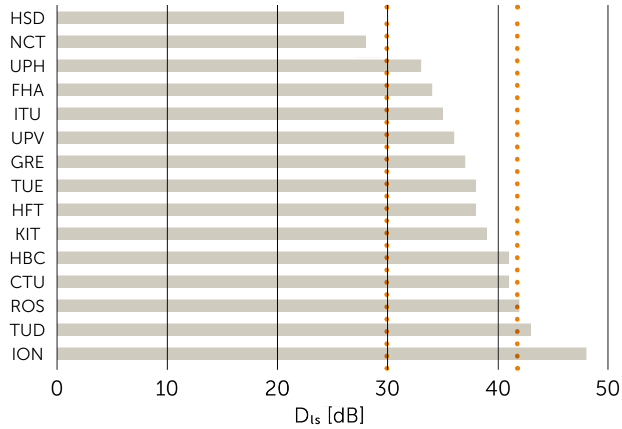
The standardized level difference determined by means of measurements were between 26 dB and 48 dB, in a comparatively wide range. The values were similar to those achieved at the SDE 2012 in Madrid. In Wuppertal, the buildings of the teams from Bucharest, Prague and Rosenheim received full marks.

From the subjective perception during the on-site building acoustics measurements and the evaluation of the frequency-dependent standard sound level difference, it can be deduced that poor measurement results (below 35 dB), on the worst facades of the demonstration buildings, were caused by acoustic leaks. These were typically in the area of the system components windows and doors due to missing or improperly set seals or contact pressures. A simple visual inspection or an audio test could be sufficient to identify these faults before commissioning. However, the time constraints of the competition made this difficult.

Based on the targeted use of a sound source outdoors, the resulting sound level was measured indoors. © SDE 21/22



Measured air exchange rates n^{50}. The dashed line at 2 marks the limit up to which points were awarded in the competition. © SDE 21/22



Measured standardized level difference $D_{ls,2m,nT,w}$ in dB. The dashed lines show the limits for maximum points (> 42 dB) and no points (< 30 dB). © SDE 21/22

indoor climate

Marvin Kaliga
(University of Wuppertal)

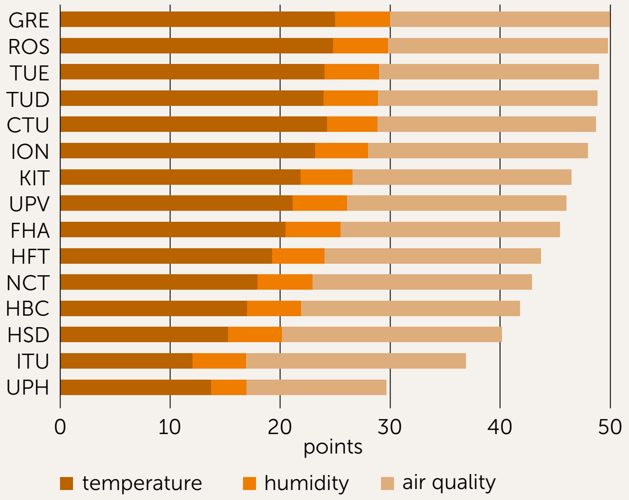
"It was a really stressful period for the monitoring. We were always opening and closing the windows."

Dalia Stoian, team from Bucharest, excerpt from the acceptance speech for the Comfort Award on 22 June 2022 in Wuppertal.

Our lifestyles are leading us to spend longer periods of time indoors than previous generations. This raises the expectations for the indoor climate. This often results in a higher volume of building technology, in recent years especially for cooling and air conditioning with significant consequences for energy consumption. To counteract this trend, the SDE 21/22 teams were focusing on design and construction measures as part of passive cooling strategies. It was not permitted to run active heating and cooling systems on site according to the regulations.

In the "Comfort" discipline, the indoor climate was specifically evaluated considering the aspects of room temperature (25 points), room humidity (5 points) and air quality (CO_2, 20 points). In each case, categories were specified in the regulations, which were defined by limits. The measured values were automatically classified into these categories for the evaluation.

A maximum of 50 points in total could be achieved for this sub-discipline. Two of the teams almost achieved this score (Grenoble, Rosenheim); others came close.



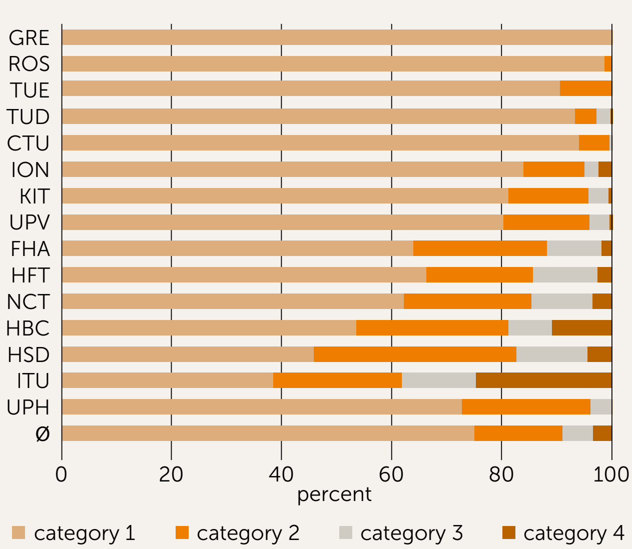
Points awarded for the indoor climate parameters in the "Comfort" discipline. © SDE 21/22

Room temperature

The limits of the different categories in this part of the competition were not constant, but were determined in accordance with DIN EN 15251 by the running mean outdoor temperature. The teams were provided with their own current measured values as well as the moving average outdoor temperature by a dashboard displaying the data. This enabled the teams to react accordingly during the daily hours of attendance between 8.00 a.m. and 10.00 p.m. by activating sun protection elements, if available, regulating the ventilation system and opening and closing windows. The indoor temperature was also evaluated between 10.00 p.m. and 8.00 a.m. However, the teams could not react to the measured temperatures by actively intervening during these periods. The teams themselves had to determine the upper and lower limits for the temperature classes and consequently make decisions on managing the temperature. All in all, they succeeded admirably for the most part.

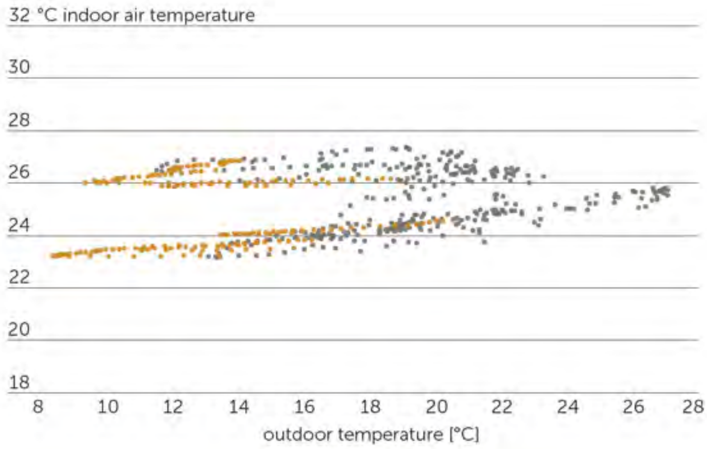
The temperature diagrams show a more differentiated view of the thermal behaviour for three exemplary teams – Grenoble, Karlsruhe and Düsseldorf. Both the correlation of the instantaneous values and the correlation of the room temperature to the running mean outdoor temperature and the resulting limits are considered. The black dots are during the decathletes' daily attendance times (8.00 a.m. to 10.00 p.m.), those plotted in orange are outside these hours (10.00 p.m. to 8.00 a.m.). In particular, the Grenoble team succeeds perfectly in keeping the building constantly running at the maximum level of comfort and maintaining a very narrow temperature range.

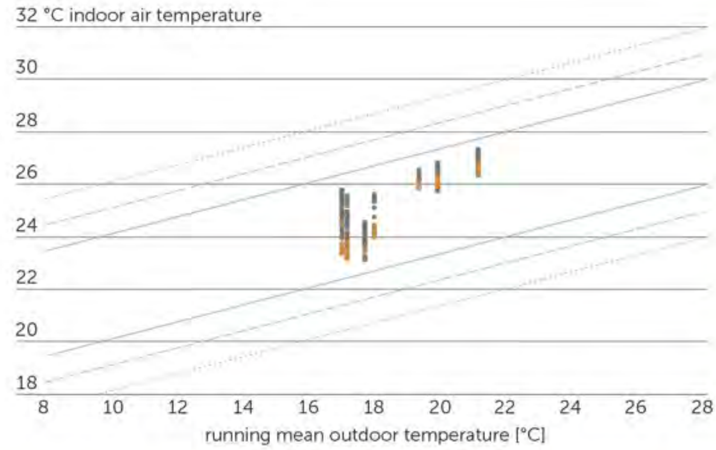
The indoor climate measurements at this Solar Decathlon Europe were significantly influenced by the consistently high summer temperatures and weather conditions. This was not necessarily to be expected. The expected differences in operating behaviour due to the different building concepts, building constructions and building techniques did not have a significant impact under these conditions.



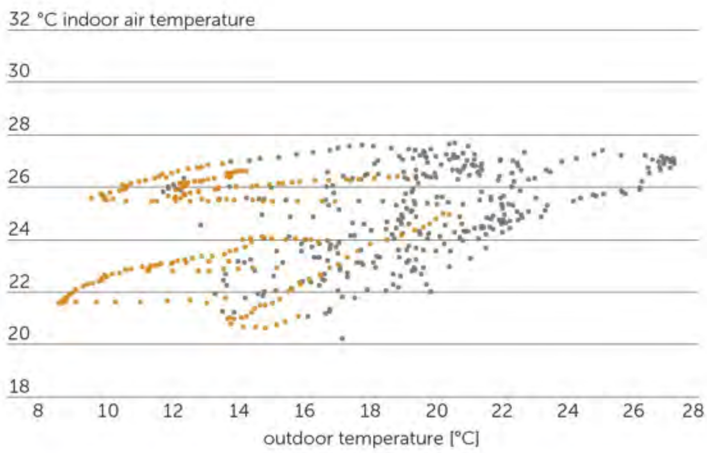
Classification of the temperature measurement data for the respective living spaces during the evaluation period into the temperature classes according to DIN EN 15251-1:2012-12. The evaluations for all teams are shown.
© SDE 21/22

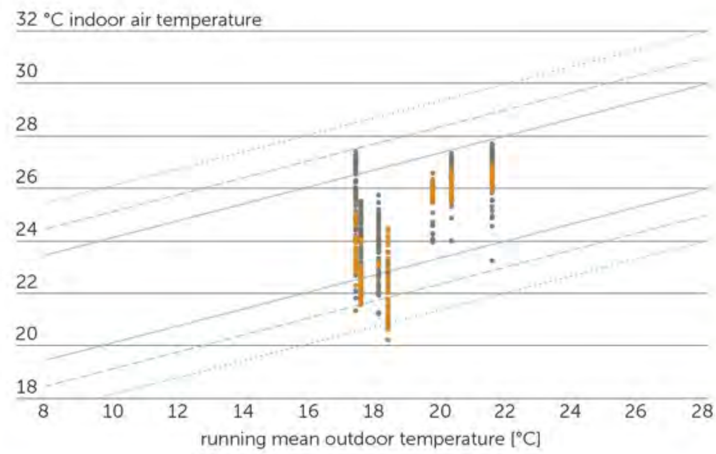
Team AuRA, Grenoble



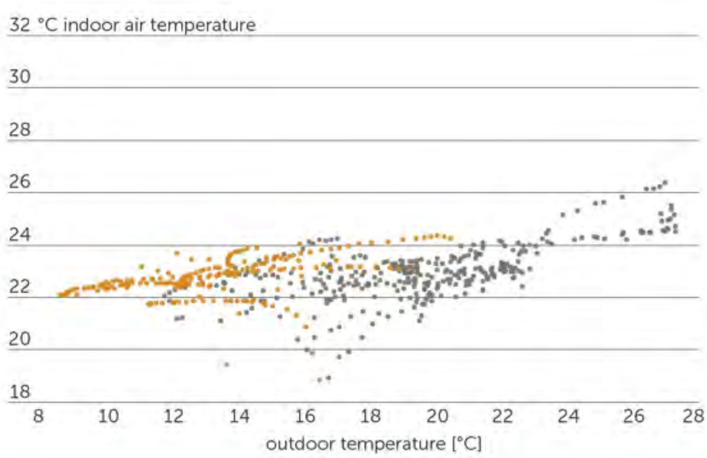


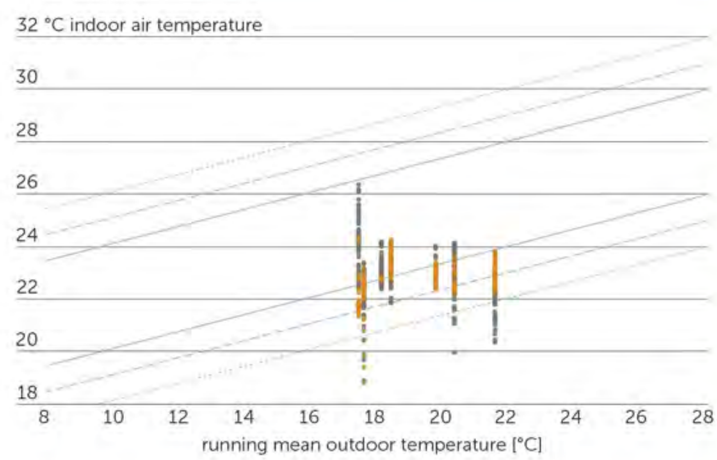
Team RoofKIT, Karlsruhe





Team MIMO, Düsseldorf





Indoor temperature evaluation during the evaluation period in relation to the instantaneous outdoor air temperature (left) and its running mean (right) for the building by the teams from Grenoble, Karlsruhe and Düsseldorf.
© SDE 21/22

08:00 - 21:45
22:00 - 07:45

limits category 1
limits category 2
limits category 3

Humidity profiles

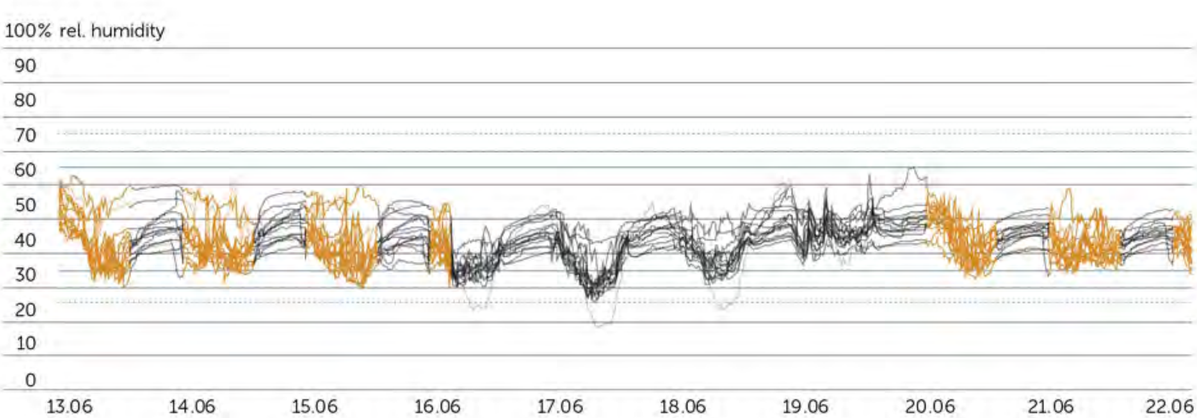
A maximum of 5 points only could be achieved in this part of the competition. This was deliberately set by the organisers, as few critical situations were to be expected due to the climatic conditions during the event. Relative humidity was also evaluated on the relevant days during the competition period without visitors between 8.00 a.m. and 10.00 p.m. every day. The measurements were not evaluated during the night between 10.00 p.m. and 8.00 a.m. The usual sources of humidity from people do not apply when nobody is staying overnight.

The development of the living area's relative humidity over time for all buildings show differences, but the majority of the recorded measured values are within the highest category. There are only a few downward peaks that can be assigned to category two during the evaluation period. No team fell below the second category's lower limit of 35 percent relative humidity during the entire evaluation period.

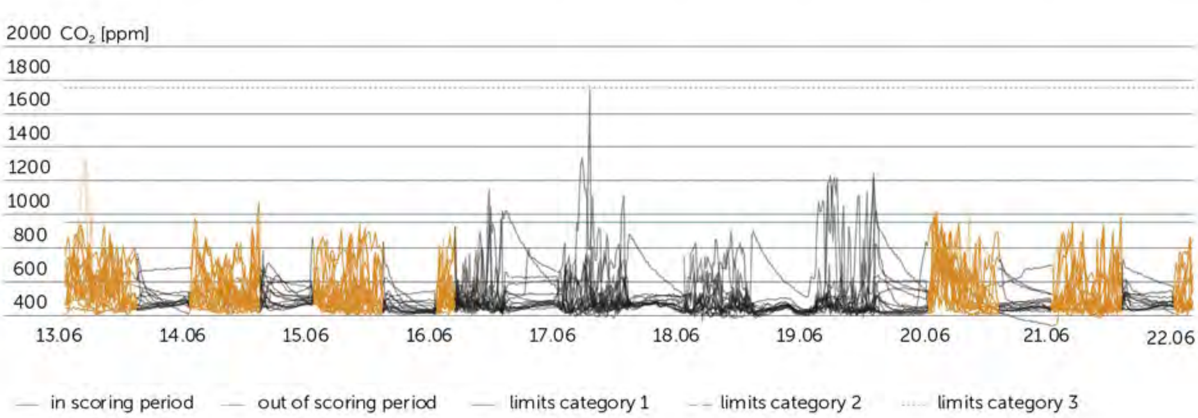
Air quality

A maximum of 20 points could be achieved in this discipline. The CO_2 concentration in the living area was recorded to determine the air quality. Due to the absence of people at night, the nocturnal measurement data was not included in the evaluation here either. The recorded data was automatically assigned to the categories with constant limits according to DIN EN 16798.

The CO_2 concentration development in the living areas of all buildings show practically no values above the best air quality class limit during the evaluation period. Due to the high outdoor temperatures, the areas were intensively aired using the windows. The effect of the ventilation systems, on the other hand, was not relevant; their night-time operation with closed windows, if applicable, was outside the evaluation period.



Development of relative humidity over time for all buildings during the competition period. © SDE 21/22



Development of CO_2 concentration over time for all buildings during the competition period. © SDE 21/22

co-heating test

Isil Kalpkirmaz Rizaoglu,
Karsten Voss
(University of Wuppertal)

Due to its nature as a high-profile event, the final of the competition in Europe always takes place outside the heating season. In light of the fact that buildings in Central Europe have their greatest energy consumption in winter, holding a building energy competition in June or September does not initially seem very meaningful.

Example of a room with fan heater (blue) and stand with the room climate measurement technology (yellow) in the TU Delft (TUD) building
© SDE 21/22

With that in mind, additional heating tests called "co-heating tests" were carried out for the first time at the SDE in Wuppertal. This involved temporarily heating the empty buildings or rooms to a temperature level significantly above the outdoor temperature. The tests took place on three consecutive days between the end of the assembly period and the start of the actual competition. Immediately afterwards, the students were asked to carry out their own simulations with measured climate data and compare them with the measurement results (discipline: Performance Gap). The standardised "SimRoom" software with predefined settings and pre-implemented, up-to-date on-site weather data was made available for this. The teams' task was to map their building using suitable input data. On the one hand, the aim was to make the teams in the competition aware that simulations in the planning phase are not only used to compare variants, but also to define the expectations of a building's thermal behaviour.

Test

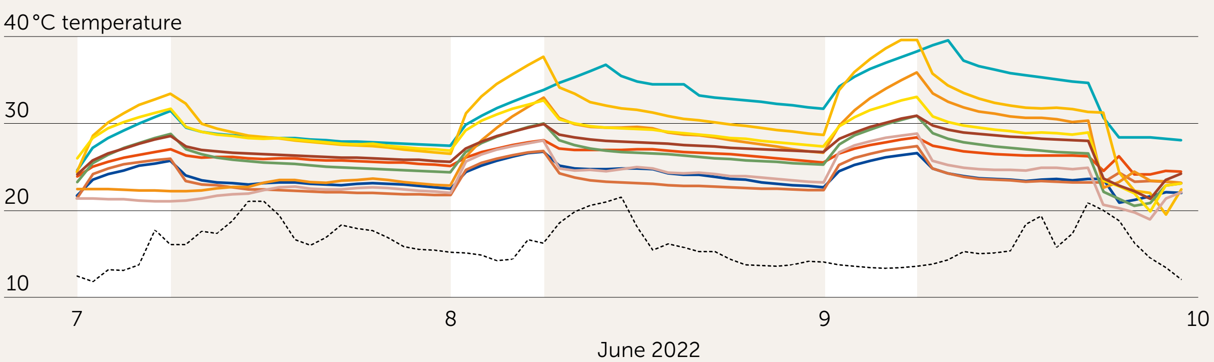
One fan heater with 3 kW power was used simultaneously in each of ten buildings for the experiment. The other buildings could not take part because the structural completion was not finished yet. In each case, the test applied to the area was intended for full heating inside the buildings. In some cases, these were smaller partial volumes (HSD, HFT). A switching signal from the data loggers was used to start up the heating at full and constant output between midnight and 6.00 a.m. on three consecutive days. No people were present in the houses, but the usual household appliances were connected (waste heat from refrigerators, etc.). Ventilation systems were not running and all openings were sealed as a result of the air tightness measurements. Movable sunshades were closed, where present. Contrary to the original plan, it was not possible to achieve a uniform starting temperature in the buildings due to delays in the construction process.

Findings

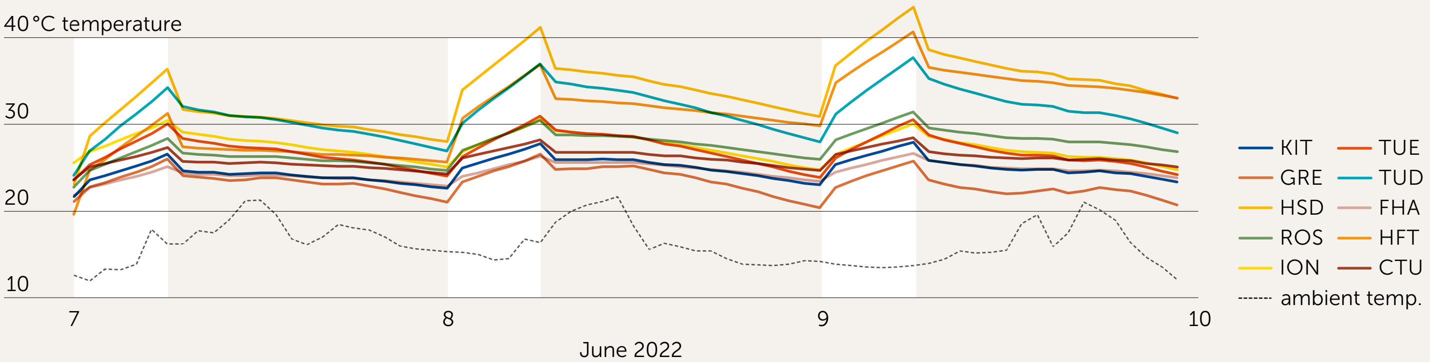
For comparable presentations to the simulation results, the measured values were combined into hourly averages. The HFT and FHA teams did not participate until the second day of the test sequence due to construction delays. As a result of data logger problems caused by the heat, the TUD team's fan heater was running longer than planned on the second and third day. It was switched off manually. Then the highly fluctuating temperature curves mark the end of the entire series of tests. The measured values clearly show the reaction to the fan heaters running. Switching them off causes the room temperature to drop until the heating is running again. The cooling down behaviour reflects the thermal insulation level, air tightness and heat capacity. In the trend over the three days, the temperature level increases in the buildings, depending on the heated volume, and reaches peak values of 40°C (HSD, TUD).

At first glance, the teams' simulation results depict the buildings' thermal behaviour quite well, with the exception of the errors in conducting the test. The parameters were not adjusted for this. The results of the airtightness measurements, were not yet known to the teams at this time and thus already explain some of the differences. The faster temperature rises in HFT and HSD are explained by the comparatively small room volumes.

The tests conducted allow for further analysis both with regard to the buildings' quality of installation and the detailed description with suitable simulation models. The work in the context of the competition was just the beginning. More co-heating tests, especially in winter conditions, are planned for the eight buildings that will remain in Wuppertal as part of the LivingLab NRW. Furthermore, the measured and published data sets, together with the very well documented buildings, provide a platform for subsequent tests in the context of research and teaching.



Measured temperature curves for the main living space in 10 buildings compared to the ambient temperature. The basis is hourly averages. The grey highlighted times mark the fan heaters running. © SDE 21/22



Simulated temperature curves for the main living space in 10 buildings compared to the ambient temperature. The basis is hourly averages. © SDE 21/22

daylight and lighting

Thomas Schielke
(arclighting)

The topic of light and lighting was reflected at the SDE 21/22 both in the “Architecture” jury discipline and in the “Comfort” and “Energy” disciplines evaluated by measurement. So it was a question of quality as much as quantity, and that applies equally to daylight and artificial light. There was also a special award for “Sustainable Architectural Lighting”.

Daylighting

Windows and their shading systems play a key role in creating a bright, spacious impression and a visual link to the surroundings. This is especially true for the mostly small-format flats found at the SDE 21/22. Large insulation thicknesses lead to reveal depths of 20 to 40 cm and reduce light incidence, especially with small-format windows. The predominantly used triple glazing with its coatings also weakens the light transmission to typical values around 70 percent.

Team identity	number window panes	typical outside reveal depth (in cm)	shading typology north	east	south	west	roof
ION	3**	20	opaque	none	overhang, wintergarden	none	opaque
ROS	2+1*	30	overhang	opaque	external venetian blind	opaque	opaque
CTU	3	15	none	overhang	none	opaque	opaque
TUE	3	16	overhang, external shutters	overhang	overhang, external shutters	overhang, external shutters	opaque
HBC	3+1	23	none	lamellas interpane	lamellas interpane	opaque	opaque
TUD	3	43	overhang	opaque	external screen	opaque	opaque
FHA	3	36*	external screen	opaque	overhang, external screen	opaque	opaque
GRE	3	10 and 15	none	opaque	overhang, external screen	opaque	opaque
KIT	3	37	overhang	opaque	external screen	external screen	none (north)
HFT	3	15	none	opaque	external PV curtain	opaque	opaque
HSD	3	7	opaque	opaque	overhang, curtain	opaque	PV glass
UPV	3	20	opaque	external shutters	opaque	external shutters	opaque
NCT	2	26	overhang and fins	opaque	none	opaque	internal PCM*** shade
ITU	3	33	opaque	none	opaque	none	opaque
UPH	3	24	none	opaque	wintergarden with PV	opaque	opaque

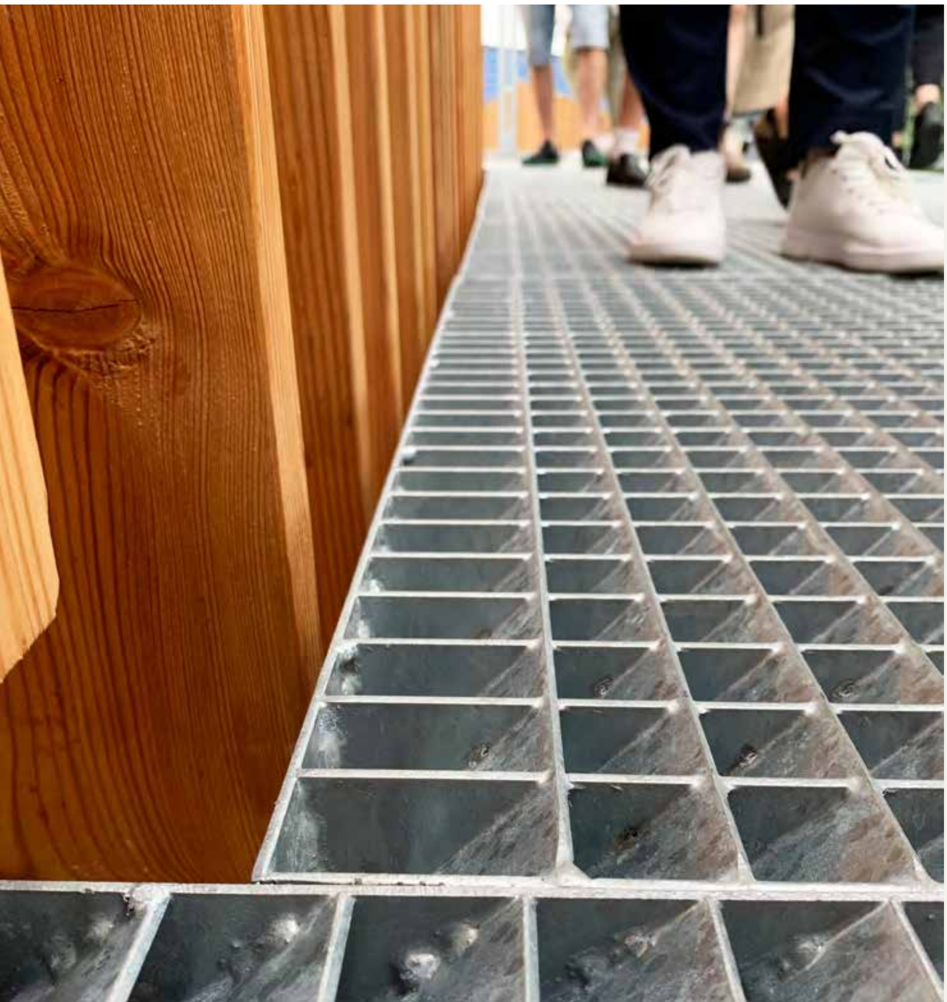
Glazing and shading typology for the projects © SDE 21/22

* vacuum glazing
** solar control glass
***phase change material

The team from Rosenheim not only offers an energy-efficient solution and even light distribution with its window design, but also achieves an attractive view for the living area with the appropriately proportioned glazing. Vacuum glazing and an external venetian blind are used. The grating slats for the arcade, set at an angle of 45° to the north façade, give the project a sophisticated look. This construction optimises the incidence of daylight for the rooms below and provides a view of the sky from there. The team from Aachen improves the light incidence through slanted window reveals on several sides. What is remarkable about the team from Karlsruhe's project is how the topic of windows is linked to recycling. Instead of insisting on identical window sizes and frame colours in the design, the team looked at a building components exchange for the required photometric properties such as size and transmission.

An interesting interplay of light and shadow characterises the design by the team from Stuttgart, in which a grid of suspended, rhombus-shaped photovoltaic elements also functions as shading for the access zone. Some teams also experiment with daylight control, either using a vertical tube for an indoor bathroom (Valencia) or distributing daylight to different rooms with a fibre optic system (Bucharest).

Slanted window reveals increase the incidence of light in the Aachen team's project © SDE 21/22



Gratings with angled slats provide a view of the sky in the rooms below © Thomas Schielke

Artificial light

With electric lighting, the focus is on flexibility and interesting connections with architectural components. The team from Stuttgart presents a conductive tape where the thin zinc conductor strip, glued to the ceiling and wall, allows for lights with different light distributions to be positioned flexibly. Both the lighting control using DALI and the 48 V supply were through the DC strip. For the bathroom, a full-surface illuminated ceiling with integrated shower outlet was created for a fresh morning shower of light. Residents can switch between three light moods with different colour temperatures to have the appropriate light spectrum for their circadian rhythm in the morning and in the evening. Icons on the wall with integrated wall sensors provide playful interaction.

The idea of flexibility is also evident in the team from Rosenheim's HDU. With the pendant lights in the kitchen, the light beam width can be conveniently adjusted with one simple turn. As a result, wheelchair users can work at the kitchen counter without any glare.

Shower of light from the Stuttgart team
© Thomas Schielke

One challenge was the lighting of the buildings at night, with the requirement to comply with the required minimum lighting level in the area of paths and entrances on the one hand, but not to cause any light pollution on the other. Some teams do without any outdoor lighting completely, which saves energy but resulted in penalty points. The team from Rosenheim designed elegantly shielded lighting on the railing for the ramp and step, and created a discreet strip light on the façade with very good visual comfort on and around the building. The concept's downward lighting also avoids light emission into the atmosphere, making it possible to see the stars according to dark-sky lighting principles.

Light characterised by systems thinking

Architectural lighting is not only defined by the key figures on energy efficiency, as life cycle considerations have clearly gained relevance at the Solar Decathlon Europe in Wuppertal. One visible trend was to use biological materials to build decorative light housings (Karlsruhe, Rosenheim). What is more sustainable from a holistic perspective: Biodegradable materials for decorative lights that look fashionable? Flexible rechargeable lights where the batteries entail ecological risks and the materials may not be in proportion to everyday use? Or lights with durable materials that are more expensive to start with but last much longer and can be used with one single lighting busbar system? With this variety of lighting solutions, the SDE 21/22 has made an important contribution to taking a more differentiated look at sustainable lighting.

Sustainable Architectural Lighting Special Award

The Deutsche Lichttechnische Gesellschaft e.V. (LiTG) launched the Sustainable Architectural Lighting Award to highlight the importance of lighting in terms of quantity and quality in sustainable building. The first, second and third prizes went to the teams from Karlsruhe, Stuttgart and Rosenheim.

Evening lighting at the Stuttgart team's house © SDE 21/22

Evening lighting at the Rosenheim team's house © SDE 21/22

water and waste water

Karsten Voss
(University of Wuppertal)

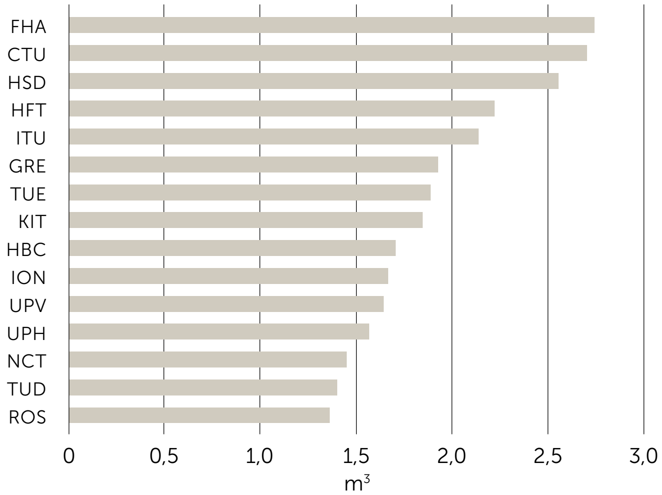
	number	total liter
hot water draw	22	1,100.00
cooking	7	16.10
washing	7	-
dish washing	10	-
Dinner	3	-

Number of prescribed actions with water consumption during the competition period. The appliances' consumption depends on their properties, the water consumption at dinner depends on the respective menus.

In times of climate change, the economical use of drinking water is becoming an issue in Central and Northern Europe too. Dry, hot summers lower the water table, causing springs to dry up and rivers to dry out. Water conservation, rainwater harvesting and greywater treatment in buildings have the potential to slow down this trend.

The houses that will make up the Living Lab NRW on the campus after the competition were connected directly to the municipal fresh water and waste water network. All the other buildings operated with storage tanks for fresh water and waste water with the associated pumps. To ensure a fair competition, the electricity consumption of these pumps was not counted towards the energy consumption.

The water consumption in the houses is the result of the typical household tasks during the competition days. However, the consumptions differ significantly despite the same tasks: for example, the most economical house only needs half the amount of the house with the highest consumption.



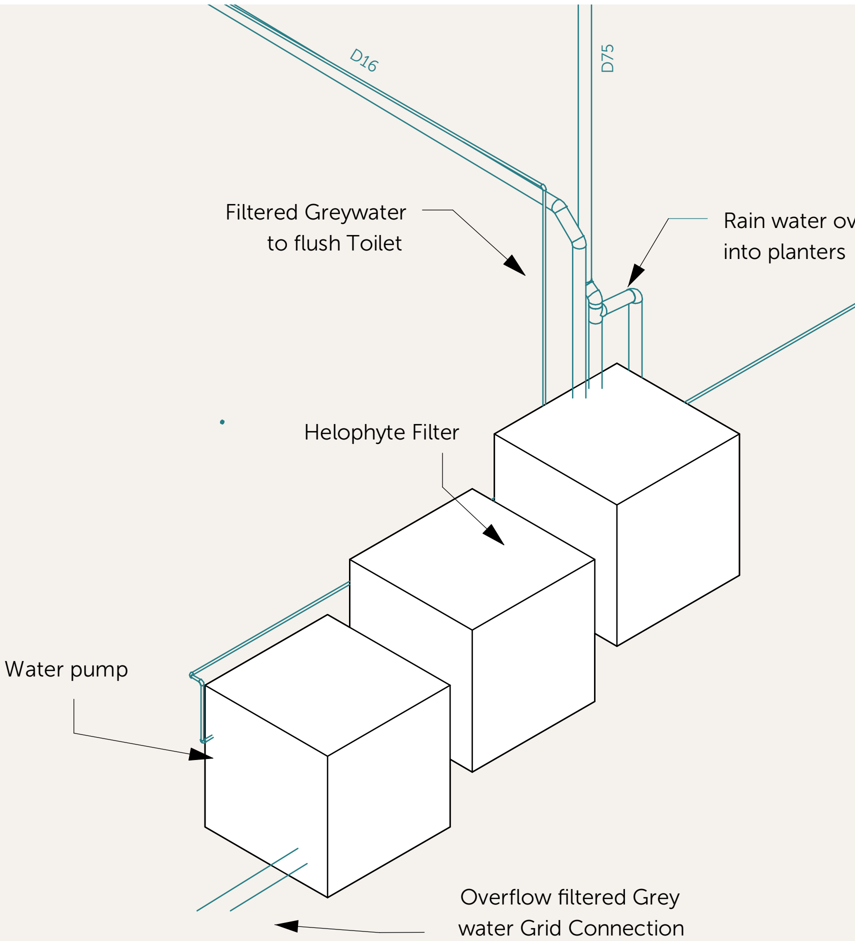
Water consumption over the competition days for 15 buildings in the competition. Data was projected for unsuccessful tasks or later entry into the competition.

50 litres at a minimum of 43°C had to be provided in 10 minutes at each of the 22 water taps.
© Claudio Montero, Energy Endeavour Foundation

Some of the teams featured plants for heat recovery from waste water. This does not save water, but it does save the energy required to heat it. This example shows the heat exchanger in the HDU by the team from Stuttgart.
© SDE 21/22

The planting of façades contributes to improving the microclimate. Green roofs also lead to rainwater retention and thus relieve the burden on the sewage system. This example shows the Aachen team's house
© SDE 21/22

Treated greywater can be used to water plants and (not in the competition) flush toilets. The example shows the system's process diagram for the team from Delft.
© SUM



solar system integration

Andrea Balcerzak
(University of Wuppertal)

From the beginning of the Solar Decathlon, photovoltaic systems have been part of all demonstration buildings. The use of solar thermal systems is usual, but it isn't mandatory.

At SDE 21/22, two teams also addressed the use of solar energy to power their construction site. The teams from Taipei and Eindhoven used tool containers with integrated PV modules during the construction phase.

Technical integration

Most of the teams set up their solar energy systems on site. In a few cases, they were also installed in advance as part of the building envelope, transported as a whole unit and merely complemented on site – this was the case for example for the teams from Karlsruhe and Eindhoven.

Based on the task of the overall design and thus the limited space available for multi-family dwellings, a maximum of 3 kW_p power and 2.5 kWh battery capacity were permitted for the electrical solar systems in the demonstration buildings. As a result, all electric solar systems were similarly sized. Each of the teams approached the upper limit of the rule.

In the majority of cases, monocrystalline silicon cells were used. Their high efficiency allows a high yield, even with limited surface area available. Almost all teams had integrated and

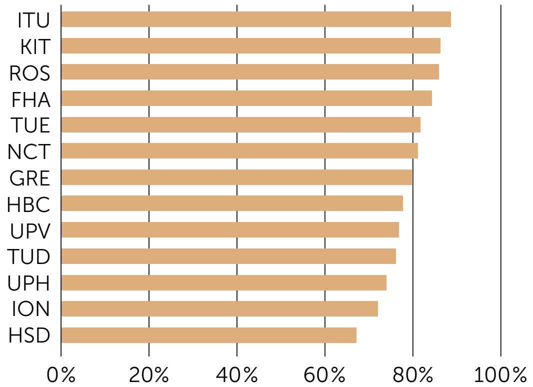
Extendible and retractable solar modules on the tool container to provide construction electricity for the team from Taipei
© SDE 21/22

Module inverters with 290 W_p by the team from Grenoble
© SDE 21/22

2.5 kWh battery storage by the team from Eindhoven
© SDE 21/22

connected their batteries on the DC side, only the teams from Düsseldorf and Eindhoven used the AC coupling. In the competition, the yield of the system consisting of PV and battery was measured after the inverter, i.e. on the AC side (see the chapter on Energy Balance). Both teams from Eindhoven and Grenoble used module-integrated inverters.

The solar system yield in relation to the energy consumption of the demonstration buildings is addressed in the Energy Balance chapter. By measuring the radiation on the solar generators, the quality of the system integration was determined for the first time at a Solar Decathlon. For this purpose, the measured energy yield was examined in relation to the yield which would theoretically be possible (performance ratio). Many teams achieve high values above 80 percent. As a comparison: in the same period and without battery storage and the associated losses, the photovoltaic system on the University of Wuppertal campus reached a value of 83 percent.



Ratio of energy generation from the PV systems including battery to the maximum possible generation according to the standard efficiency (performance ratio). This is based on the total values over the entire competition period.
© SDE 21/22

Ten out of 16 teams used solar thermal systems. As well as solar thermal collectors in familiar construction methods, there were six systems with a hybrid construction, so-called PVT collectors. The background for this is the scarcity of space when dealing with multi-family dwellings. There were PVT collectors in the form of PV modules with integrated pipework on the rear (e.g. Karlsruhe and Rosenheim). The team from Aachen used standard PV modules which were thermally activated by using a pipe system which was clipped onto the back side.

Rear (front in image) and front side (rear in image) of the PVT collectors used by the team from Biberach
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Pipe system on the rear of the PVT collectors used by the team from Eindhoven
© VIRTUe / SDE 21/22

The team from Biberach used PVT collectors with the additional function of an outside air heat exchanger on the back. During the competition, most collectors were operated in combination with heat pumps (e.g. Biberach and Karlsruhe) or heating elements (Istanbul/Lübeck) for water heating in connection with thermal storage tanks. At SDE 21/22, as in all previous competitions, the thermal yields of the collectors were not recorded by measurements.

The Out of Competition Solar Award, in the context of the SDE 21/22, honoured in particular outstanding energy concepts involving the interaction between photovoltaics and solar thermal energy. The two award winners were the teams from Eindhoven and Aachen.

The team from Eindhoven had integrated solar thermal energy and PV modules into the inclined roof of the technical room, and impressed

Team identity	City	Solar system	Module design	Number of modules/collectors	Module/collector area [m²]	Nominal elec. power [kWp]	Systems active in competion	Monocrystalline	Polycrystalline	Thin film	Organic PV	Tube collector	flat plate collector	Plug & play	Clip-on thermal activation	Backside air heat exchanger
				System sizes				**PV cell type**				**ST type**		**PVT type**		
CHA	Gothenburg	PV	glass/laminate modules	no details available				•								
CTU	Prague	PV	PV laminated on metal panels	32	30.7	2.7	•			•						
FHA	Aachen	PVT	glass/laminate modules	16	14.8	3.0	•	•	•						•	
		PV	glass/glass modules	13	-	-	○	•								
GRE	Grenoble	PVT	glass/laminate modules	4	7.5	1.6	•		•					•		
		PV	glass/glass modules	4	11.2	1.4	•		•							
HBC	Biberach	PV	glass tubes	94	56.7	3.0	•			•						
		PVT	flat plate collector	22	49.5	9.9	*	•								•
HFT	Stuttgart	PV	glass/laminate modules	4	6.2	1.0	•		•							
		PV	diamond polycarbonat sheets	224	41.7	0.9	•				•					
		PV	diamond polycarbonat sheets	385	54.4	1.1	•				•					
HSD	Düsseldorf	PV	insulation glass modules	-	-	2.7	•	•								
		PV	insulation glass modules	-	-	-	○	•								
ION	Bucharest	PV	glass/glass modules	8	14.6	3.0	•	•								
		ST	vacuum tube	2	4.7	-	•					•				
ITU	Istanbul/Lübeck	PV	glass/glass modules	16	19.5	3.0	•	•								
KIT	Karlsruhe	PVT	glass/laminate modules	10	16.7	3.0	•	•						•		
		PVT	glass/laminate modules	8	13.3	2.4	○	•						•		
NCT	Taipei	PV	glass/laminate modules	9	15.0	3.0	•	•								
		ST	vacuum tube	2	8.4	-	○					•				
ROS	Rosenheim	PVT	flat plate collector	8	15.0	3.0	•	•						•		
		PV	glass/glass modules	10	-	-	○	•								
		PV	glass/glass modules	15	-	-	○	•								
TUD	Delft	PV	glass/laminate modules	8	14.6	2.9	•	•								
		PV	glass/glass modules	36	-	-	○	•								
TUE	Eindhoven	PV	glass/laminate modules	5	8.6	1.8	•	•								
		PV	glass/glass modules	12	10.1	1.2	•	•							•	
		ST	flat plate collector	1	1.6	-	○						•			
UPH	Pecs	PV	insulation glass modules	10	16.6	2.8	•	•								
UPV	Valencia	PV	glass/laminate modules	4	7.8	1.5	•	•								
		PV	glass/glass modules	9	12.6	1.5	•	•								
		ST	vacuum tube	3	7.1	-	○					•				
						Ø 2.9										

The solar systems used.
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PV: photovoltaic PVT: hybrid collector ST: solar themal collector
○ system not in operation during the competition * only thermal part active in competition

Visible PVT façade shown
by the team from Biberach
© Steinprinz / University of Wuppertal

Thermal storage:

- Ice storage (in black) integrated into the technical room by the team from Aachen
- Clay construction boards with component activation are used for thermal distribution for heating and cooling by the team from Aachen

Various roof solar systems:

- Tilted PV modules on the roof of the team of Delft
- Tilted PVT modules on the green roof of Aachen

the jury with their intelligent building and energy management system. This manages the coordination between thermal and electrical storage, and regulates the used form of energy generation based on supply and demand.

The team from Aachen convinced with their overall energy concept. The PVT system on the roof provides heat and electricity for a brine heat pump. A special feature here is the ice storage with small 3D bodies that the team printed themselves. These bodies contain water. The ceilings are made of clay construction boards with component activation. This is used as a distribution system for heating and cooling the building.

Design integration

Solar systems are a central design challenge in the SDE houses. They may be expressly high-lighted or inconspicuously integrated into the architecture. Both strategies were presented at SDE 21/22. Here, the typxe of integration also always reflects the overall design of the existing building or the filling of gaps between buildings. As a result of this, there are often combined solutions on roofs and façades which, when considered on their own, are not necessary for operating the demonstration buildings and were therefore not actively connected in terms of elec-tricity or thermal energy in their entirety during the competition.

The shape of the roof is crucial for the visibility and integration of the solar systems. The major-ity of teams chose a flat roof. Flat roofs allow the modules to be aligned in the ideal manner in terms of orientation and inclination, regardless of the orientation of the building itself.

These systems were practically not visible for the visitors, especially not in the case of the two-storey constructions with standard modules designed by the teams from Aachen, Delft and Gothenburg.

Solar systems on flat roofs can also provide shade for rooftop patios and conservatories in the demonstration buildings. The daylight shining through and the view from beneath the respective modules provided a wide variety of views, as shown by the teams from Biberach, Grenoble, Prague and Valencia. To do this, the team from Biberach used innovative, tubular photovoltaic modules as pergola roofing. These were originally developed for large-scale application in agriculture (agri photovoltaics). The team from Grenoble reused glass-glass modules from their demonstration building at Solar Decathlon Europe 2014.

Various pergola roofs:

- Thin-film modules in a tubular shape (from below) in the roof garden pergola roofing by the team of Biberach
- PV modules at the end of the rooftop garden, viewed from below from the team from Grenoble

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The integration of the solar systems used.
© SDE 21/22

Team identity	City	Storeys	Roof shapes	Solar system	Roof systems: Roof integrated	Roof systems: Roof added	Roof systems: Pergola	Roof systems: Conservatory	Façade system: East	Façade system: West	Façade system: South	Visual integration: Non-visible	Visual integration: Visible, added	Visual integration: Visible, integrated	Coloured	Additional functions
CHA	Gothenburg	I	Free form	PV			•	•					•			
CTU	Prague	I	Flat roof	PV			•						•			shading
FHA	Aachen	II	Flat roof	PVT		•						•				
				PV							○			•	•	curtain wall
GRE	Grenoble	I	Flat roof	PVT			•							•		shading
				PV			•							•		shading, daylighting
HBC	Biberach	I	Flat roof	PV tube			•						•			shading
				PVT					•		•			•		curtain wall
HFT	Stuttgart	II	Flat roof	PV		•						•				
				PV		•							•			shading
				PV					•	•	•		•	•		shading
HSD	Düsseldorf	II	Flat roof	PV	•									•		insulation, shading, daylighting
				PV					○	○	○			•		insulation, shading, daylighting
ION	Bucharest	I	Flat roof	PV		•						•				
				ST tube		•						•				
ITU	Istanbul/Lübeck	II	Flat roof	PV				•						•		shading, daylighting
KIT	Karlsruhe	I	Sawtooth roof	PVT		•						•			•	
NCT	Taipei	II	Gable roof	PV		•							•			
				ST tube		•							•			
ROS	Rosenheim	II	Gable roof	PVT		•							•			
				PV				•	•					•		shading, daylighting
				PV							○			•	•	curtain wall
TUD	Delft	II	Flat roof	PV		•						•				
				PV							○			•	•	image print, curtain wall
TUE	Eindhoven	I	Flat roof	PV		•								•		
				PV					○	○	○			•	•	curtain wall
				ST flat	•									•		
UPH	Pecs	II	Flat roof	PV				•						•		shading, daylighting
UPV	Valencia	II	Flat roof	PV		•							•			
				PV			•						•			shading
				ST tube		•						•				

PV: photovoltaic   PVT: hybrid collector   ST: solar themal collector   ○ system not in operation during the competition

In contrast, the teams from Istanbul/Lübeck, Pécs and Rosenheim chose to integrate the systems visibly in the inclined roofs of their conservatories as glazing to provide shade.

Contrary to the flat roof arrangement, for all of the other roof shapes shown (gable roof, saw-tooth roof, free form), the placement of the solar systems is determined by the roof alignment on the building and the inclination of the roof.

The HDU of the team from Düsseldorf had the solar cells integrated into a saw-tooth roof with an east-west orientation and into the movable insulation glass slats of the façades.

The PVT system of the team from Karlsruhe was not visible on the opaque parts of the saw-tooth roof, because of to the elevation of their one-storey building.

Various integrations in conservatories:

- PV modules in a sharply inclined roof from the team from Pécs
- Glass-glass modules in the inclined roof from the team from Istanbul/Lübeck
- Glass-glass modules in the slightly inclined roof from the team from Rosenheim

Moveable integration in roof and facade:

- PV integration in moveable tripple glazing demonstrated by the team from Düsseldorf

- Visible standard PV and solarthermal collectors shown by the team from Taipei
- Non-visible PVT modules integrated in the roof of the winning team from Karlsruhe


levelup

The solar systems on the façades take on a special role. This is where the greatest demands are in terms of the design, as everything is visible to the viewer from a short distance. In addition to the photovoltaic systems, the PVT collectors used at the demonstration building of the team from Biberach were also a very good example of façade integration. The big challenges here are coordinating the geometry, choice of material, colour and joining technique with the other façade materials.

With the façade, there is also a focus on integrating the geometry. The team from Stuttgart used the smallest module size. These are diamond-shaped organic photovoltaic cells which were fitted into a steel frame with steel cables and installed in trellis form in front of the façade. The students determined the arrangement of the three differently sized PV cells using a self-created simulation analysis that calculated itself automatically based on the installation site. By comparison, the team from Rosenheim had the largest solar modules which were used to clad the façade and were given a monochromatic colouring.

The houses of the teams from Aachen, Eindhoven and Delft had solar modules with customised design scheme on their ventilated curtain walls.

The team from Delft demonstrated how well building integrated photovoltaic systems can be adapted to suit the situation. The solar modules, which are printed with a historic Dutch motif, reflect the urban context of the building.

Module sizes:

- PV façade with large custom modules shown by the team from Rosenheim
- Organic photovoltaic modules in custom formats used as shade elements on the demonstration building from Stuttgart

Curtain walls with coloured PV modules:

- The team from Aachen applied a greenery façade on the ground floor and green PV modules on the top floor
- PV modules with a structured print on the façade of the Eindhoven demonstration building
- PV modules with ceramic print on the façade of the Delft demonstration building

heat pumps

Jan Martin Müller
Karsten Voss
(University of Wuppertal)

Starting from a heat supply with district heating, gas or oil in the existing buildings, the energy concepts for the renovations and extensions were in the vast majority of cases based solely on the use of electric heat pumps with waste heat, geothermal heat or outside air as heat sources. Hybrid collectors are also used (PVT). The heat pumps are intended solely as central appliances and not in individual living units and predominantly operate embedded surface heating systems in floors, sealings and walls. Some teams combine the heat pumps with gas boilers (Bucharest, Biberach) or district heating (Rosenheim, Pécs, Prague). Only one team uses wood pellet heating (Grenoble). One special feature is a concept using solar-generated hydrogen as a seasonal storage system (Aachen). Here, the waste heat from power generation by a fuel cell in the winter is used.

All HDUs on the Solar Campus were "purely electric houses", i.e. with electricity as the sole energy source for all energy services. In this respect, the whole building energy concepts from the design challenge could not always be transferred unchanged. There were heat pumps in 11 of the 16 buildings on the Solar Campus. All were operated with outside air as a heat source, in combination with PVT collectors in 5 projects.

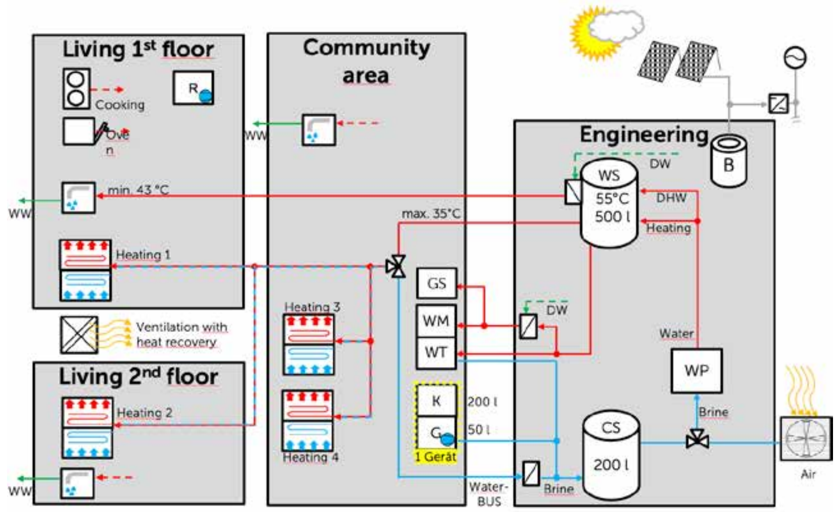
Heat supply concepts for whole buildings and their renovation (design challenge)
© SDE 21/22

Team Identity	City	Team Name	Heat pump	Option cooling	Heat source	Heat sinks	Additional/other heat source
CTU	Prague	FIRSTLIFE	•		Outside air	Domestic hot water, embedded surface heating (extension)	District heating (existing building)
FHA	Aachen	LOCAL+	•	•	PVT, ice storage	Domestic hot water, embedded surface heating	Solar thermal energy (PVT), waste heat electrolyser and fuel cell
GRE	Grenoble	AuRA	/				Wood pellet boiler
HBC	Biberach	X4S	•		PVT	Domestic hot water, embedded surface heating	Solar thermal energy (PVT), gas boiler
HFT	Stuttgart	coLLab	•		Municipal sewage system	DHW, radiant ceilings panels (existing), embedded surface heating (addition)	
HSD	Düsseldorf	MIMO	•	•	Outside air, waste heat appliances	Domestic hot water, embedded surface heating	
ION	Bucharest	EFdeN	/				Various
ITU	Istanbul/Lübeck	Deeply High	•	•	Ground source heat pump	Domestic hot water, embedded surface heating	
KIT	Karlsruhe	RoofKIT	•		Exhaust air, PVT	Domestic hot water, embedded surface heating	Solar thermal energy (PVT), biogas (for cooking only)
NCT	Taipei	TDIS	/				Solar thermal energy
ROS	Rosenheim	levelup	•	•	PVT, ground source heat pump	Domestic hot water, embedded surface heating (addition)	District heating, solar thermal energy (PVT)
TUD	Delft	SUM	•	•	PVT	Domestic hot water, air heating (addition), radiators (existing)	Solar thermal energy (PVT)
TUE	Eindhoven	VIRTUe	•		PVT, ground source heat pump	Domestic hot water, embedded surface heating	Solar thermal energy
UPH	Pécs	Lungs of the City	/				District heating, solar thermal energy
UPV	Valencia	Azalea	•	•	Outside air	Air heating	Solar thermal energy

The use of geothermal probes as a heat source was not permitted on site. The hybrid collectors with additional air heat exchangers from the Biberach team and the integration of waste heat from domestic appliances from the Düsseldorf team were particularly interesting.

The team from Aachen integrated an ice storage one site. In order to manage heat pump operation more efficiently, the heat is almost always delivered to the rooms through embedded surface heating systems. Almost all systems are supported by solar collection for water heating, meaning that almost no heat pump operation is required in the summer.

Only the teams from Aachen, Valencia and Rosenheim rely on natural coolant (propane) for the heat pumps, while all other systems use synthetic coolant in the circuits.



B	Battery storage	F	Freezer	TD	Tumble dryer
CS	Cold buffer storage	HE	Heat exchanger	WM	Washing machine
D	Dishwasher	HP	Heat pump	WS	Water storage
DHW	Domestic hot water	PV	Photovoltaic	WW	Waste water
DW	Drinking water	R	Refrigerator		

Power scheme by the team from Düsseldorf
© Team MIMO / SDE 21/22

Heating concepts for the house demonstration units on the Solar Campus in Wuppertal
© SDE 21/22

Team Identity	City	Team Name	Heat pump	Option cooling	Heat source	Heat sinks	Synthetic refrigerant	Natural refrigerant	Additional/other heat source
CTU	Prague	FIRSTLIFE	•		Outside air	Domestic hot water, embedded surface heating	R410A		
FHA	Aachen	LOCAL+	•	•	PVT, ice storage	Domestic hot water, embedded surface heating		R290 (Propane)	Solar thermal energy (PVT)
GRE	Grenoble	AuRA	•		Outside air	Air heating	R1234ze		Solar thermal energy (PVT)
HBC	Biberach	X4S	•		PVT	Domestic hot water, embedded surface heating	R410A		Solar thermal energy (PVT)
HFT	Stuttgart	coLLab	•		Outside air	Domestic hot water	R1234ze		Electric instantaneous water heater
HSD	Düsseldorf	MIMO	•	•	Outside air, waste heat units	Domestic hot water, embedded surface heating	R410A		
ION	Bucharest	EFdeN	/						Solar thermal energy
ITU	Istanbul/Lübeck	Deeply High	/						Heating rod
KIT	Karlsruhe	RoofKIT	•		PVT	Domestic hot water, embedded surface heating	R410A		Solar thermal energy (PVT)
NCT	Taipei	TDIS	/						Solar thermal energy
ROS	Rosenheim	levelup	•	•	PVT	Domestic hot water, embedded surface heating		R290 (Propane)	Solar thermal energy (PVT)
TUD	Delft	SUM	•	•	Outside air	DHW, air heating (upper floor), radiator (ground floor)	R32		
TUE	Eindhoven	VIRTUe	•		PVT	Domestic hot water, embedded surface heating	R407C		Solar thermal energy
UPH	Pécs	Lungs of the City	/						Heating rod
UPV	Valencia	Azalea	•		Outside air	Domestic hot water, air heating		R290 (Propane)	Solar thermal energy

energy balance and building-grid interaction

Karsten Voss
(University of Wuppertal)

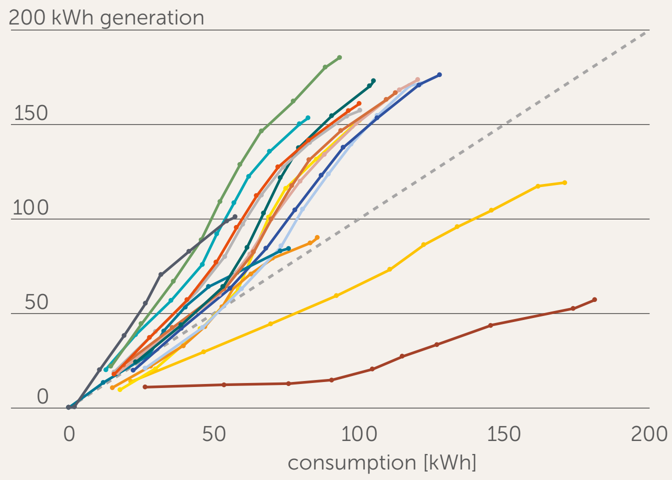
Starting from a heat supply with district heating, gas or oil in the existing buildings, the energy concepts for the renovations and extensions were in the vast majority of cases based solely on the use of electric heat pumps with waste heat, geothermal heat or outside air as heat sources. Some teams combine the heat pumps with gas boilers (Bucharest, Biberach) or district heating (Rosenheim, Istanbul / Lübeck). Only one team uses wood pellet heating (Grenoble). One special feature is a concept using solar-generated hydrogen as a seasonal storage system (Aachen).

All HDUs on the Solar Campus were “purely electric houses”, i.e. with electricity as the sole energy source for all energy services. In this respect, the whole building energy concepts from the design challenge could not always be transferred unchanged. The aim was to generate at least as much electricity on site as is needed to run the HDU. With the sunny conditions during the competition, this should not be a big challenge, especially as systems for cooling were not allowed to be run and therefore no energy was used for this.

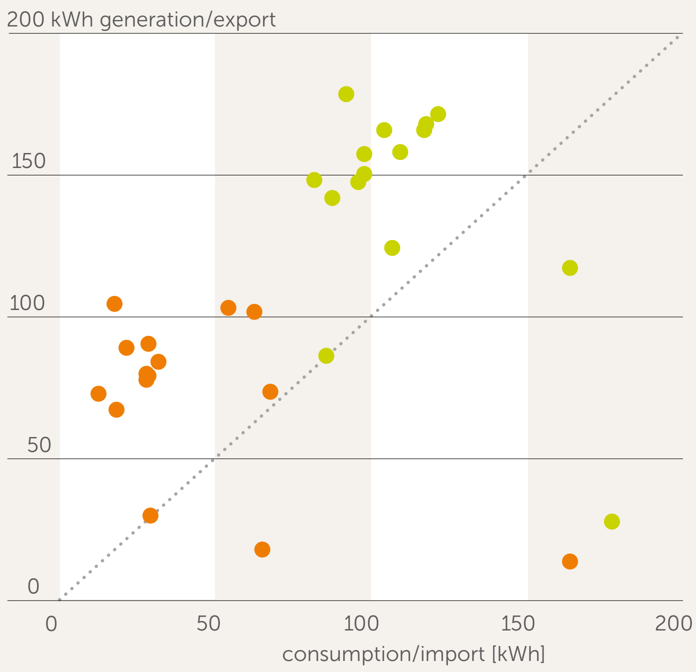
As a result of the competition rules, the solar power systems were all of a similar size with approx. 3 kW_p. The differences in the energy balance are therefore the result of the system alignment, performance and energy consumption. At the interface to the Solar Campus shared power grid, it became measurable which share of the generated electricity was used by the HDU itself and which was fed into the grid. With battery storage units of almost the same size (2.5 kWh) in all houses, this shows the adaptation of consumption to solar power availability (demand site management). The batteries were connected on the DC side, with few exceptions. Battery charging from the mains was not permitted. However, in individual cases this was done on a small scale as “self-protection” to prevent complete discharging.

All the buildings except for two (Prague, Düsseldorf) show a clearly positive or even energy balance. The two teams’ high energy consumption, in combination with the less than ideal operation of the solar power systems, was the decisive factor for the negative generation and consumption balance. This behaviour is also reflected in the development over the competition days.

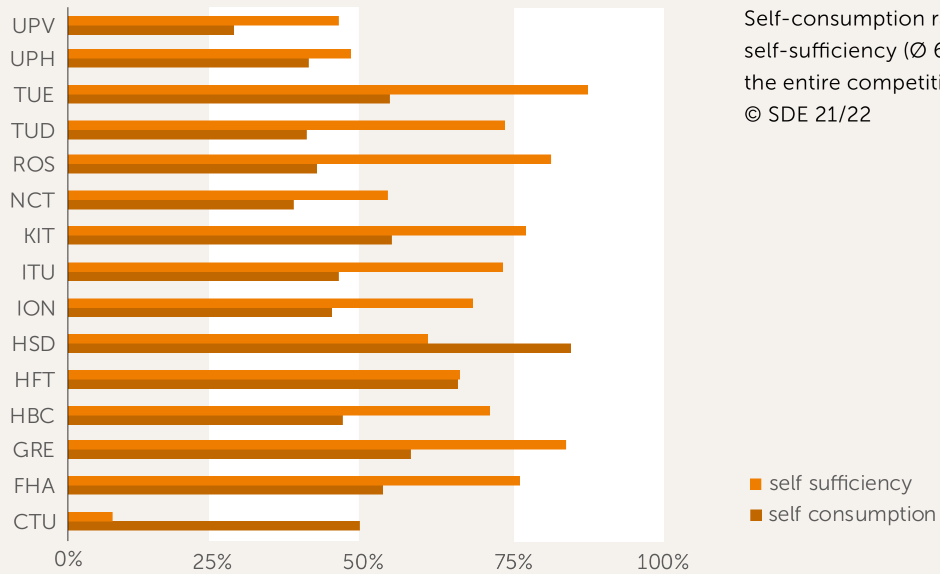
The import and export balance becomes clear at the interface to the power grid. Its difference to the generation and consumption balance is the proportion of consumption from the building’s own power. This describes the proportion of the electricity generated that is not fed into the grid but consumed on site. It is expressed as a percentage of the generation. In contrast, the degree of self-sufficiency characterises the proportion of electricity consumption that is directly covered by the solar and storage system. It is expressed as a percentage of the consumption. Due to the battery systems, the self-consumption rate and degree of self-sufficiency are significantly higher than in systems with complete surplus feed-in. This is especially true in light of the high solar radiation values during the competition period.



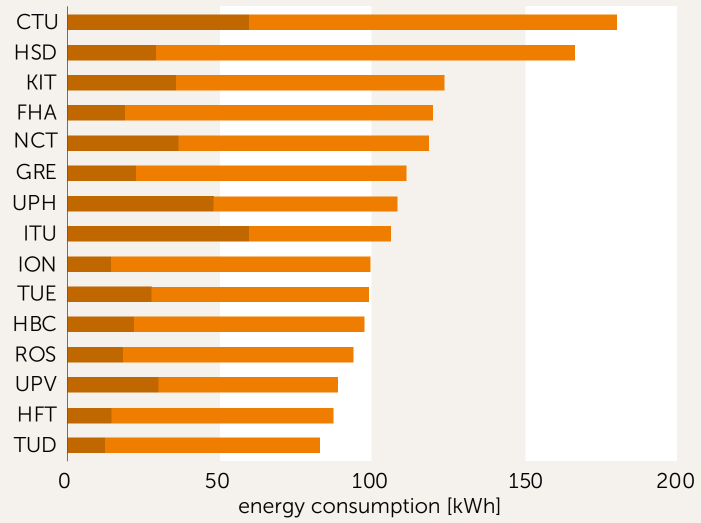
Development of power generation and consumption over the 10 days of the energy competition. Each line marks one of the 15 buildings, each dot a day. Some of the teams could not participate in the competition on all days due to technical problems
© SDE 21/22



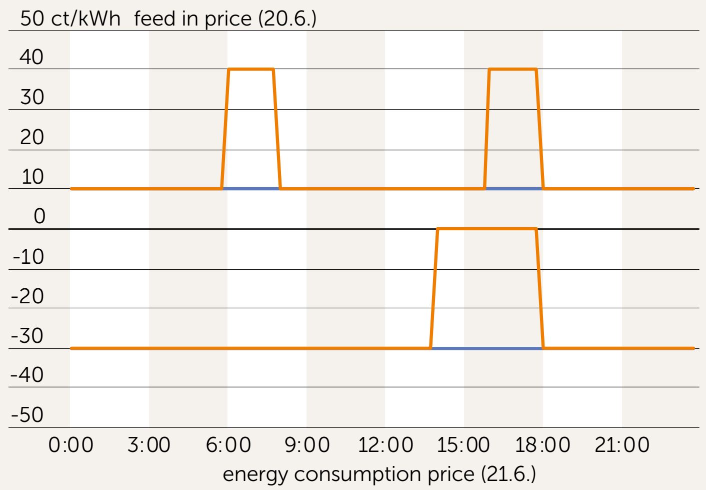
Comparison of power generation and consumption as well as export and import at the interface to the power grid as total values over the entire competition period. Each pair of dots marks a building
© SDE 21/22



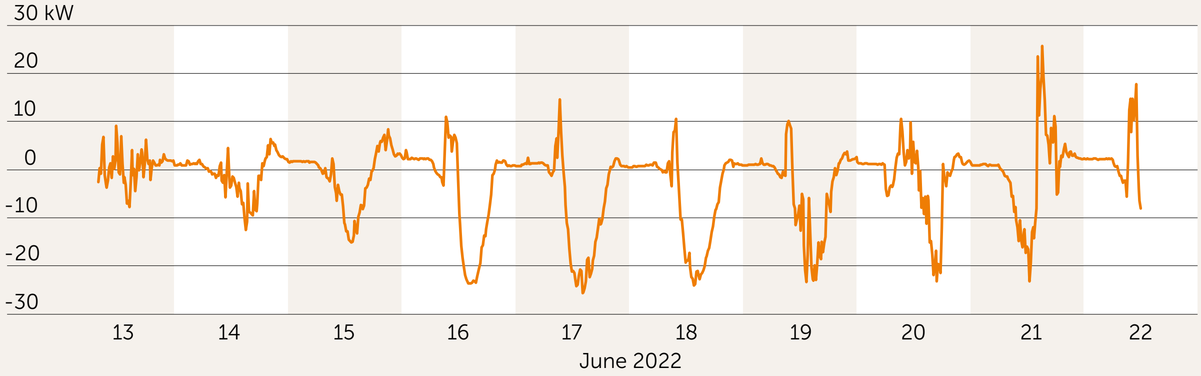
Self-consumption rate (Ø 49%) and degree of self-sufficiency (Ø 65%) for all buildings over the entire competition period
© SDE 21/22



Composition of the houses' electricity consumption for the household and lighting areas as well as building services over the entire competition period
© SDE 21/22



Rate information given to the teams for 20 June (preferred feed-in) and 21 June (consumption adjustment)
Positive: revenue, negative: costs.
© SDE 21/22



Development of electricity import (positive) and export (negative) in the Solar Campus power grid
© SDE 21/22

In terms of energy use, consumption for household appliances, lighting and small consumers was dominant over building services, as expected. Here, there is a factor of 2.2 between the most economical project and the one with the highest consumption. In addition to differences in the consumption of household appliances, there were also differences, for example due to the type of laundry drying (tumble dryer or line), the presentation media (screen or projector) and the more or less intensive use of lighting.

Building services primarily involved the ventilation, water heating and building automation, as active space heating and cooling using the heat pumps was excluded. The differences are even greater here with a factor of 4.6. This is affected by whether solar thermal systems take over the hot water preparation or heat pumps or cartridge heaters are used, among other things

Doing without tumble dryers reduces electricity consumption in the household (Team Istanbul / Lübeck)
© Claudio Montero,
Energy Endeavour Foundation

Solar collectors provide hot water in 13 out of 15 projects and thus reduce the building services electricity consumption, here in the case of the Bucharest and Rosenheim teams.
© SDE 21/22

Visualization of the energy management for the occupants in the Eindhoven house.
© SDE 21/22

life cycle assessment

Jan Martin Müller
Karsten Voss
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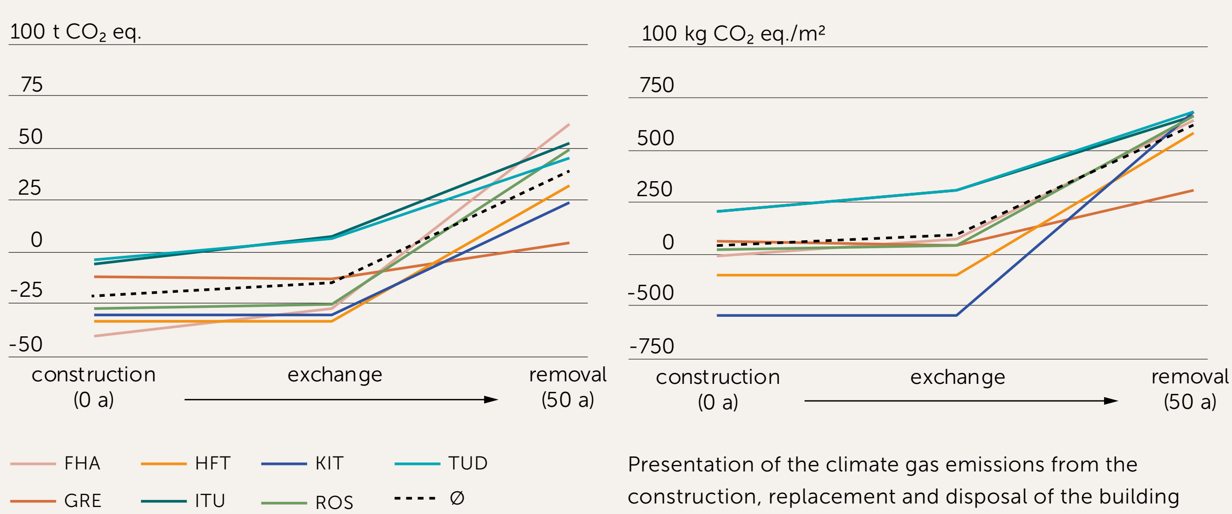
The energy expenditure for the construction, maintenance and disposal of a building generally increases with an improvement in a building's energy efficiency and the use of solar systems. This share is often referred to as "grey energy". This is associated with growing greenhouse gas emissions and other negative effects on the environment. The greenhouse gas emissions were therefore to be determined approximately as an example for the house demonstration unit (HDU) as part of the "Engineering & Construction" discipline. If these emissions and not just the operational emissions during a building's use phase are to be offset in a life cycle assessment, annual surpluses from operating solar power systems are required. These are then included in the assessment as emission credits (life cycle carbon footprint). The restriction to greenhouse gas emissions and disregarding of other environmental impacts is a simplification in this process.

The emissions balance from the construction, maintenance, replacement and disposal was considered by all teams over a period of 50 years, as agreed, and on the basis of other standardised specifications. These figures could be determined for the entire building structure from the calculation tool for the recycling potential. In the end, plausible results were available for seven buildings. Their different sizes of 64 m² to 156 m² are an important influencing factor: smaller buildings have more envelope area per floor area and therefore require more material per area. The weight of the buildings from 40 t to 75 t is also determined by the size and thus the amount of material used. Mainly biotic building materials, in particular wood, were used for the buildings. According to the normative calculation rules for the life cycle assessment of buildings, this leads to negative emissions in the sense of carbon credits (EN 15978-2011: Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method). Essentially, the embodied emissions in the material are only released at the end of the service life. The contribution from the replacement of building components usually remains comparatively low for a period of 50 years. All teams used standardised tables from the competition documents for the components' utilization times that are common in practice.



Presentation of the climate gas emissions from the construction, replacement and disposal of the building structure using the example of seven buildings. The diagram on the left shows the absolute figures, the one on the right shows the emissions in relation to the net floor area. © SDE 21/22

Climate gas emissions are also associated with the production, replacement and disposal of technical equipment in the buildings. The database to examine them closer is significantly more incomplete than for building materials. Furthermore, there is a lack of experience regarding the disposal of photovoltaic systems, as many previously installed systems are still in operation after 40 years. With this in mind, only the production phase was considered in the competition and standardised specifications were provided for all the teams. These were, for example, data on the emissions from the construction of PV systems in relation to the installed power or comparable values for typical ventilation, electrical or water installations in a building with a floor area of 100 m². Tables with standardised information on the usual utilization times were also provided, similar to the building materials.

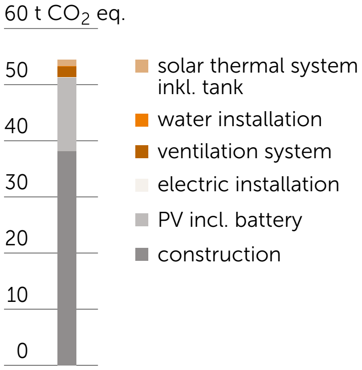
Based on such assumptions, a rough classification of the influences on a life cycle assessment is possible, but it is impossible to differentiate between individual projects. If we also look at the average values for the structural design of all seven buildings, we see that its share dominates the life cycle assessment with 70 percent. It should be noted that the foundations were not considered under the competition conditions. The second important factor with 24 percent is the photovoltaic system, of comparable size in all projects and with battery storage (3 kW_p, 2.5 kWh) here. However, like all technical installations, it was considered to have a useful life of 25 years and was therefore assumed to be replaced once during the 50 years. All other influences remain minor. This also includes the question of whether a solar collector should be used or not. This type of analysis results in almost 55 t of climate gas emissions in total from the construction, maintenance and disposal of the building.

Assuming that all emissions from running the building are already offset due to energy efficiency measures, solar installations and feed-in credits for solar power in line with a zero net energy building, annual feed-in surpluses could

Presentation of the overall design for the transformation of a hotel in the French Alps near Grenoble. The transformation contributes to using the load-bearing components for a long time
© Team AuRA / SDE 21/22

theoretically also offset these 55 t of climate gas emissions. Based on the current figures for power generation emissions in Germany and a photovoltaic system's usual electricity yields, this would require a system with an additional 7 kW_p output. Such a large system with about 42 m² is not likely to be able to be placed on a block of flats per 100 m² living space in addition to the 3 kW_p system with its 18 m².

The good news, however, is that the greener the power grid becomes in the future, the more the emissions attributed to building products, and thus to a building, will decrease. The preservation and further development of existing buildings without destroying them is another important contribution to the life cycle assessment of buildings. Therefore, the focus of the SDE 21/22 was precisely on this area. It is particularly important to use durable constructions for much longer than 50 years.



Breakdown of greenhouse gas emissions from construction, maintenance and disposal using the example of a 100 m² building at the SDE 21/22 (average)
© SDE 21/22

building performance simulation tools

Isil Kalpkirmaz Rizaoglu
(University of Wuppertal)

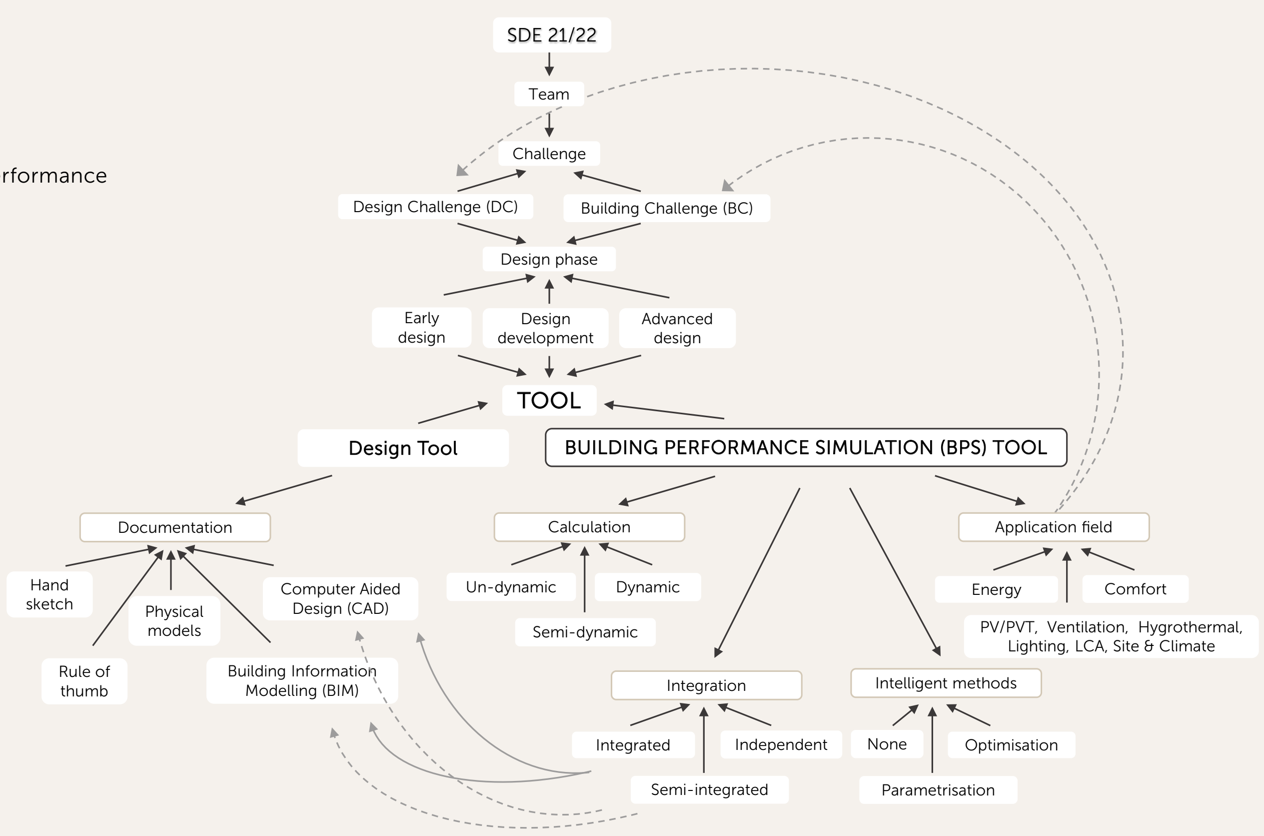
Adoption of Building Performance Simulation (BPS) tools during the planning and design in an integrated manner is required to fulfil the changing needs and expectations in architecture, engineering, and the construction of buildings. SDE 21/22 was unique with the use of a rich variety of such tools in the design challenge, as well as the building challenge.

BPS tools were mainly utilised in the scope of the Contest 2 - Engineering & Construction, Contest 3 - Energy Performance; and Contest 7 – Comfort, as well as Contest 1- Architecture, regarding the optimisation of passive and active solar energy systems with the designs.

Some of the teams made use of BPS tools starting from the early design phase, where schematic design, form finding and massing studies were included to explore design alternatives. Some others used them starting from the design development phase to compare, evaluate and determine prominent design alternatives. But still, all of the teams used BPS tools to assess the performance of their final designs. Accordingly, a wide variety was observed regarding the tools in terms of calculation methods (un-dynamic, dynamic, semi-dynamic), area of use (i.e., energy, comfort, design integration), level of integration with the design tools (i.e., integrated, semi-integrated, independent), as well as intelligent design options provided by the tools (i.e., parametrisation and optimisation).

More than 90% of the teams focused on energy performance. This was followed by comfort, PV/PVT and daylight availability investigations. Only a few teams used tools, such as computational fluid dynamics, for optimising the ventilation.

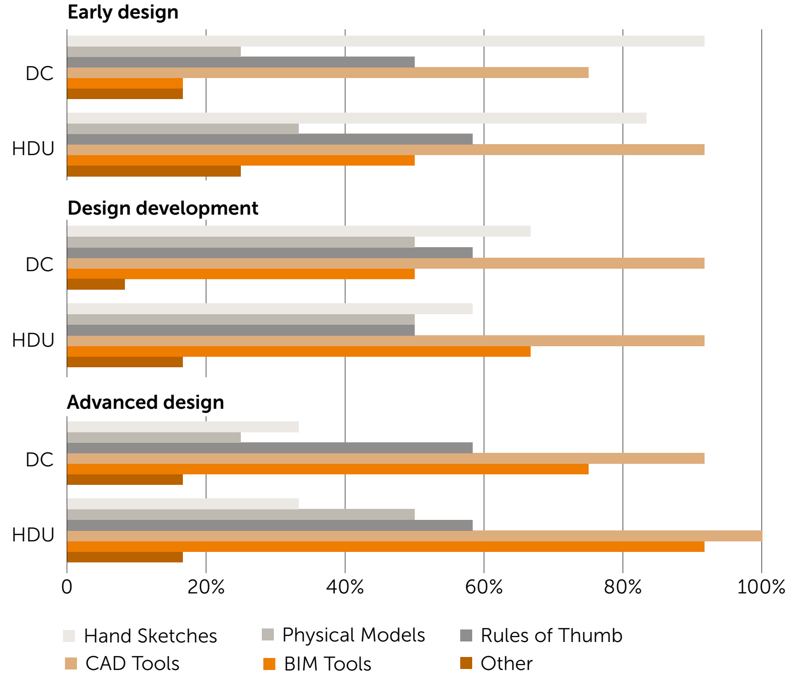
Use of Building Performance Simulation Tools
© SDE 21/22



Survey – Use of Building Performance Simulation Tools

To capture the teams' views and learn about their experiences regarding the use of BPS tools in SDE 21/22, a survey was conducted directly after completion of the competition. Twelve teams participated. The results are represented in percentage (%) by the teams' answers.

The teams were asked which design tools are used in which phase. It was seen that while the use of hand sketches and physical models were common in the early steps, use of digital tools, i.e. Computer Aided Design (CAD) and Building Information Modelling (BIM) tools became more dominant in further steps of the design process. When the challenges are compared, adoption of CAD tools was intensive in both the Design Challenge (DC) and the Building Challenge (BC) with House Demonstration Unit (HDU). BIM was only dominant in the Building Challenge design phases, yet less than CAD tools.



Use of design tools based on design phase during the Design Challenge and the Building Challenge with its HDU
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Energy	Comfort	PV/PVT System*	Ventilation	Hygrothermal	Lighting	LCA**	Site & Climate
FIELD							
Use	Thermal comfort	Design	Passive	Heat	Daylight design	Cost	Site integration
Cost	Air quality	Production	Mechanical	Moisture	Artificial light design	Carbon footprint	Radiation
Balance	Humidity	Grid integration			Visual comfort	Circularity	Shadow
TOOL							
Design Builder	Design Builder	PVlib Python	Ladybug Tools	WUFI	Autodesk Revit	UMI Tool	RESBy
MATLAB/Simulink	SimRoom	PVGIS	Plancal Nova	Lesosai and Flixo	IDAICE	eLCA/Bauteileditor	Vi-suite
Ladybug Tools	TRNLizard	AutoCalSol	DDS-CAD	Therm	Dialux Evo	SimaPro 9.0	Ladybug Tools
IDAICE	TRANSYS 18	Polysun	TRNFLOW	PsiTherm	Radiance	Caala	Climate Consultant
SimRoom	ENERCALC	TRNLizard			VELUX	OneClickLCA	Climate Studio
EN-13790 Tool	ETU Sim. Gold	Sunny Design			IES-VE		
Plancal Nova	IES-VE	PV*SOL			RELUX		
EnergyPlus	PHPP	T*SOL Valentin					
DDS-CAD		OpenModelica					
TRNLizard		PV syst 7					
TRANSYS 18		POLYSUN					
ENERCALC		SolarEdge					
ETU Sim.Gold							
IES-VE							
PHPP							
ClimateStudio							
Open Studio							

*PV:Photovoltaic / PVT: Photovoltaic Thermal System **LCA: Life Cycle Assessment

Building Performance Simulation Tools and their fields of application
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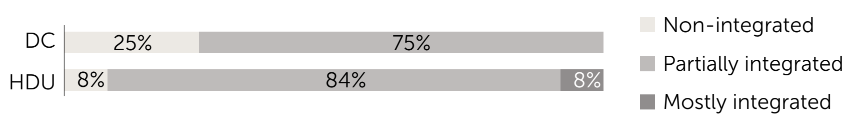
A level of integration, which refers the availability of a BPS tool directly in a design ecosystem, was asked. Within the scope of this survey, four levels of integration were defined: non-integrated, partially integrated, mostly integrated and fully integrated. Non-integrated refers to a BPS use in which all design process and performance simulations are conducted completely in different and separate ecosystems, and there is no file exchange between these two processes. Fully integrated means that all BPS tools used are available in the design tools. Results show that level of integration increased from the Design Challenge to the Building Challenge - HDU, but it was mainly partial.

Regarding the phase at which the teams started using BPS tools, the teams showed different patterns for the Design Challenge; one third started in the early phase, one third in design development and the last third in the advanced design phase. On the other hand, for the Building Challenge – HDU, the teams mostly started to involve BPS in their design workflows at the early design phase. The overall influence of the conducted simulations on the architectural design decisions were considered differently. The teams mainly agreed on that particularly during early design, BPSs were useful for creating design alternatives, raised confidence for decision making and supported creativity.



Level of integration of BPS tools into the digital design ecosystem during the Design Challenge (DC) and the Building Challenge (BC) - HDU
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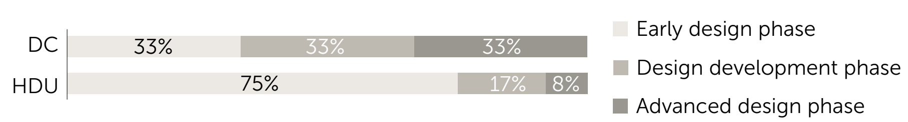

Use of BPS tools in different design phases of the Design Challenge (DC) and Building Challenge (BC) - House Demonstration Unit (HDU)
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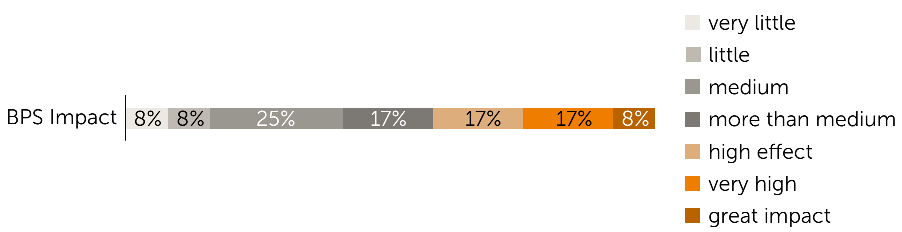

BPS impact on architectural form – related design decisions
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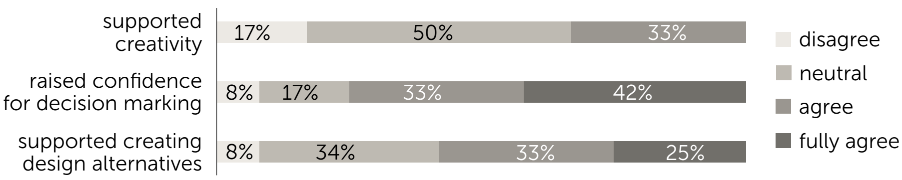
The teams report that only a small amount of the simulation work was done by external experts. For internal works, mostly team members from the field of engineering were more active. Regarding the level of students, it is seen that involvement of students from graduate and undergraduate levels were almost evenly distributed.

Teams asked about the top three features of a BPS tool to be used starting from the early design phase put emphasis on “ease of use”. The next most-voted features are “guidance (e.g., by providing explanations for limit values)” and “comparison of design alternatives”. “Integration with a design tool”, “availability of intelligent design/simulation methods, i.e. parametrisation, automation, optimisation etc.”, and “being suitable for both early and advanced design stages” are voted equally.



Descriptions about the effect of
BPS tools in the early design process
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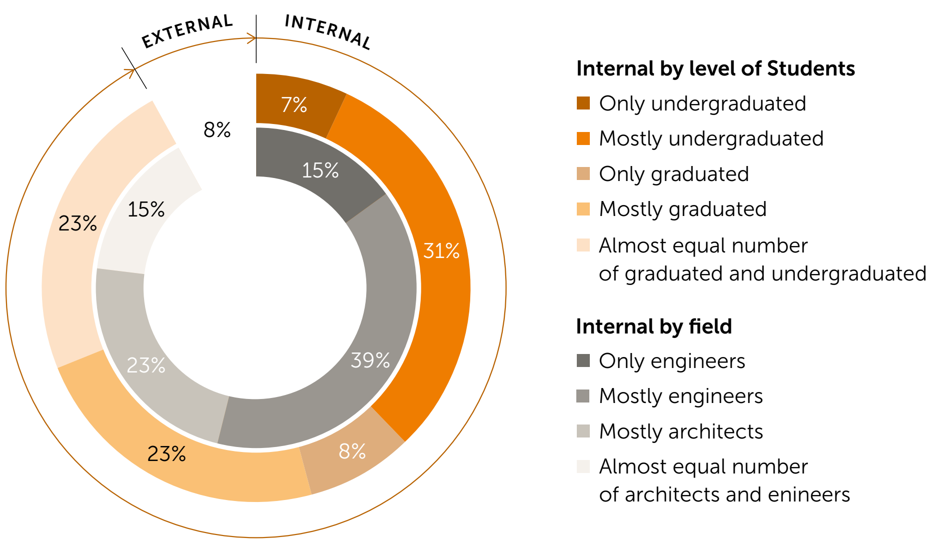

Who conducted BPS?
© SDE 21/22

building information modelling

Anica Meins-Becker, Gamze Hort
(University of Wuppertal)

At the SDE 21/22, all teams were provided with a modelling guide to create digital twins for the house demonstration units.

The building information models created on this basis were regularly checked by the BIM Institute at the University of Wuppertal as part of the deliverables and corrected by the teams if necessary. As a result, 16 architectural models and ten technical building equipment models are available as IFC models, which can be used for future research projects or other applications, for example. They are available on the Internet through the Knowledge Platform (https://building-competition.org/).

The BIM method was used for the first time in the Solar Decathlon Europe 21/22. By specifying a BIM modelling guide, a uniform basis for the creation of building information models was provided for the teams with different BIM skills. This briefly explains the basic principles of model creation and provides the specifications for the model and project structure (such as the number of floors, complying with a naming convention, applying a classification system) and for the geometric as well as informative level (how do rooms and building elements have to be geometrically modelled and what information must be stored for the respective building elements?). For the latter, a catalogue listing the respective building elements and the information to be delivered was provided for both the architectural and technical building equipment models. The teams were free to enrich the building information models with more information, which was used, for example, in the context of the competition.

Finally, eight of the 16 architectural models supplied were rated with the top grade A, seven with B and one with C. Five of the ten technical building equipment models supplied were rated A and the remaining five were rated B. The models only differ minimally in their quality; for example, some elements were modelled on the wrong floor or overlap each other, were assigned to the wrong IFC class or the English language was not chosen for the attribution, so the further use of the models is limited. Overall, the results for the first use of the BIM method during the Solar Decathlon and the certainly demanding planning and implementation of the projects turned out very well.

Main Document:
- → Target Definition and Process
- → Project Structure
- → Components and Models to be Delivered and Classification
- → Naming Convention

Attachments:
- → Requirements Catalogue – Architecture Model
- → Requirements Catalogue – Technical Building Equipment
- → Solibri Ruleset

Provision of a modelling guide for the standardised modelling of the building information models
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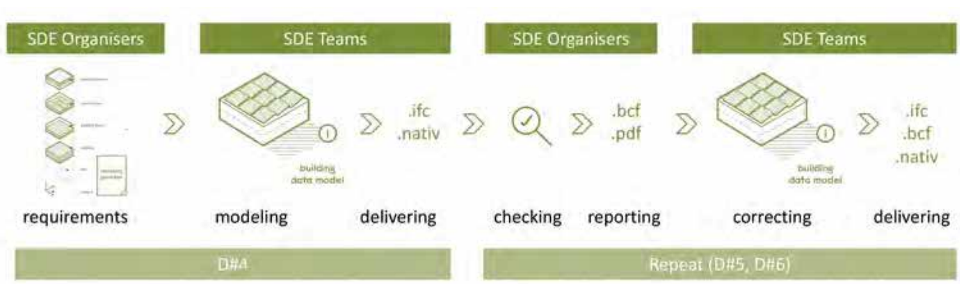

Process for creating, checking and correcting the building information models
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Green BIM Award

The BIM Institute at the University of Wuppertal, together with buildingSMART Deutschland and the Association of German Engineers, also presented the “Green BIM” Out of Competition Award to three teams. On the one hand, the test results of the use of the BIM modelling guide to create BIM models were used as evaluation criteria, since a flawless building information model is the basic prerequisite for any further use of BIM. Another criterion was the inclusion of concepts and content for the application of sustainability goals using the BIM method, such as the improvement of resource efficiency, CO_2 reduction and the reusability of building products.

A questionnaire for the teams was also launched for this purpose: 13 out of 18 teams applied BIM as a method in accordance with the BIM modelling guide other than for creating building information, without being asked to do so in the context of the competition. For example, in the following cases:

→ Determining masses and quantities to order materials,
→ Checking economic viability using cost parameters,
→ Optimising energy efficiency through simulations,
→ Communicating and collaborating on specific models (architecture, building services, outdoor facilities planning) using a coordination model or
→ Using the data for prefabrication.

Furthermore, eight out of 18 teams use the BIM method with a focus on application in the area of sustainability in the context of the Green BIM Award.

A jury selected the three winning teams taking the quality of the building information models into account as well as the application of a Green BIM use case. The three teams from Delft, Eindhoven and Karlsruhe not only provided exemplary building information models, but also saw the building as a future material resource and presented how digital planning can promote ecologically and socially sustainable building methods. They integrated various information into their building information models, such as the results of various simulations to optimise energy consumption, as well as information on materials and their origin, costs and technical specifications in line with a precisely informed digital twin, thus creating an exemplary database for future business management.

The results and discussions with the teams confirm the interest shown in and the acceptance of the implementation of the BIM method during the Solar Decathlon. The teams specifically mentioned the standardised database (single source of truth) for the various project participants and the use of this for different use cases as an advantage of the BIM method. However, the demanding planning and implementation of the SDE projects contributed to the fact that the application of the BIM method was a challenge in terms of time, especially for teams without participants with BIM knowledge.

Presentation of the Green BIM Award to the teams from Delft, Eindhoven and Karlsruhe
© SDE 21/22

building costs

Lubna Sukhni
(University of Wuppertal)

The jury evaluation in terms of Affordability & Viability was performed considering the fit of the teams' project development to the social and economic context of the chosen city, district, neighbourhood and defined group of residents. This covers the design as well as the building challenge. The jury members had to handle the full complexity of this contest and take into account the prepared topical reports, the cost estimation tables and the personal interviews on site. The following section covers the evaluation of the cost tables only.

Exterior and interior of the house of the Team VIRTUe from Eindhoven © Steinprinz / University of Wuppertal

Demonstration Unit Costs

As part of the preparation of the contest documents, each team had to estimate the direct building costs of the demonstration unit using a standardised format by the SDE 21/22 organisers. The direct costs are defined by the total of the building material and the service technology costs without tax. Planning and installation costs are not considered, as these tasks are done by the students or the supporting craftsmen.

The average HDU construction costs, determined based on the estimates from thirteen projects with suitable data, were found to be 360,000 € or 1,600 € per m^3 gross volume. On the one hand, the costs reflect the material and technology intensity along with the material and system selection (absolute costs). On the other hand, the size of the HDU has to be taken into account. Therefore, costs are compared in relation to the HDU gross volume. Cost in relation to the floor area (€/m^2) is no suitable indicator in the SDE, as many of the HDUs offer medium or non-conditioned spaces, typically not accounted as floor area.

A large variety of costs are found ranging from 40 % (Eindhoven) to 240 % (Düsseldorf) of the average. Differences like this were noticeable in the appearance of the demonstration buildings on the Solar Campus. On average, 17 % of the costs spent on the service technology, whereas 83 % were spent on the construction materials. Comparatively the Eindhoven team's project represents the lowest fraction for the service technology costs; the highest investment in terms of building technology was the HDU of the Biberach's team.

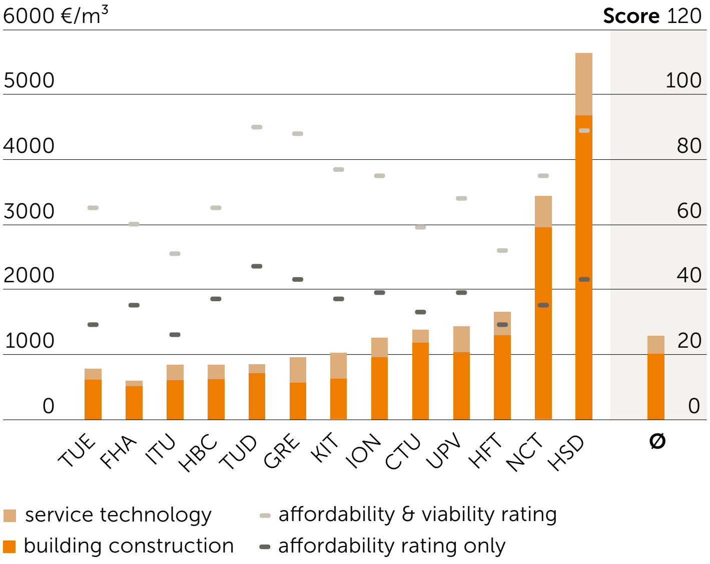
For various reasons, the cost of the demonstration units cannot be simply compared to statistic data from normal houses. In general, costs for building materials and components significantly increased due to the worldwide crises caused by the pandemic and the Ukraine war. The HDUs represent apartments of larger buildings, but due to the circumstances of the competition need extra constructions like the load bearing structure for the grounding, the terrace, the water tanks and much more. Although service technology such as heat pumps or ventilation systems might be centralised for the whole building, for the competition they had to be designed as decentral units. Installations like the PV systems contribute to the investment but also generate income by feeding electricity to the public grid. Nevertheless initial costs are only a single aspect of the total building life cycle costs. The energy costs to run the buildings are low or even negative in the case of a positive annual energy balance and suitable feed in tariffs.

Jury members awarded Delft, Grenoble and Düsseldorf the highest scores in the contest, considering all aspects and material provided. The high ranking of the Delft team in terms of affordability was derived by handling the problem on two levels. These were, firstly, the urban scale; the selection of the targeted building typology, the scalability, visibility and reproducibility. The other level was the building scale; reducing the construction costs through the simplicity of construction and a high level of modularity. Furthermore, the financing concept to make the investment decision appealing for engaging major investors in the sector.

Düsseldorf has landed second place, as they succeeded in convincing the jury with a well-structured analysis of the relevant aspects of affordability and viability and in detailing which measures and operating costs can be reduced through their sustainable design.

Grenoble was awarded third place, targeting a certain typology for reuse (ski resorts) which can be refurbished into a housing structure through minimal intervention; The residual characteristic for both typologies enhances their approach. The revival of a location that is deserted due to the loss of its economic value as a result of climate change, the propagation of inhabitants' social responsibility to sustain the living quality and community cohesion were the main aspects that convinced the jury.

Exterior and interior of the house
of the team MIMO from Düsseldorf
© Steinprinz / University of Wuppertal



Estimated building net material costs
(no tax incl.) per gross volume in €/m³ and
rating of the Affordability & Viability jury
© SDE 21/22

mobility

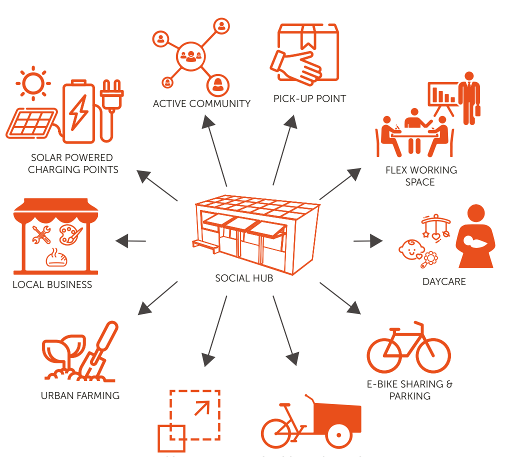
Olivia Spiker
(University of Wuppertal)

With their mobility concepts, the teams have shown how an urban transportation revolution might succeed. These were to be prepared as part of the plans for the overall building. Good options for taking successful action in the urban environment consist of the reduction of private car traffic using restrictive measures (push measures), with the simultaneous improvement of environmentally friendly alternative means of transport or offers (pull measures). This was the task in the area of mobility. The goal was to create sustainable mobility concepts which are customised to the neighbourhood, preferably without privately-owned passenger cars.

All the teams integrated pull measures into their concepts, whereas the design of push measures proved somewhat more hesitant, as this was only done by eleven out of eighteen teams.

One of the most frequently chosen pull measures was the establishment of mobility hubs – bundling points for various mobility options. The team from Eindhoven, for example, created a place in which mobility needs are connected with other daily needs. Their social hubs included e-bike & cargo bike sharing and pick up points, as well as flex working spaces and a childcare facility. With these social hubs, supply structures are decentralised and creates offerings in the neighbourhood for everyday necessities. These, in turn, lead to the avoidance of road traffic or the reduction of journey times.

Team Eindhoven also envisioned various transit stations in order to provide sharing services and strengthen inter-modal transportation.



Social hub Functions

Social hub Conceptual Render

Social hub for the avoidance of traffic
© VIRTUe / SDE 21/22

Shared E-Bike Station

Bus & Cycle

Park & Cycle

Transit stations for strengthening the environmental alliance
© VIRTUe / SDE 21/22

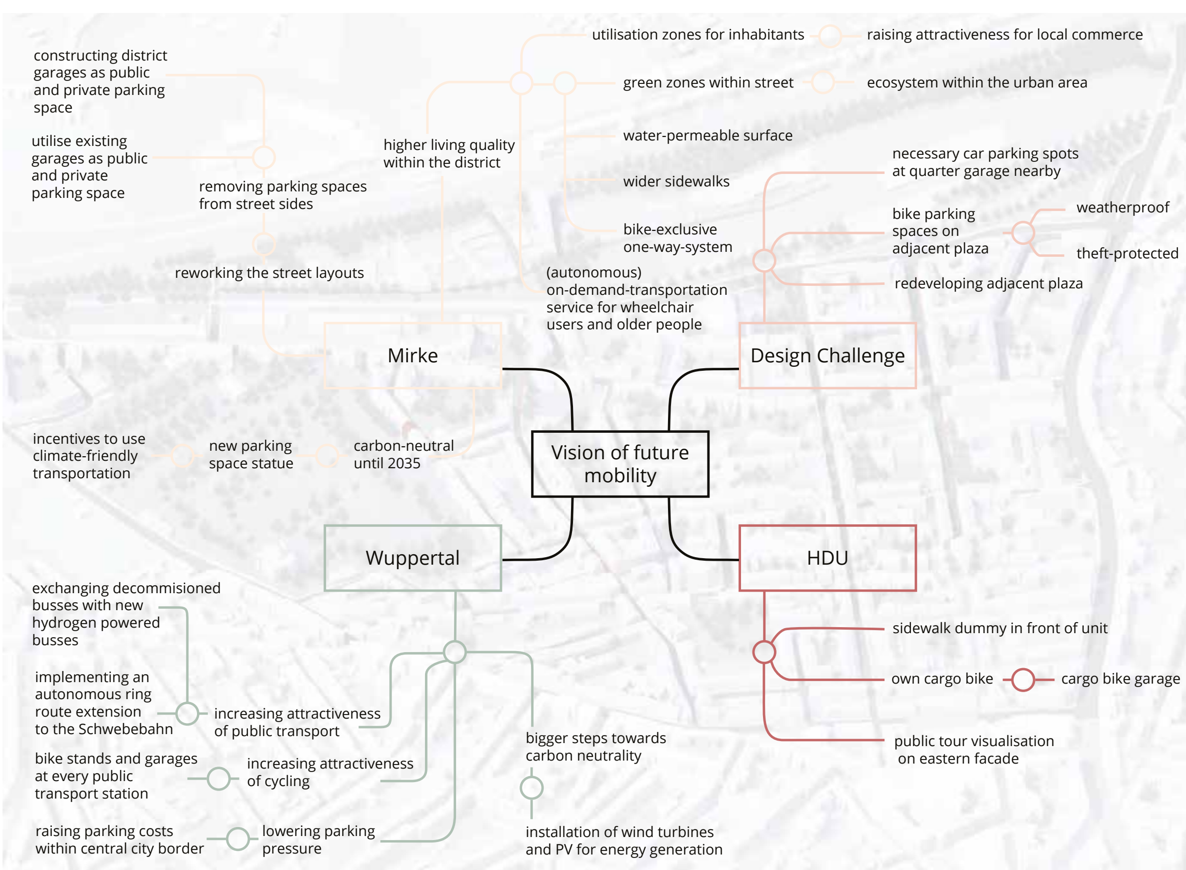
The Grenoble team created a teleworking space in its building so that commuting distances to work can be reduced. The team from Pécs envisioned a 10-minute neighbourhood in which the most important amenities are available directly in the neighbourhood.

The winning team in this discipline, Aachen, impressed with its overall concept.

Essentially, all the concepts include the strengthening of pedestrian and bicycle traffic with individual measures such as bike and car sharing systems, often in connection with an app which coordinates the offer, the improvement of public transport services, bicycle parking facilities or the widening of pavement widths.

The most frequently-chosen push measure includes the removal and/or re-purposing of areas for motorised individual transport into facilities for pedestrian and bicycle traffic. The newly-created space is then used to make the

Residential space instead of parking space
© SUM / SDE 21/22



Mind-map on the mobility vision of the team from Aachen
© LOCAL+ / SDE 21/22

neighbourhoods more liveable. The team from Delft illustrated this by taking the area in front of their overall building as an example.

Ideas that are not state of the art include the integration of a special cable car system (Aachen and Karlsruhe) and changing the streetscape with Art Routes (Eindhoven).

The team from Karlsruhe planned to connect the neighbourhood with the central railway station via a cable car with detachable cabins (upBUS from RWTH Aachen) which can continue to drive around autonomously (within the neighbourhood) as minibuses.

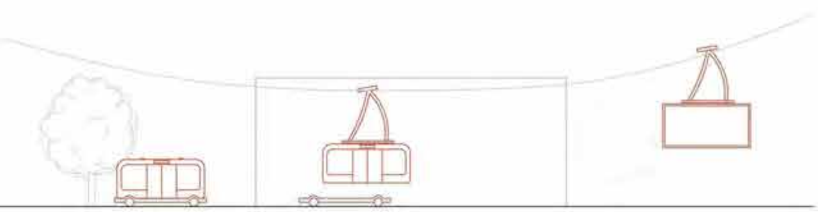
The Eindhoven team brought cheer to pavements with colourful, abstract patterns, creating Art Routes which are available exclusively for pedestrians.

Mobility tasks

The mobility tasks had to be fulfilled during the competition period. The teams were required to run errands as energy-efficiently as possible on a total of nine occasions; fetching crates of mineral water using transport bikes, for example.

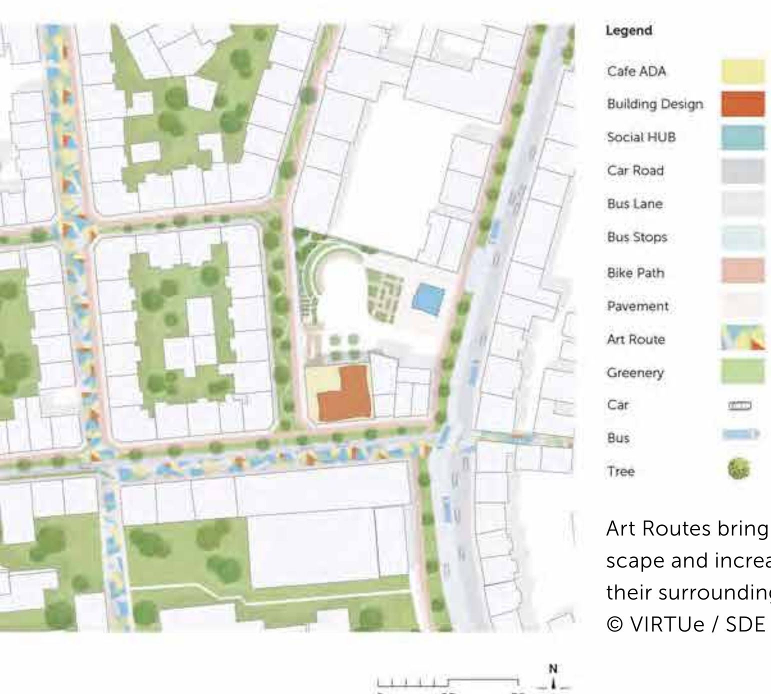
The team from Düsseldorf created a particularly pleasant parking space at their HDU for their rented transport bike. The rented bike was from the local transport bike rental company, and was also available for rent by the public during the competition of the mobility tasks.

All of the tasks were almost fully completed by the teams.



Integration of a cable car with detachable autonomous minibuses
© RoofKIT / SDE 21/22

Protected parking facility for a transport bike at team from Düsseldorf, © SDE 21/22



Art Routes bring cheer to the streetscape and increase the quality of their surroundings for pedestrians
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House Demonstration Unit of the team from Karlsruhe
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Team Portraits

The student team contributions are the heart of every Solar Decathlon. The next chapter gives the space for a detailed presentation of all projects, both the whole-building level and the demonstrator level. The teams themselves authored the sub-chapters.

House Demonstration Unit
of the team from Eindhoven

context, strategies and technologies overview

	BKU Bangkok	**CHA** Gothenburg	**CTU** Prague	**FHA** Aachen	**GRE** Grenoble	**HBC** Biberach	**HFT** Stuttgart	**HSD** Düsseldorf	**ION** Bucharest	**ITU** Istanbul/Lübeck	**KIT** Karlsruhe	**KMU** Bangkok	**NCT** Taipei	**ROS** Rosenheim	**TUD** Delft	**TUE** Eindhoven	**UPH** Pécs	**UPV** València
URBAN SITUATION																		
Renovation & extension					•													
Closing gaps	•			•									•				•	•
Renovation & addition of storey		•	•			•	•	•	•	•	•	•		•	•	•		
Location Wuppertal (Design Challenge)	•			•		•		•	•		•					•		
Other location (Design Challenge)		•	•		•		•			•		•	•	•	•		•	•
Living Lab participant		•	•	•				•					•		•		•	•
ARCHITECTURE (HDU)																		
Common space	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Green roof			•	•		•	•	•					•	•	•	•	•	
Green façade	•		•	•			•	•	•		•		•	•			•	
Passive House building standard	•	•				•			•		•		•	•	•			•
Buffer space					•			•	•		•		•	•			•	•
Solar chimney/ trombe wall							•			•			•				•	•
Passive cooling	•	•		•	•	•	•	•	•	•	•		•	•	•	•	•	•
Advanced thermal mass activation	•			•	•	•		•	•		•			•	•	•		•
Recycled or reused building materials	•	•	•	•	•	•	•	•	•		•		•	•	•	•	•	•
Experimental building materials	•	•	•		•		•	•				•	•	•	•		•	•
SOLAR SYSTEMS (HDU)																		
Additive PV (elevated)			•	•	•	•	•		•		•		•	•	•			
Building integrated PV		•		•		•		•		•		•		•	•	•	•	•
Hybrid solar systems (PVT)	•		•	•	•	•								•		•		
Solar thermal systems		•		•					•	•	•		•			•	•	•
Battery storage	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MECHANICAL INSTALLATIONS (HDU)																		
DHW heat recovery				•		•	•		•		•	•		•	•	•	•	•
Heat pump	•		•	•		•		•		•		•	•	•	•	•		•
Reversible heat pump				•	•	•		•							•			•
Mechanical ventilation		•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•
Ventilation heat recovery	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•
Grey water treatment	•		•						•	•	•			•	•		•	•
Rain Water utilization	•	•	•		•			•	•	•	•			•	•	•	•	•
INNOVATIVE INSTALLATIONS (HDU)																		
Smart controls	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•
Experimental service systems	•	•	•			•		•		•			•	•	•	•	•	•
Recycled service systems		•												•				

House Demonstration Unit
of the team from Bucharest
© Steinprinz / University of Wuppertal

TEAM NAME | TEAM IDENTITY

AuRA | GRE

UNIVERSITY

grenoble school of architecture grenoble, france

TASK

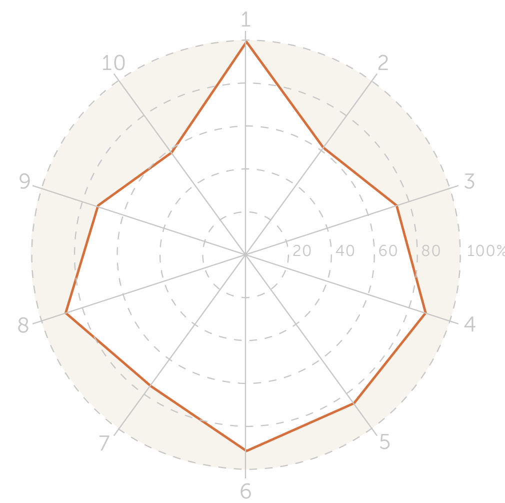
renovation & extension

LOCATION OF DC

château-bernard

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
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our vision

	2553 m²	64 m²
	5	1
		28 m²/p

The greatest challenge of the 21st century will be sustainable development with room for all forms of life. Objective indicators keep revealing an advanced and growing state of degradation of the planet, the effects of which must be limited.

Our team has decided to take up this challenge by proposing a project in the Vercors region in the French Alps. The project opens up a vision for the region of belief in our collective capacity to change the course of events.

What are the alternatives to metropolises and megacities? We believe that there is a real balance to be established between overpopulated urban areas and less densely populated areas in France. A better balance would increase the whole country's resilience in the face of energy, health, and climate stresses which are set to increase in number and intensity in the coming decades.

Rather than the densification of the city, distributed urbanism is the best way forward.

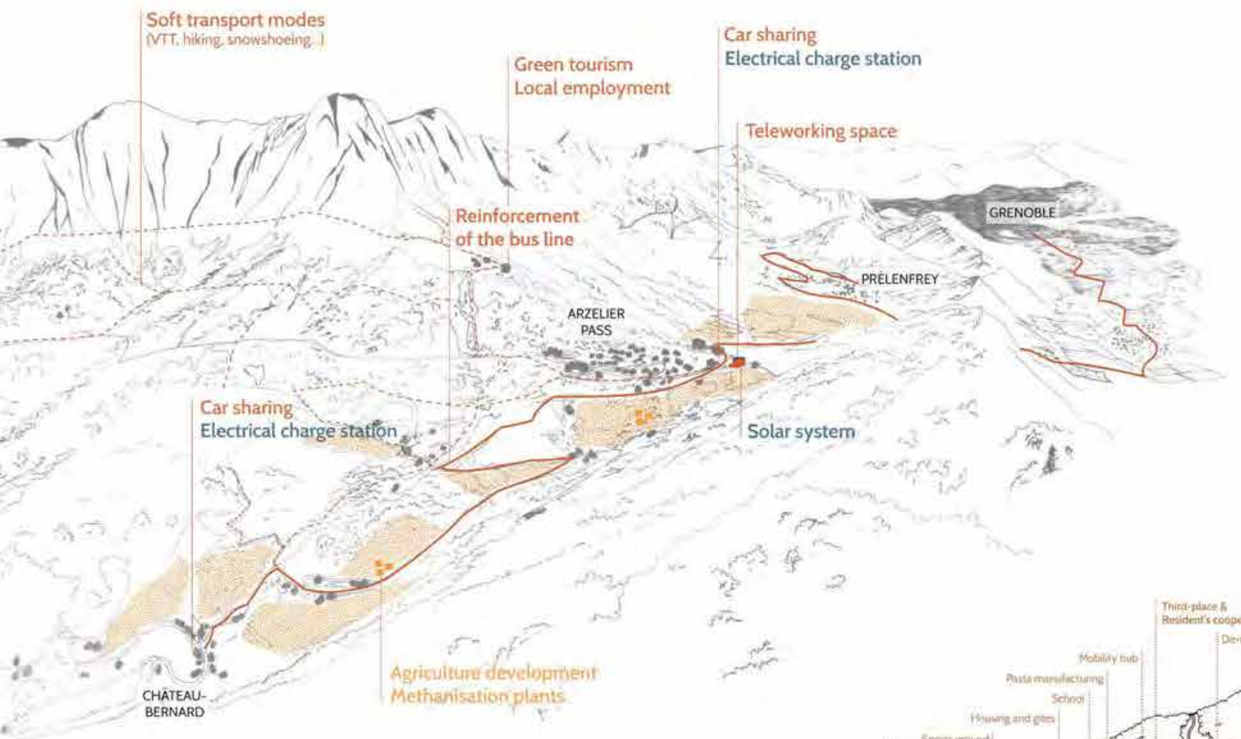
We have set out to create a community project that can serve as a lever for resilience. Our project proposes to accompany the transformation of the tourist model of a former ski resort by launching a raft of action projects taking their cue from the rehabilitation of existing buildings. These relate to:

- The new tourism of mid-mountain, and the seasonal habitat;
- Care and health as levers of social and economic development;
- Education and leisure facilities;
- Food resilience based on a sustainable agricultural system;
- The transformation of existing buildings into permanent housing.

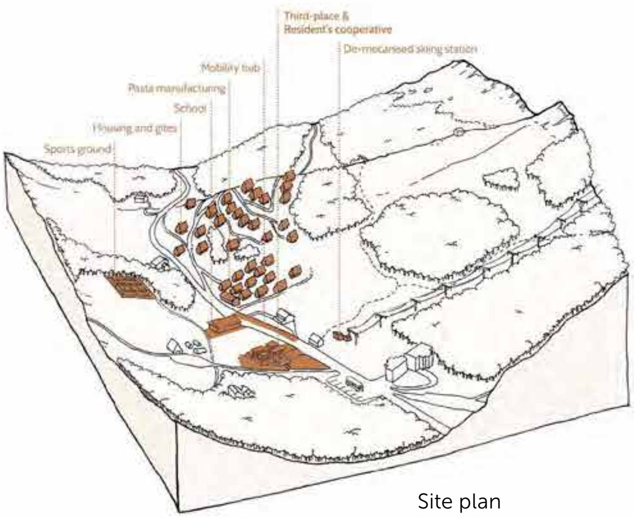
The project brings together the ambitions of our team, incorporating architecture, urbanism and landscape in its concerns. Through collaboration with local protagonists, the project seeks to attract new populations and activities to the area.

urban context and mobility

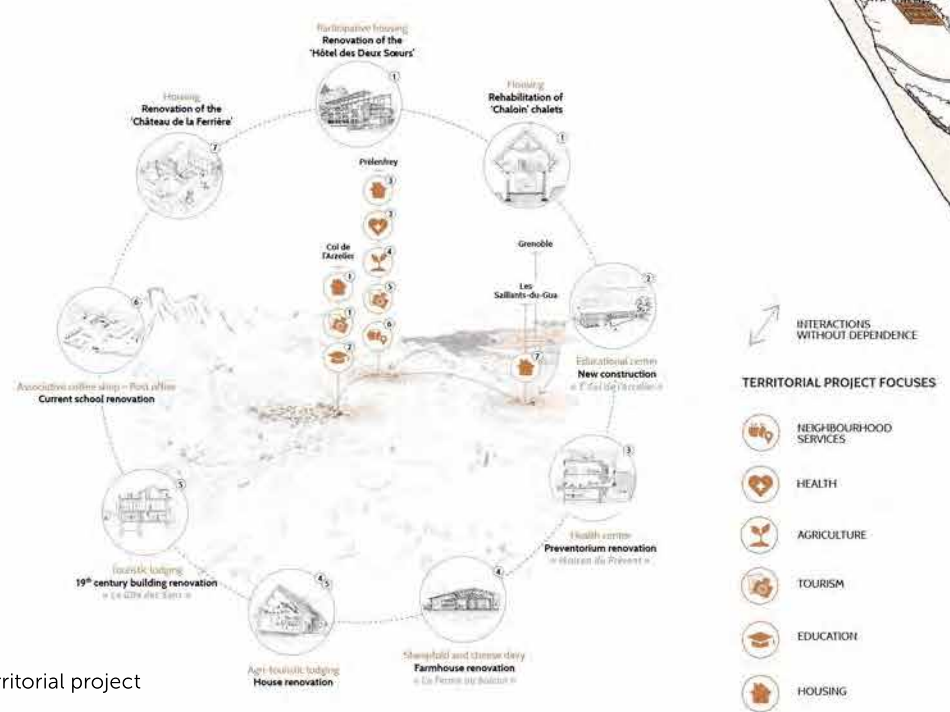
Perched at an altitude of 1,154m, the site is marked by verticality and mountain weather conditions which are an obstacle to active mobility. It is aimed at promoting sustainable mobility in this relatively sparsely populated area.



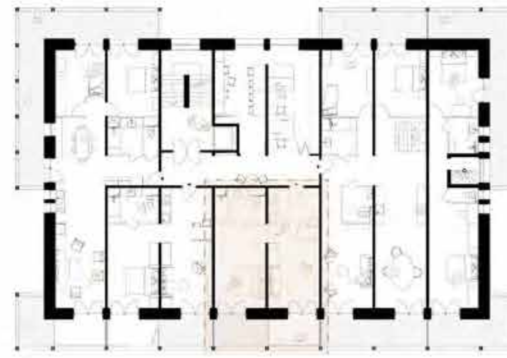
Mobility plan



Site plan



Territorial project

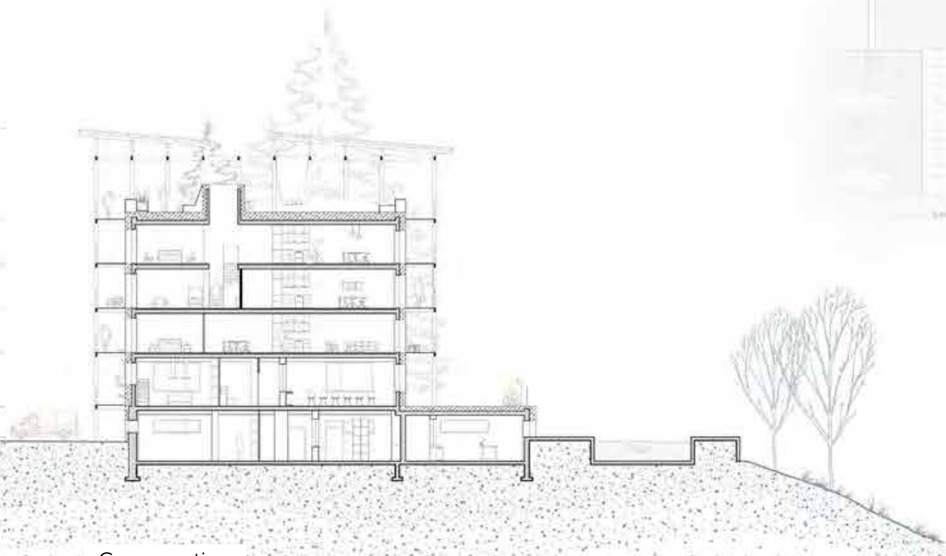


Floor plan

design challenge (dc) overview

Dialogue with the landscape and the region: the space on the roof affords an incredible view of the surrounding landscape. The design of the roof was conceived as a dialogue with the environment.

Groundfloor plan



Cross section

South elevation

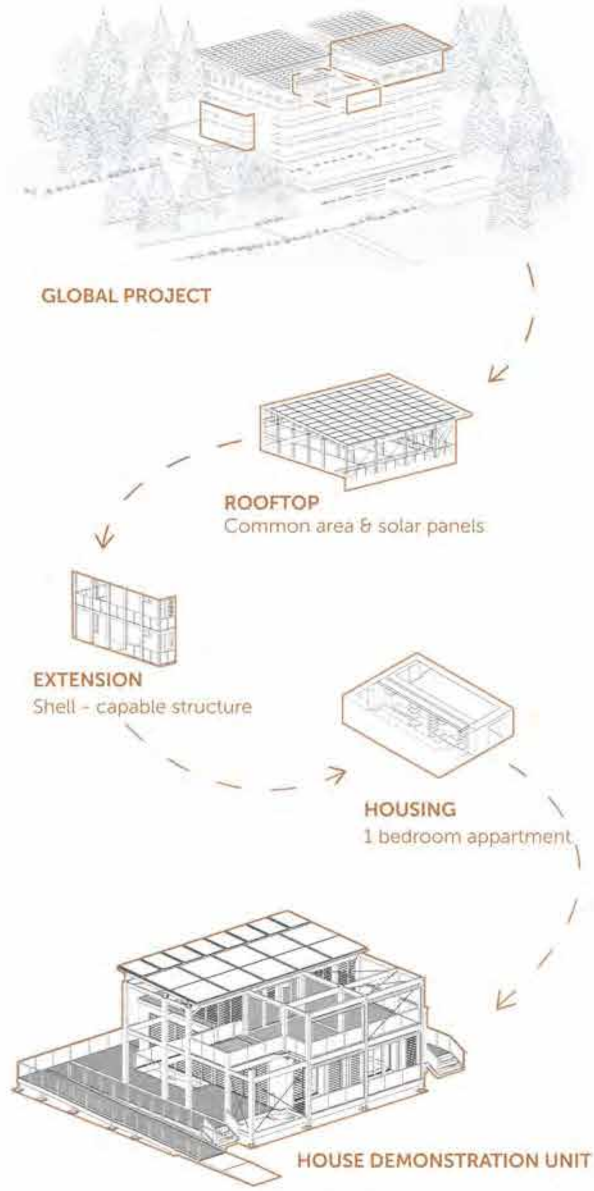
house demonstration unit

The architectural and bioclimatic tool of Grid, Skin, Shell

The Grid, the building services network, is inserted into the existing gridded structure, making it easier to anticipate changes and facilitating maintenance.

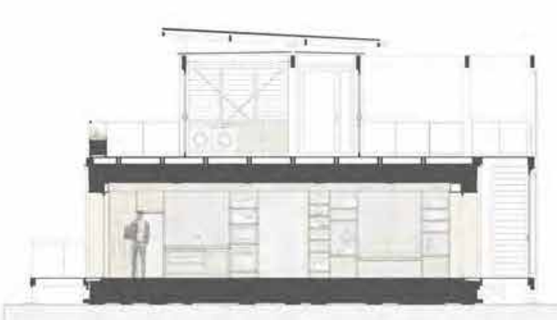
According to local construction traditions, the Skin, the thermal envelope added to the building, is made of straw insulation.

The Shell is a wooden extension to the building that can support new uses and protect and capture solar gain.

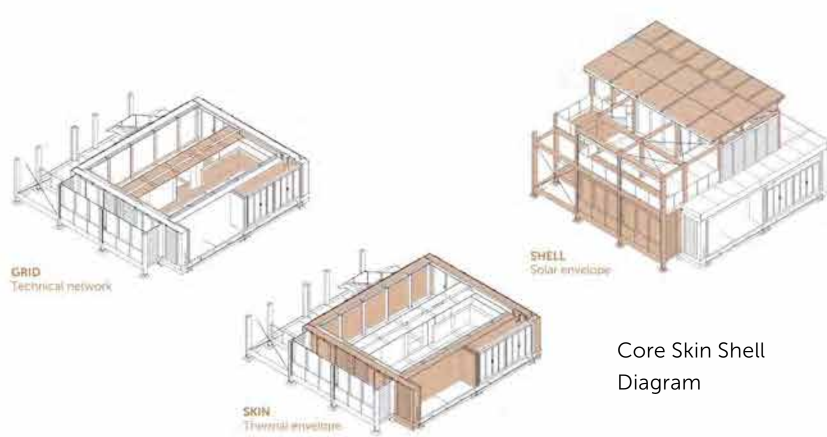


Transformation of the Design Challenge into House Demonstration Unit

Ground floor plan



Section AA



Core Skin Shell Diagram

key figures, team and sponsors

Further project information:
https://team-aura.org/

Sponsors

La Région Auvergne-Rhône-Alpes
Caisse des Dépôts Groupe Mécénat
Ministère de la Culture
République Française
Agence National de la Cohésion des Territoires
République Française - Agence de la Transition Écologique
Préfet de la Région Auvergne-Rhône-Alpes
Isère le Départment
Spurgin Leonhart
Banque Populaire
cea
ines.2S Solutions Solaires
zehnder
legrand
Blanc Menuiserie
Bouygues Construction
Simpson Strong-Tie
Ducerf Groupe
Allplan
somfy
pro clima
Griesser
Serge Ferrari
Stäubli
VMZINC
Ferco
Dimos
Jacob Delafon Paris
MGI Habitat Innovant
eDF
Alpex
AKTerre
diamond
Enphase
Faro
Vissmann
Ecomat38
Blanchon
Piveteaubois
icoba ingénierie conseil bâtiment
Dualsun
Saint-Gobain
Imagineer
oventrop
Vicat
Swiss Krono
certisolis
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Steico
TF
Wpd
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FC photo
Labaronne citaf
GL events
K2 systems
HPNT Systems
Caeli Energie
CPG Construction Products Group Europe
douze cycles
SFS
Alsafix
Cluster montagne
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habitat & humanisme
UR c|a.u.e Auvergne-Rhône-Alpes
Enerplan Syndicat des professionnels de l’energie solaire
ville aménagement durable
L’union sociale pour l’habitat
France Féderation Promoteurs Immobiliers
Plan bâtiment durable
Centrales Villageoises du Trièves
Federation Française du Bâtiment
CSTB
A tout France
Agence Qualité Construction

TEAM NAME | TEAM IDENTITY

X4S | HBC

UNIVERSITY

biberach university of applied sciences biberach, germany

TASK

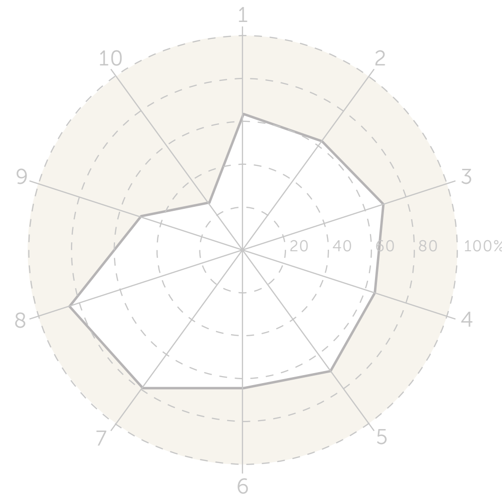
renovation and addition of storey

LOCATION OF DC

wuppertal

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

area	2004 m²	60 m²
floors	6	1
per person		30 m²/p

We are creating solutions for climate change in the urban context. We have to rethink our view on cities and change the built environment in order to achieve greater sustainability and address social and economic demands at the same time. This is where the extension of cafe Ada acts an example for a transferable approach.

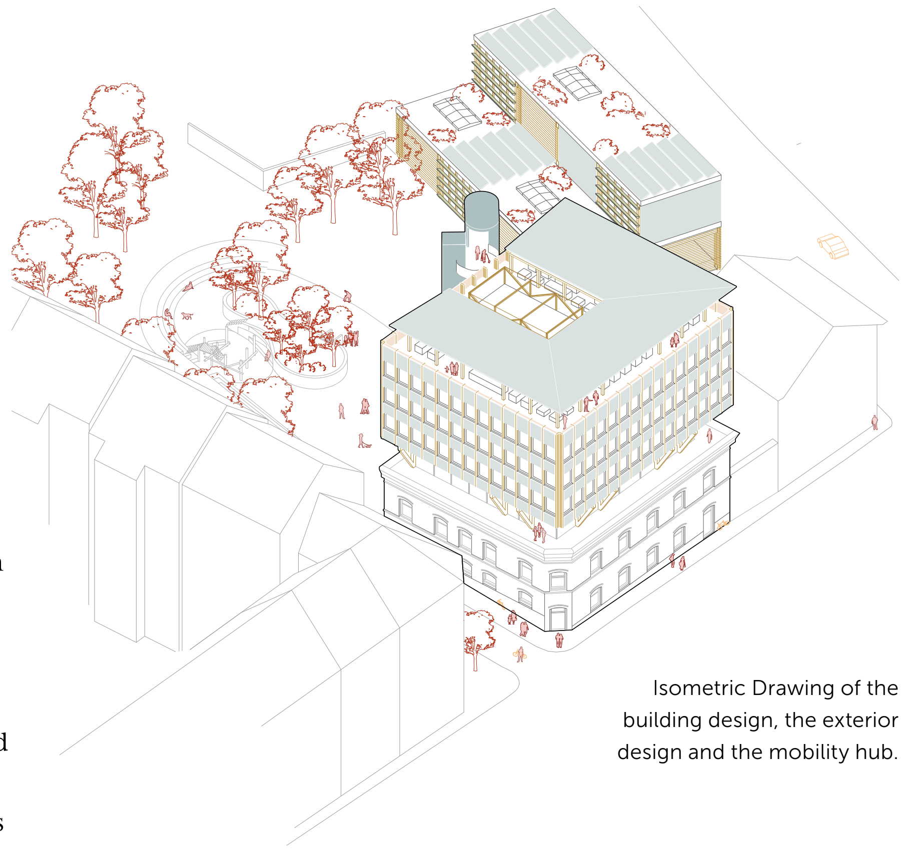
Densification solves urban issues like excessive land use, increased traffic due to spread-out cities or social isolation. With floor plans of different sizes, the building provides living space for the growing demand for one or two-person households as well as for families of up to four people. For this concept it is essential to reduce the floor area per person and to offer communal areas for flexible use.

Cost-effective constructions that can be built quickly are achieved by solid timber elements. A great share of prefabrication, minimal loads and separable components are some of the advantages of this construction.
The engineering and construction concepts are aligned along the principle of reducing heat losses by a highly insulated building envelope which is optimised for solar passive gains. This approach is combined with the active use of solar energy on the façade and roof to produce heat and electricity.

To make sustainability affordable, we make use of existing efficient technologies integrated into a highly efficient and resilient system design. Then the components of the system are used multifunctionally wherever possible.

Our sustainability concept is based on sufficiency, efficiency, consistency and resilience. These ideas are pursued in the three sub-areas of Architecture, Energy and Construction.

urban context and mobility



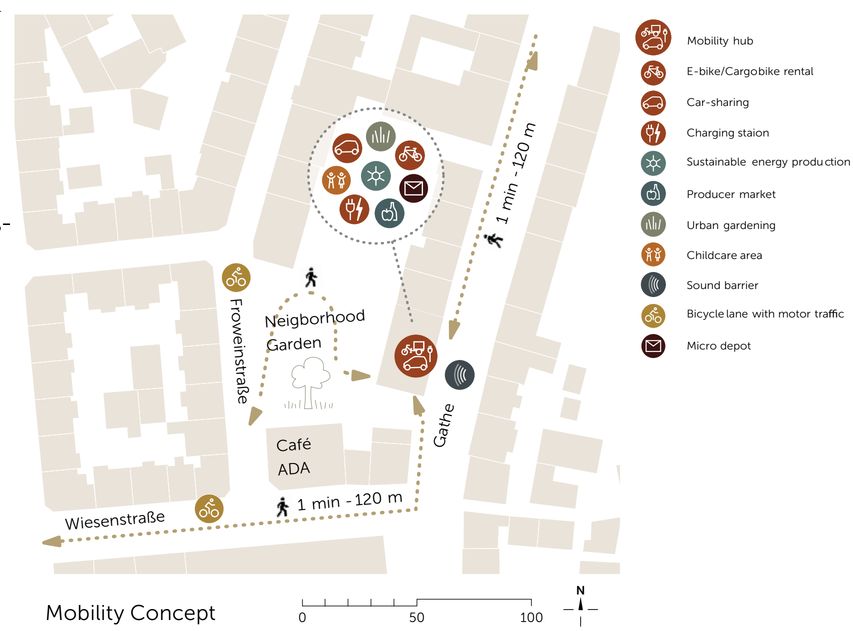
Isometric Drawing of the building design, the exterior design and the mobility hub.

Café Ada and its extension are part of the Mirke district. The height of the building is adapted and the architectural expression from the surrounding buildings is used to integrate the extension into the neighbourhood.

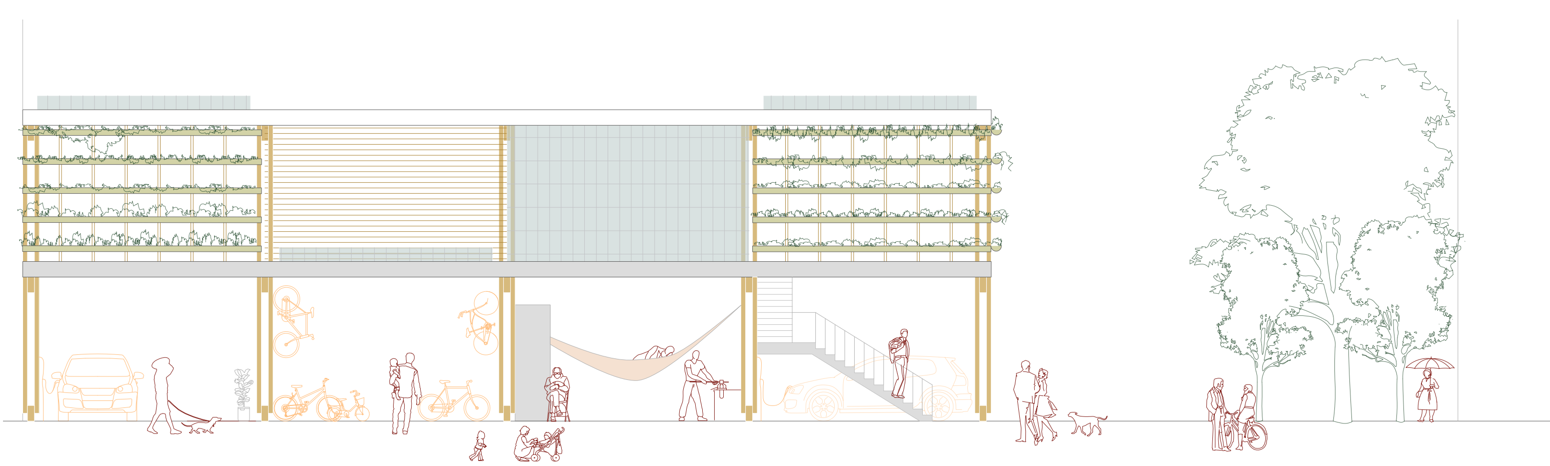
Communal exterior spaces such as an urban gardening area, a playground area for kids and outdoor seating in the form of stairs and a terrace for Cafe Ada are offered. With green areas and a micro forest, a pleasant atmosphere for all residents and neighbours is created and social togetherness is strengthened.

In terms of mobility, the building is integrated into the existing mobility structure and influences the urban transportation network in a positive way. Private parking spaces are minimised and combined with mobility alternatives in the mobility hub. A small DIY workshop, a garage, a bike rental service and a car sharing system are available.

Streets become shared space for individual traffic and public transport. Buses, cars, bikes and pedestrians are treated equally and the speed limit is reduced.



Mobility Concept



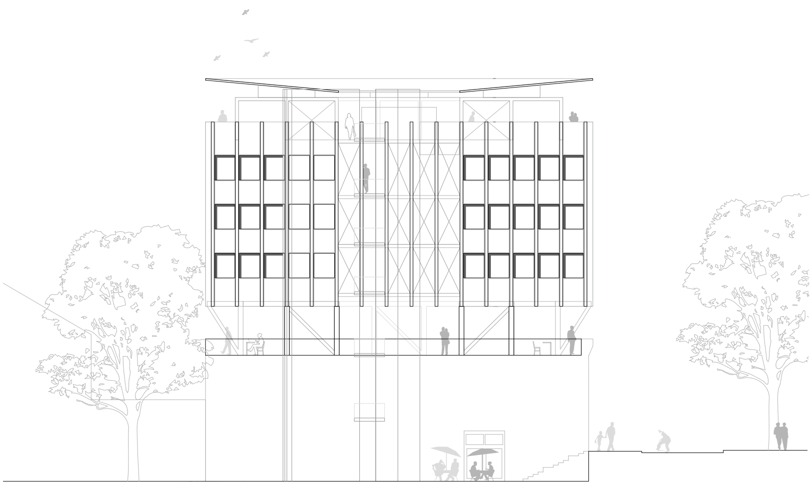
design challenge (dc) overview

To preserve the district's character, the existing building with its brick façades will stay discernible. While the north façade of the extension is completely transparent to enable further communication between the interior and exterior, the other façades are more introverted to create privacy in the living areas.

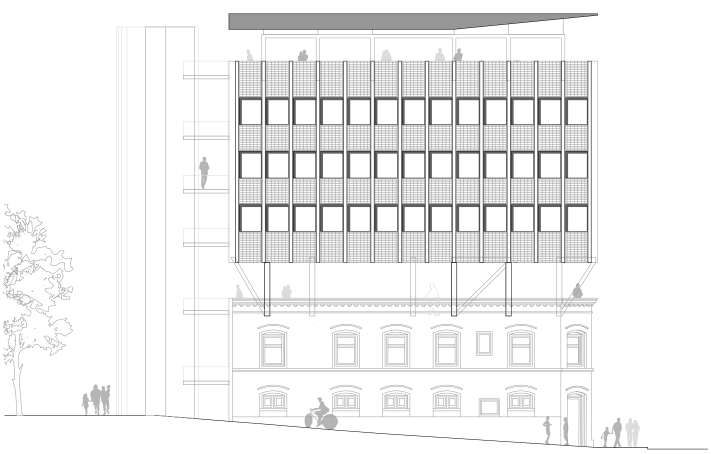
An exterior stairway and an elevator lead up to access the individual stories in a barrier-free way. They are connected by an atrium that expands up to the roof. It extends the living space and is designed to supply a certain degree of privacy while also giving the residents the opportunity to interact with each other.

The apartments are located along a servant layer that includes the bathrooms, kitchens and technical areas. The servant layer then opens up to the living spaces, which feel light and spacious.

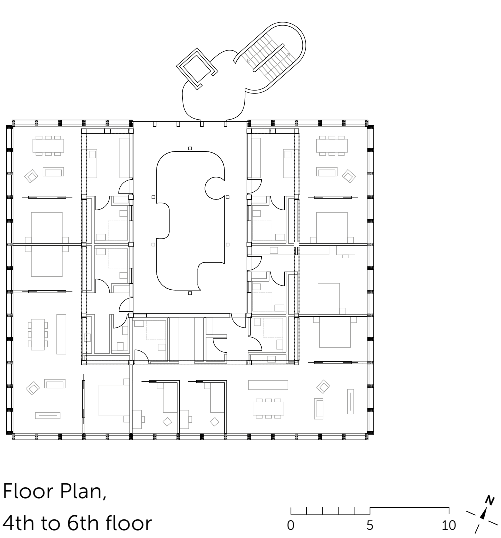
The floor plan and the façade are based on a grid and give the opportunity to use the floor plan very effectively and in variable ways.



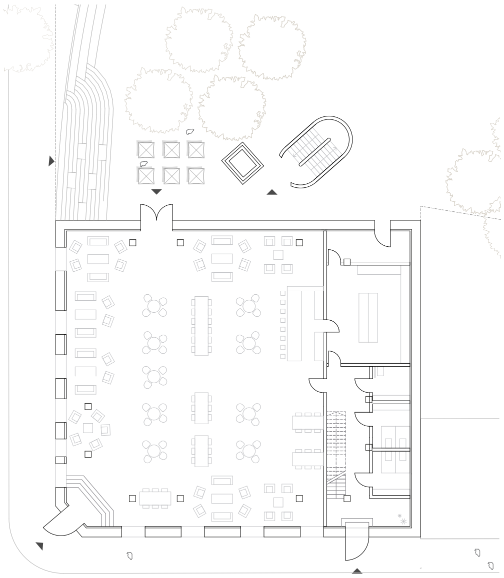
Elevation North



Elevation West



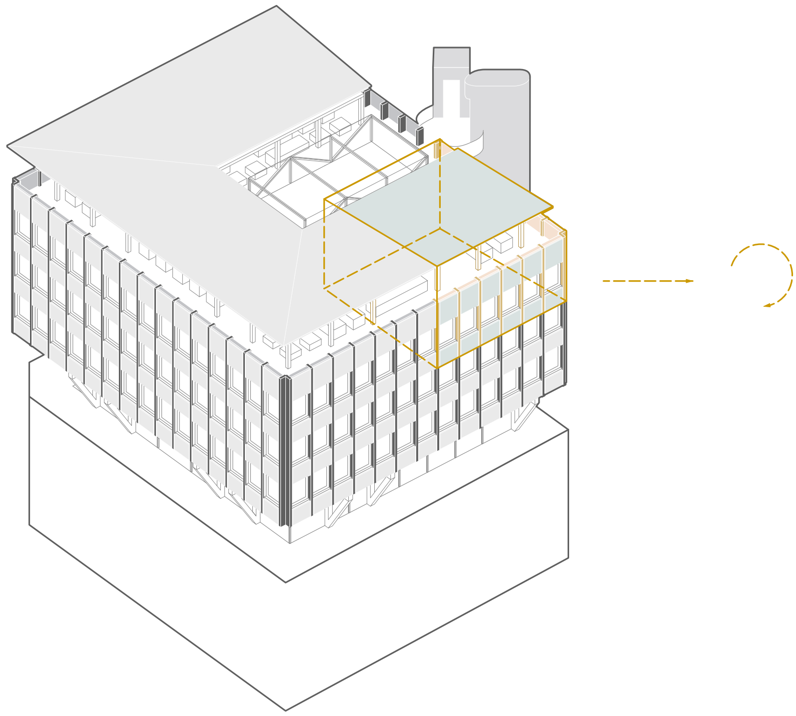
Floor Plan,
4th to 6th floor

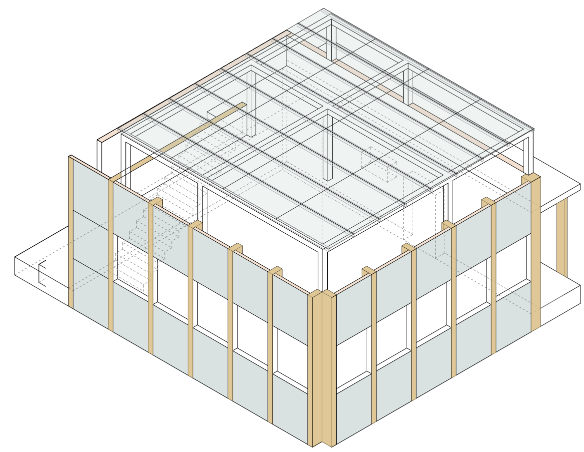


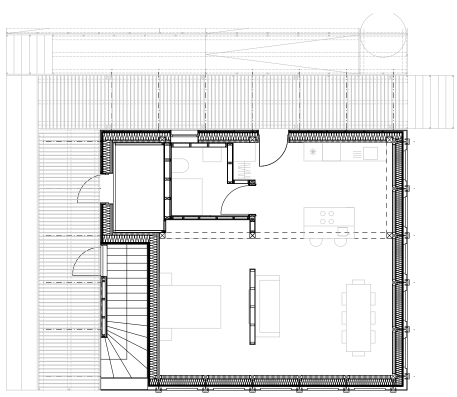
Floor Plan, Ground Floor

house demonstration unit (hdu) overview

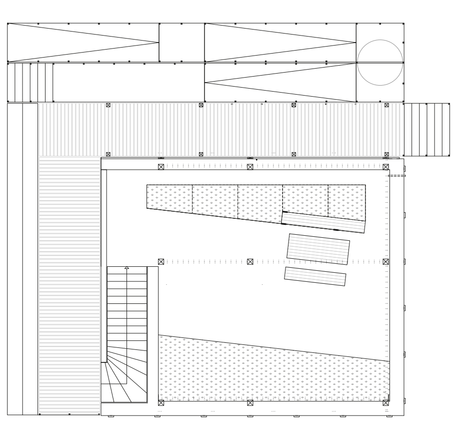
The House Demonstration Unit represents our building design and is extracted as a two room apartment from the top floor. In addition, the entrance situation and the roof garden are representatively displayed.







Floor plan ground floor



Floor plan roof garden

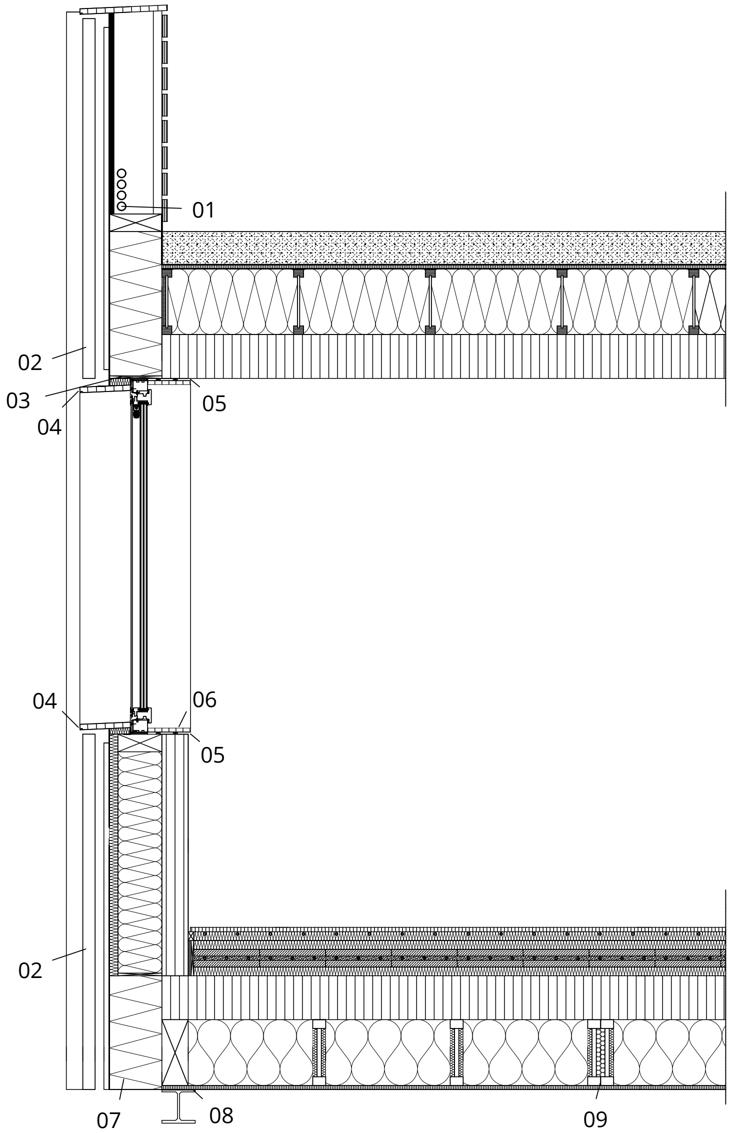
Like the extension to Café Ada, the unit is structured by layers. The servant layer includes the kitchen, the bathroom, the entrance area and the technical areas.

The servant layer is complemented by the open living area, including the living space and the bedroom. Its spacious and light-flooded interiors create a pleasant atmosphere.

In addition to the transparent solar panels on the roof, PVT panels are integrated into the eastern and southern façade. The western façade is painted black to display that the building design originally continued in this direction. Remaining wall surfaces are covered by wooden panels.

The rooftop garden is used for urban gardening and energy creation to supply the whole building with food produce and energy.

house demonstration unit (hdu) details



For the construction, mainly renewable materials or materials that can be almost completely recycled are used. First, the level of circularity and the carbon footprint are identified for each building component. The layers of the component structures are then joined together in such a way that they can be later separated by type, deconstructed and reused or recycled.

This concept allows the building to become a long-term urban mine for the future and takes into account the earth‘s finite natural resources.

01 - Pipes for PVT Collectors
02 - PVT Collectors
03 - Termination Board
04 - Outer Embrasure
05 - Shadow Gap
06 - Inner Embrasure
07 - Board Insulation from soft Fiberboard
08 - Damp proof Courses
09 - Element Join

Ceiling Structure 67,2cm

- extensive greening 15cm
- drainage layer
- damp proof courses
- elka strong board 2,2cm
- sarking membrane
- cellulose insulation 30cm
- web girder 30cm
- prestressed dowel wood 20cm

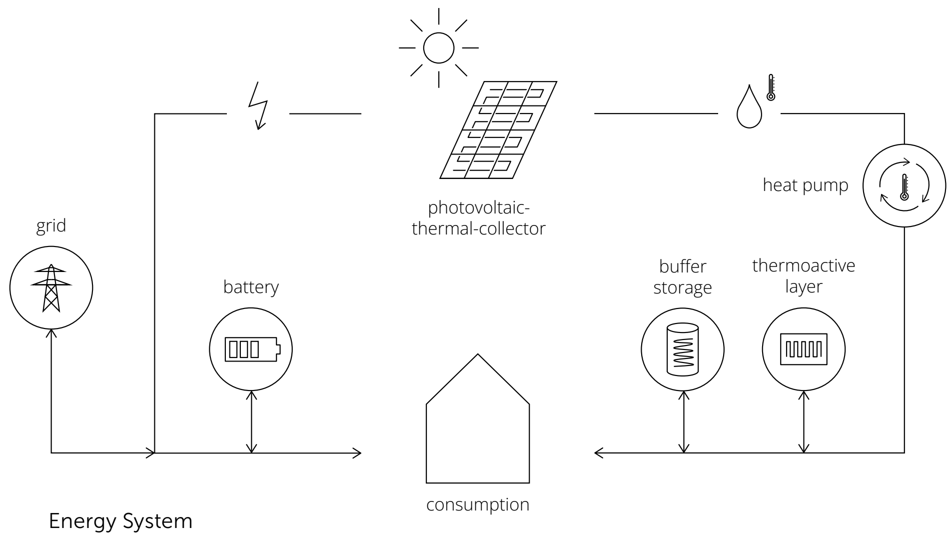
Wall Structure 48cm

- prestressed dowel wooden wall 12cm
- cellulose insulation 20cm
- ladder rack 20cm
- soft fiberboard 4cm
- sarking membrane
- battens 2,4cm x 4,8cm
- air 4cm
- PVT collectors 5,6cm

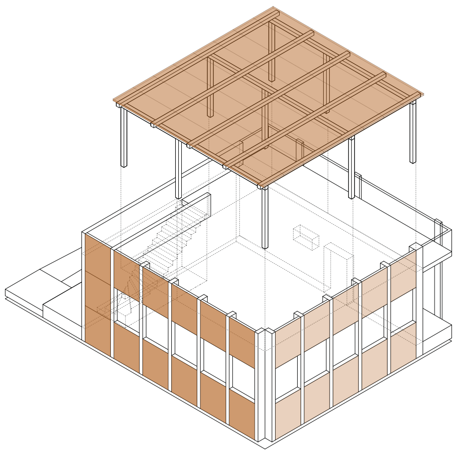
Floor Structure 68,2cm

- plank floor 2cm
- soft fiberboard with floor heating 4cm
- soft fiberboard 4cm
- recycled concrete panels 3cm
- pipes in sand 2cm
- recycled concrete panels 3cm
- soft fiberboard 4cm
- prestressed dowel wood 20cm
- cellulose insulation 30cm
- ladder rack 30cm
- oriented strand board (OSB) 2,2cm
- sarking membrane

solar system



Energy System



Solar Energy Gaining

The rooftop terrace, shielded by the solar wings can be used for urban gardening by the residents and social gatherings.
© Steinprinz / University of Wuppertal

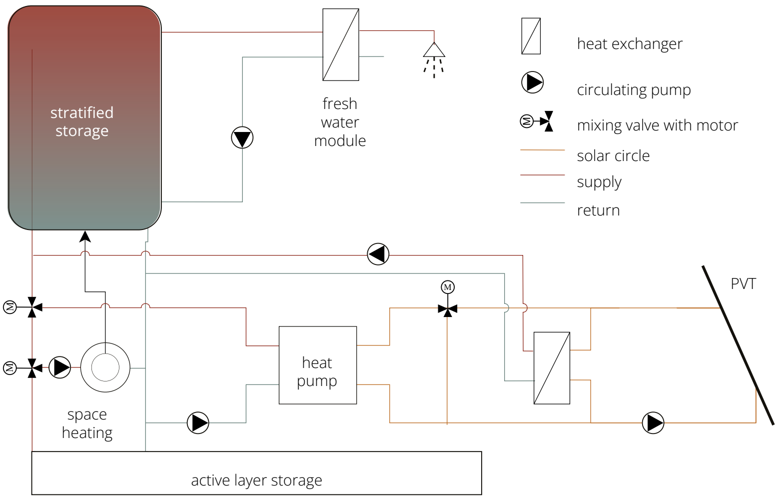
Te solar system uses semi-transparent PV modules on the roof. These are newly developed tubular thin-film PV modules. The solar yield is more even and higher in the daily sum due to the more favourable angle of irradiation. In addition, vertically installed uncovered PVT collectors are used on the facade. The collectors serve as a heat source for a power-controlled heat pump. The power control is used to adapt the operation to the electrical and thermal solar yield. This improves the COP of the system, especially during the heating season. We decide for a solar facade because it scales with the number of storeys while the area of a roof remains constant.

Two thermal storages help to realise this efficient mode of operation and decoupling the heat demand from the solar yield: A buffer storage tank with two thermal zones stores heat for surface and hot water preparation. The bigger one uses the thermal mass of the impact sound insulation and therefore grows with the living space of the building.

The electrical system uses a battery constructed from common Li-ion cells as storage. The modular concept of the battery allows the use of second-life cells and the exchange of individual cells. The electrical system itself is carried out as a hybrid AC/DC-System to run battery inverter at its best efficiency.

energy supply

Schematic diagram of the combined system for heating and domestic hot water.



Prototyping the AC/DC hybrid electrical system with french cleats.

Building Envelope

The highly thermally insulated building envelope, efficient technology and energy-saving household appliances and lighting minimise the energy used by the building and its residents. At the same time, the façade and roof are optimised for active solar gains and used to generate heat and electricity from solar energy. Through the energetic renovation of the existing building and the associated reduction of the system temperatures, a joint energy supply of the existing building and the extension can be realised.

Solar Energy Gaining

Uncovered PVT modules are used in the east, west and south façades as well as on the roof of the Unit. The concept combines a newly developed buffer storage with the use of a thermoactive layer which thus provide large storage capacities.

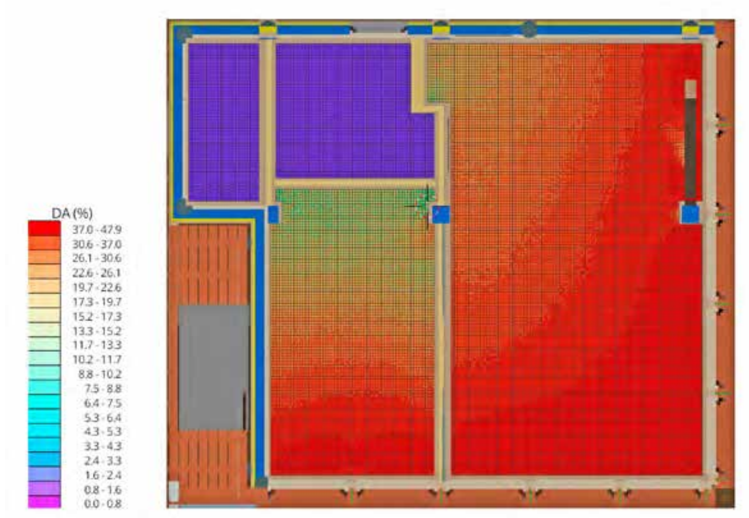
Heating

The large storage capacities are used to operate the heat pump, preferably when PVT collectors are heated by solar radiation and the energetic consumption of the heat pump can be covered by the photovoltaic energy. The operation of the entire building services is managed by an intelligent building management system and adapted to the needs of the users. The low system temperatures due to the minimised heating energy consumption and the use of decentralised fresh water stations serve as a basis for increasing the solar thermal yield and increasing the coefficient of performance of the heat pump.

Electrical System

The electrical power supply relies on a hybrid AC/DC system. Low-power consumers such as lighting, computers or consumer electronics are supplied with direct current. This significantly increases the degree of utilisation of the system consisting of photovoltaics and battery.

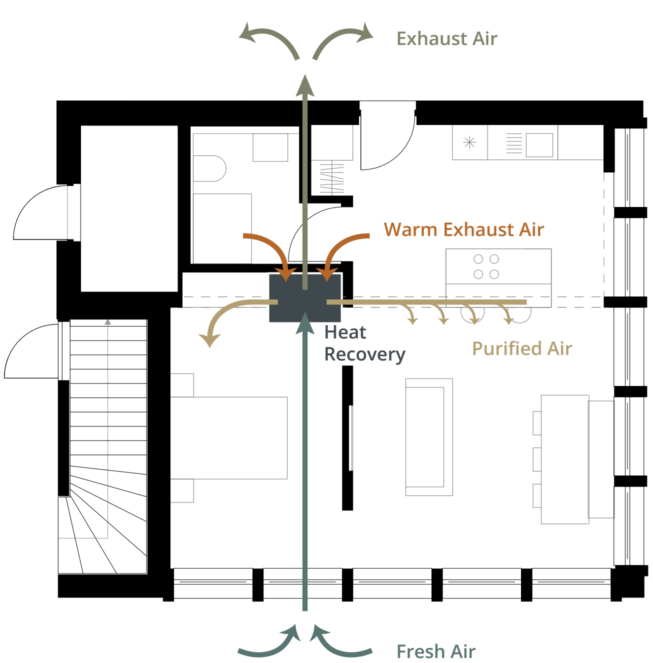
indoor climate dc and hdu



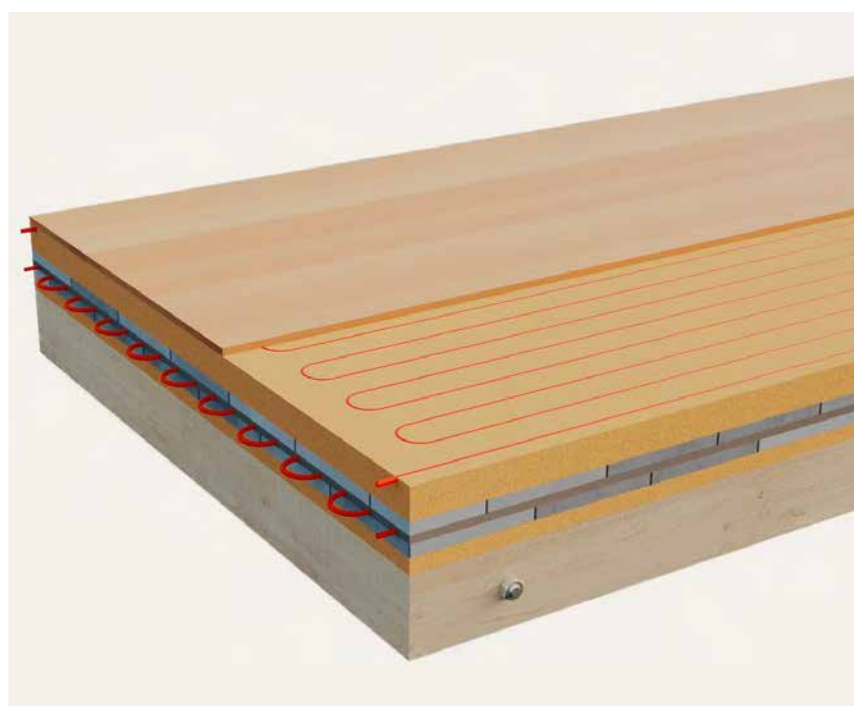
Simulation of Daylight Autonomy (DA) for the HDU.

Indoor Climate

Due to our resilient building and high requirements on the quality of the building envelope in terms of insulation, air tightness and us of passive solar energy along with an highly effective shading system, the indoor climate is very balanced throughout the year. Together with the silent, humidity and CO_2-controlled ventilation system with heat recovery the building envelope provides high thermal comfort. The size and position of the windows are designed with respect to daylighting. The unheated atrium which provides the common access to the different dwellings serves as a buffer zone. The north-oriented transparent face of the atrium and a shading system integrated into the roof prevents from over-heating during summer time.



The ventilation system with heat recovery provides fresh air for the occupants and lowers the heating demand.



Thermal comfort is realized through active heating and passive cooling within the different layers of the flooring.

key figures, team and sponsors

We would like to thank our sponsors for their support and cooperation. Special thanks to Biberach University of Applied Sciences for allowing us to take part in the competition and to the Carpentry Training Centre Biberach for providing us with the best master carpenters in the world.

Further project information:
https://team-x4s.de/

Public sector
Federal Ministry for Economic Affairs and Climate Action
Ministerium für Ernährung, Ländlichen Raum und Verbraucherschutz Baden-Württemberg

Package L
Geberit AG
Hochtief AG
Tubesolar AG

Package M
Alwitra GmbH
GUTEX Holzfaserplattenwerk H. Henselmann GmbH & Co. KG
Technische Alternative RT GmbH
Paul Bauder GmbH & Co. KG
Bucher KG
Consolar Solare Energiesysteme Gmbh
Enerquinn GmbH
E.u.r.o.Tec GmbH
Grundfos GmbH
Holzbau Bildungszentrum
Joulia SA
Lignotrend Produktions GmbH
Maico Elektroapparate-Fabrik GmbH
Mühlschlegel Holzhandelsgesellschaft mbH & Co. KG
OBI Markt Biberach
MOLL bauökologische Produkte GmbH
Rapunzel Naturkost
Serge Ferrari AG
STEICO SE
Waterkotte GmbH
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Package S
Leviat GmbH
Thermisto GmbH
Akademie der Hochschule Biberach
bau-technik-barth
BayWa Agrar Biberach
best wood SCHNEIDER GmbH
BIOFA Naturprodukte W. Hahn GmbH
elka-Holzwerke GmbH
Fahrradprofis
Grüner und Mühlschlegel Bauunternehmen GmbH & Co. KG
Grohe AG
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Ingenieurbüro Mencke & Tegtmeyer GmbH
KSV Natursteinwelt
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Biberacher Ernährungsakademie B-EA
Graphisoft Center Süd
Mafell AG
Sinfiro GmbH & Co. KG
Verfasste Studierendenschaft
Zimmerei Merten

TEAM NAME | TEAM IDENTITY
MIMO | HSD

UNIVERSITY
düsseldorf university of applied sciences düsseldorf, germany

TASK
renovation and addition of storey

LOCATION OF DC
wuppertal

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
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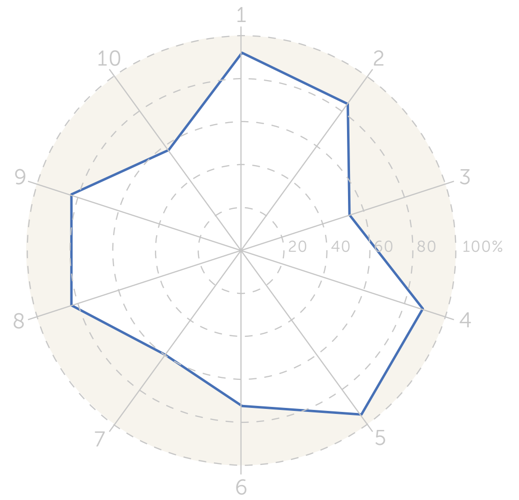
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Marvin Hillebrand, MIMO / SDE 21/22

our vision

	2268 m²	115 m²
	6	1
		21 m²/p

Our vision

MIMO is an interdisciplinary team drawn from all seven faculties of Hochschule Düsseldorf (HSD) University of Applied Sciences, which has developed a concept for resource-efficient urban redensification. Guided by the principle of "Minimum Impact Maximum Output" (MIMO), the usage concept, including the living space and the technical approaches, focuses on generating local value added by achieving maximum benefit at the cost of minimum interference. The task addressed by Team MIMO is the renovation and addition of a storey to a warehouse dating from 1905 in Wuppertal's Mirke district, which is used by Café Ada and its dance centre. The renovation is hallmarked by cautious interventions and preservation of the external appearance, as well as functional improvements and energy optimisation. In addition to architectural and technical challenges, the team also faces the challenge of integrating the social space with the surrounding district. The key aim is to create alternative living spaces for the quarter.

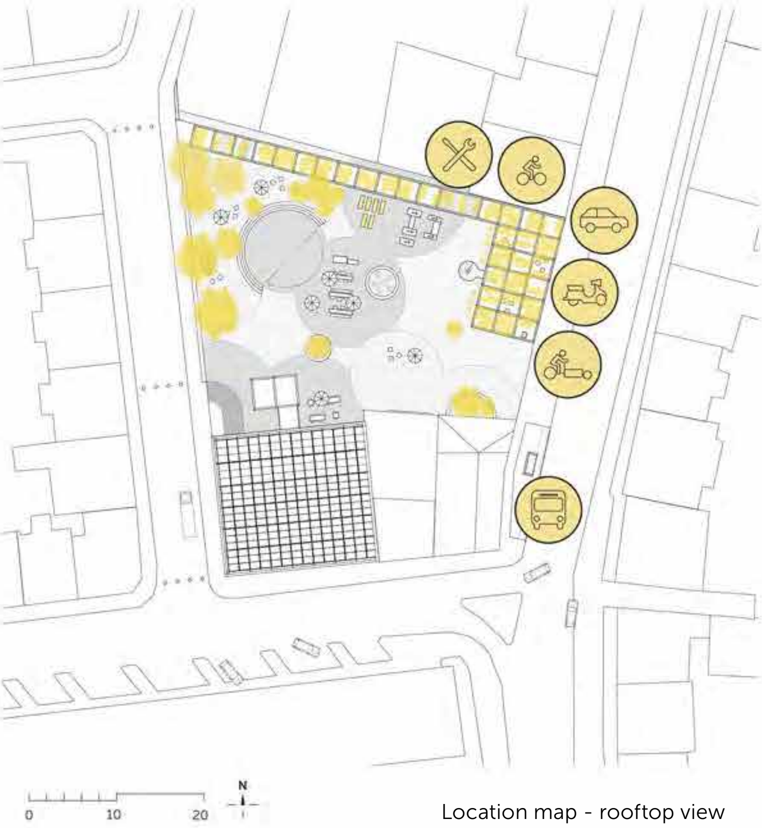
Living Modules

A total of 15 stacked, glue-free solid wood residential modules on three floors provide private living space for one to four people each. The space per unit is greatly reduced. The gaps between the individual modules are mainly used as communal living space, which makes room for informal encounters and social interchange: "the more you share, the more you have". The urban garden, reached via the outer stair tower, forms a semi-public greenhouse for leisure and vegetable growing. The roof terrace takes on the role of a village square.

Climate Shell

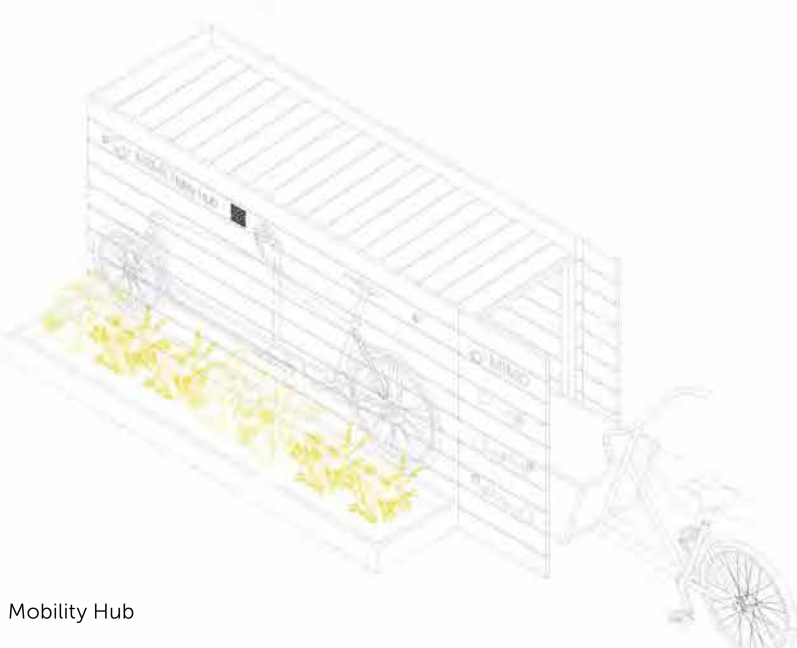
The "climate shell" is fundamental to the design. It surrounds the living modules as well as the spaces between them and thus produces the outer layer of the rooftop extension. Through glass skylights and louvre windows, it permits natural ventilation, lighting and passive cooling of the common areas. A coordinated arrangement of PV cells in the partially transparent shell generates electricity throughout the day, providing shade and passive heat input without blocking the view.

urban context and mobility



Location map - rooftop view

bicycle workshop
e-scooter
e-cargo bikes
e-cars
e-bikes
bus stop



Mobility Hub

In order to turn the Ada area into a lively meeting place in the Mirke district and thus promote communication and participation in this city district, several contact points are being set up for the residents, e.g. a packing station and vending machines for vegetables produced on the roof garden, regional products such as milk, honey, eggs or practical items like bicycle inner tubes or seeds. In addition, various mobile sharing services are to be expanded and established for the district by equipping them with a fixed station on the property. The Café Ada serves as a waiting and meeting point.

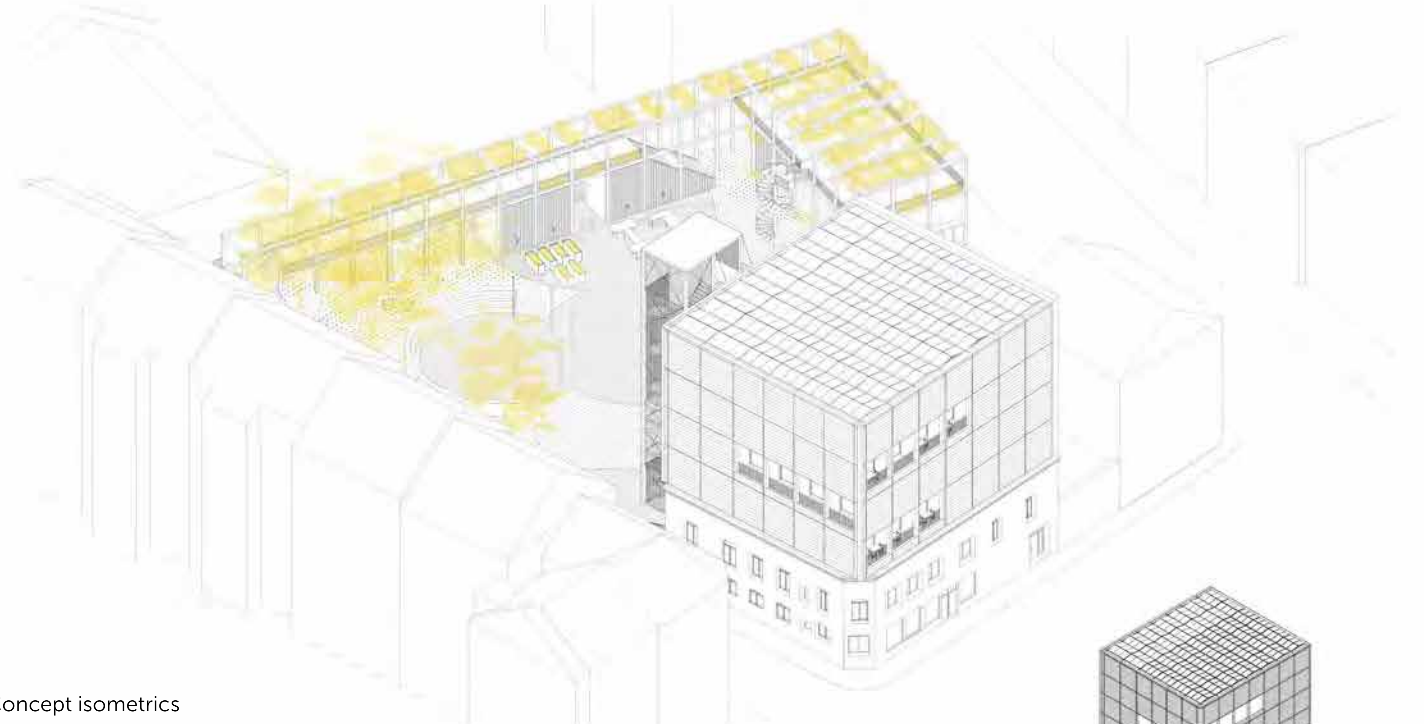
Our main concern is to promote cycling. The proximity to the Nordbahntrasse walking and cycle track as well as the efforts undertaken by the city of Wuppertal to set up further cycle paths speak for the establishment of a repair station on the property and the rental of bicycle accessories and safety equipment via a mobile bicycle service. In addition to e-cars and scooters, an offer for e-bike sharing is also to be established. For this purpose, a pick-up/return station with a charging function will be set up on the property. In addition to standard e-bikes, e-cargo bikes are also to be offered in cooperation with local bike rentals.

Ground plan

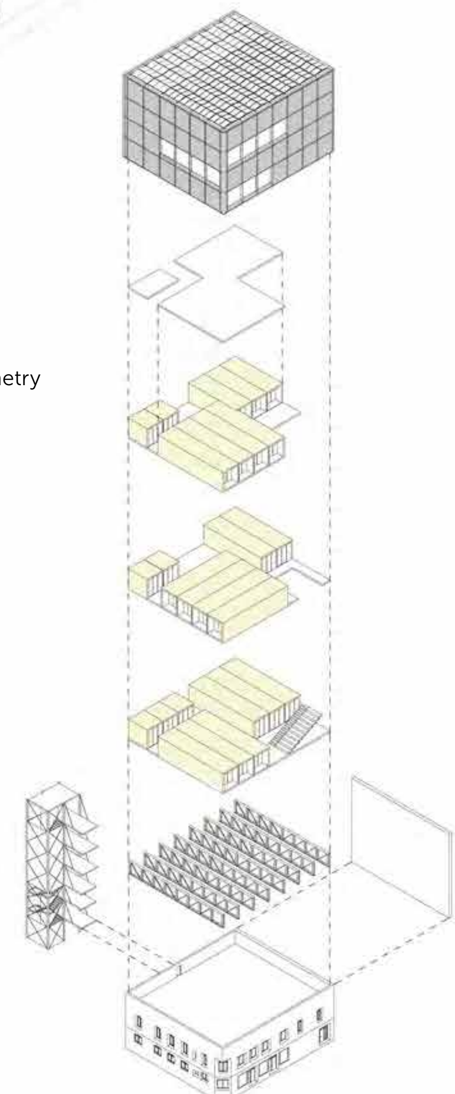
0 250 500 N

design challenge (dc) overview

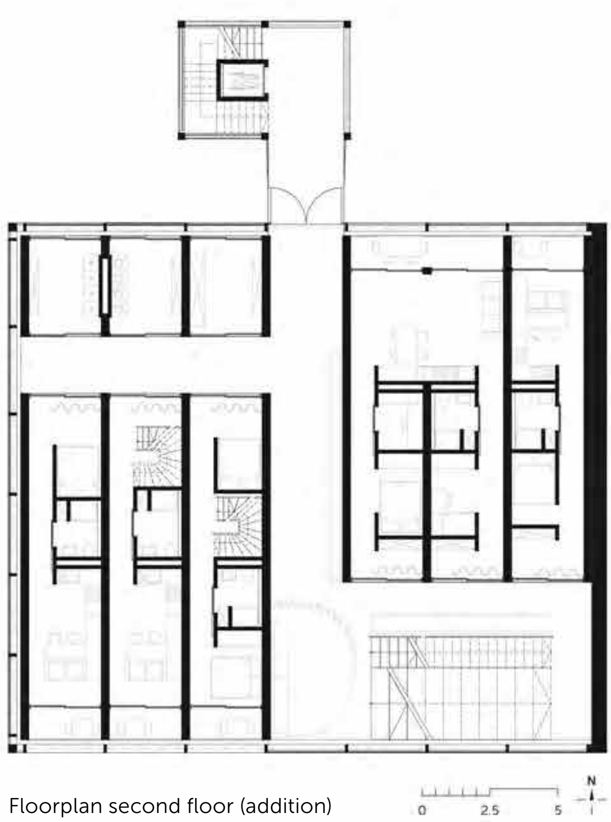
In the addition of storeys, various apartments are stacked on top of each other, such as student, duplex, double and family apartments. Community spaces in-between, such as a communal staircase, form places where people can meet and gather. An external stair tower facilitates the functional separation of the existing building and the extension.



Concept isometrics

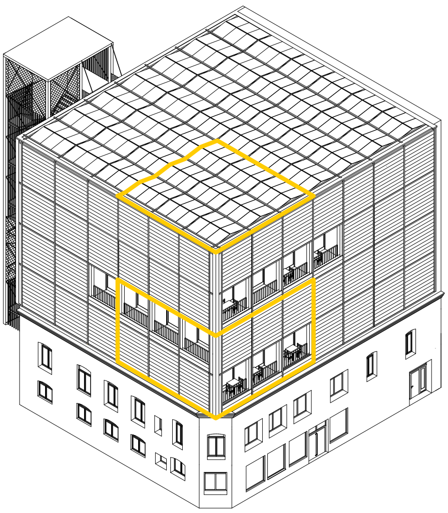


Exploded isometry

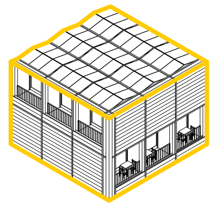


Floorplan second floor (addition)

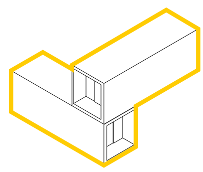
house demonstration unit (hdu) overview

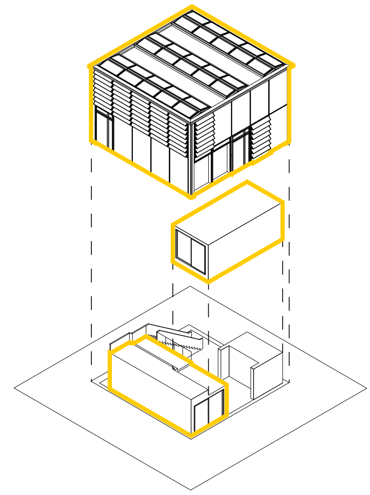


climate shell



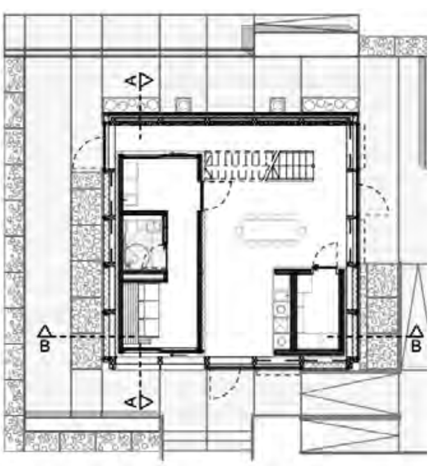
living modules





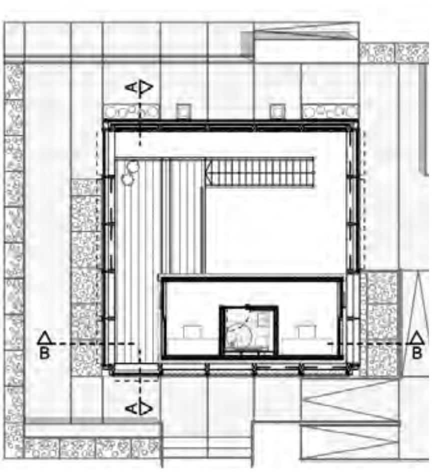
Transformation DC to HDU - Two living modules surrounded by a climate shell.

The addition will be presented as an HDU with two stacked, compact solid wood residential modules and a communal area within a climate shell. The intelligently controlled facade with roof windows and slats that can be opened and fitted with PV is also being transferred.

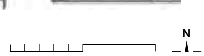


Floor plan ground floor

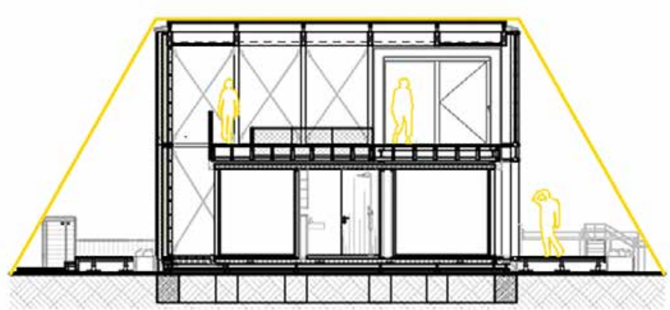
On the ground floor, there is a plant room containing the energiBUS system, a living module with a bathroom, compact kitchen unit and a living room that can be turned into a bedroom or dining room through multifunctional furniture. The space between is intended for communal use.



Floor plan upper floor



Another living module is stacked on top of the first one. The rooms of this residential box are used in a similar way, but a study room is established instead of the kitchen. Due to the 90° rotated arrangement of the modules, a small roof terrace is created on the roof of the ground floor box.



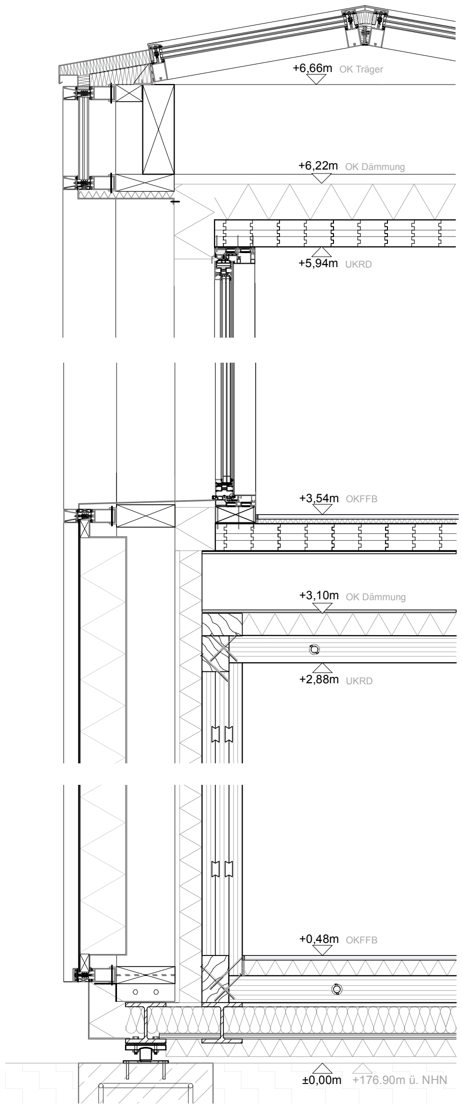
Section A-A

Section B-B

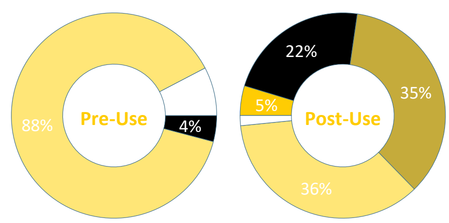
house demonstration unit (hdu) details

The modular approach of the DC and prefabricated components enable the transferability of the overall concept and aim for reduced local emissions and construction time as well as material efficiency. Our HDU presents one of many possibilities how the living modules can be put together and thus can be adjusted optimally to the residents and site conditions.

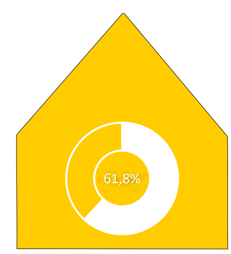
Two stacked solid wood residential modules and a communal area within a fully functional climate shell form the demonstration unit. Multifunctional furniture allows a flexible usage of space within the modules, which are complemented through community space with a roof terrace. The energiBUS system on the ground floor regulates heat supply and load management. A little mobility hub with a free cargo bike on the outdoor facility represents the mobility concept.



Construction detail east facade



Closed loop-potential (ceilings)



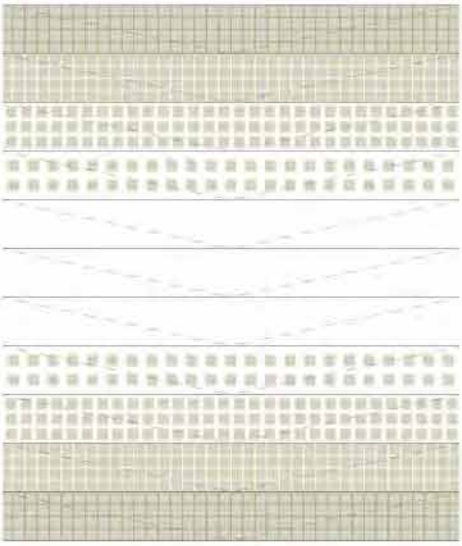
Urban Mining Index

Roof	
Schueco FWS 60.SI Green Mullion transom facade	85mm
Roof beam Glulam	18x40cm
enameled glass triple glazed	
Transom solid structural timber	7,5x26cm
Solid wood column	14x26cm
Hard insulation WLG 032	
Sheet metal, edged	

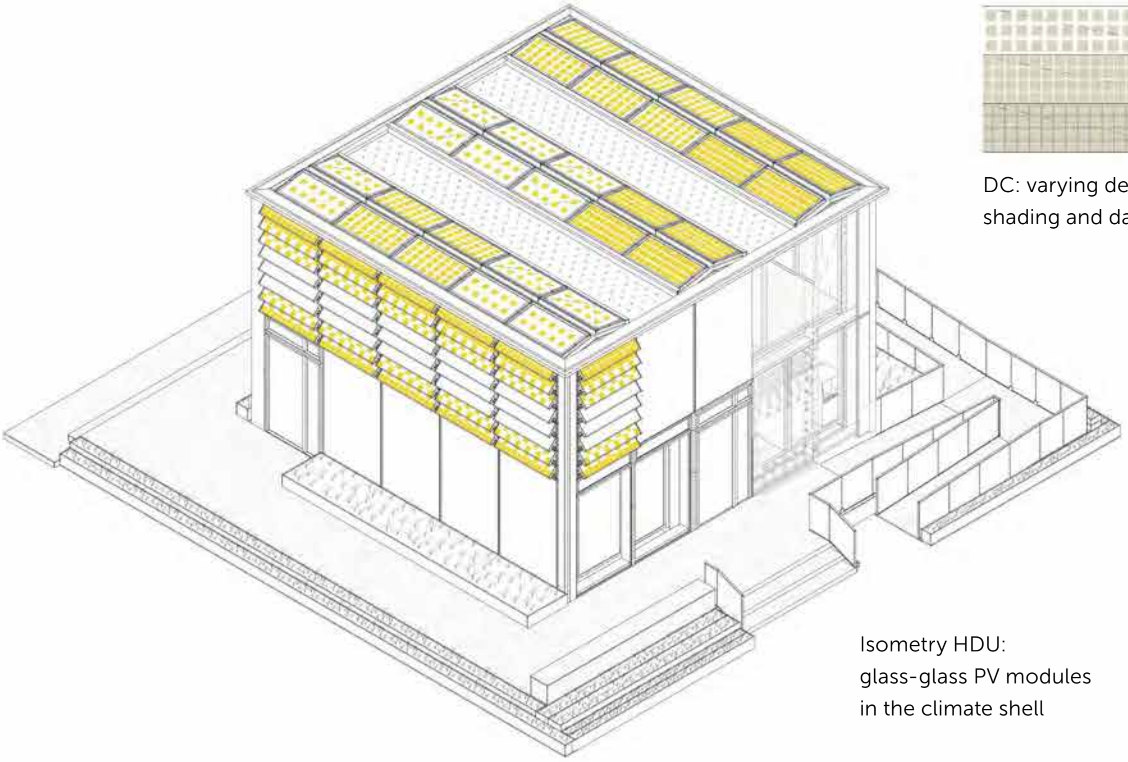
Facade	
first floor	
Schueco Sliding oor ASE 80.HI	294x240cm
Sheet metal, edged	
Gardient	
Schueco FWS 60.SI Green Mullion transom facade	105mm
High pressure profile without impact	60mm
Middle Transom solid structural timber	10x26cm
Solid wood column	14x26cm
Interior Finishing Gypsum Board	12,5 mm
ground floor	
Opaque façade module	184x310cm
Aluminum tray	
Hard insulation WLG 040	20cm
enameled glass	
Schueco FWS 60.SI Green Mullion transom facade	7,5x26cm
lower Transom solid structural timber	
If necessary bottom edge relined	14x26cm
Solid wood column	

Living Modules	
first floor	
ceiling	
Cork insulation WLG 045	16cm
Holzius board stack ceiling	12cm
floor	
Parquet floor screwed	2cm
Wood fiber insulation WLG 044	7cm
Holzius board stack ceiling	12cm
Support	
Steel beam IPE 270	
Installation level	184x310cm
Installationsebene	
ground floor	
ceiling	
Cork insulation WLG 045	10cm
Holzius board stack ceiling	12cm
floor	
Parquet floor screwed	20mm
Wood fiber insulation WLG 044	70mm
Holzius board stack ceiling	20mm
Steel beam HEB 180	
Steel beam IPE 270	120mm
Mineral wool WLG 032	30mm
Glue Free Massiv board	80mm
Wood fiber insulation impregnated WLG 044	30mm
Rear Ventilation	

solar system



DC: varying density of PV cells to regulate shading and daylight, insights and views



Isometry HDU:
glass-glass PV modules
in the climate shell

Solar facade of the HDU
© Marvin Hillebrand, MIMO / SDE 21/22

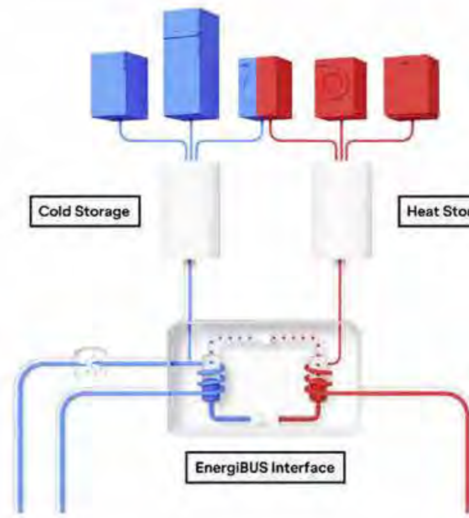
The design is surrounded by a climate envelope including openable louvre windows and skylights. Polycrystalline PV cells with a total output of 8.2 kW_p are embedded and are a permanently elastic form of BIPV by means of a highly transparent multi-component gel. A maximum of 3 kW_p may be used during the competition finals. An inverter grips the 10° inclined east- and west-facing roof surfaces via two MPP-trackers.

The same applies to the PV in the east and west facades, while 0.67 kW_p in the south facade is connected to the central management system as a so-called balcony system with a micro inverter. A 5 kWh battery storage system is connected to this (reduced to 2.5 kWh in competition). The yield of 4,525 kWh/a more than compensates for the total electricity demand of 3,062 kWh/a including user electricity and e-mobility in the annual balance.

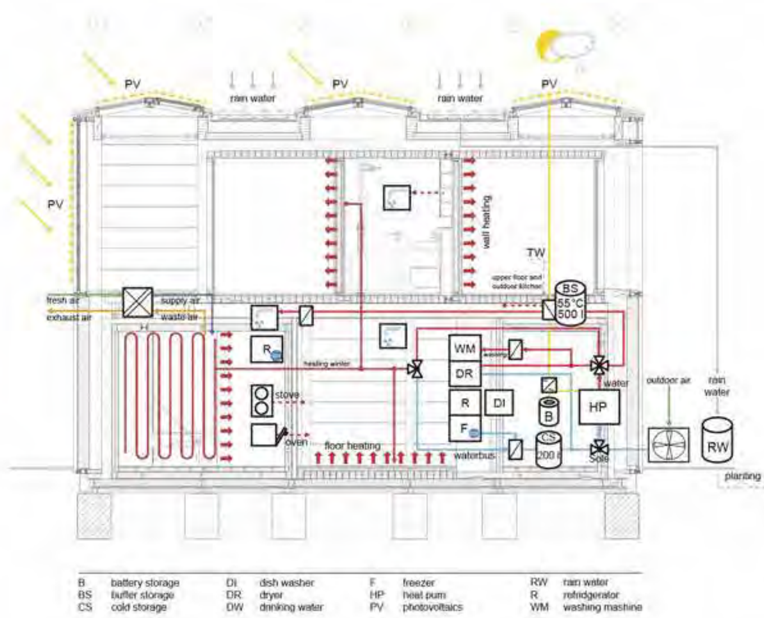
energy supply

The energiBUS was further developed at the HSD for implementation. In addition to an air-source heat pump (6 kW_{th}), a 200 litre cold storage tank and a 2 x 200 litre heat storage tank are used and provide heating and cooling for the household appliances, hot water stations and heating. The heat transfer in the residential modules takes place via wall panel heaters with a heating capacity of 70 W/m², which are embedded in clay walls of the bathroom cores.

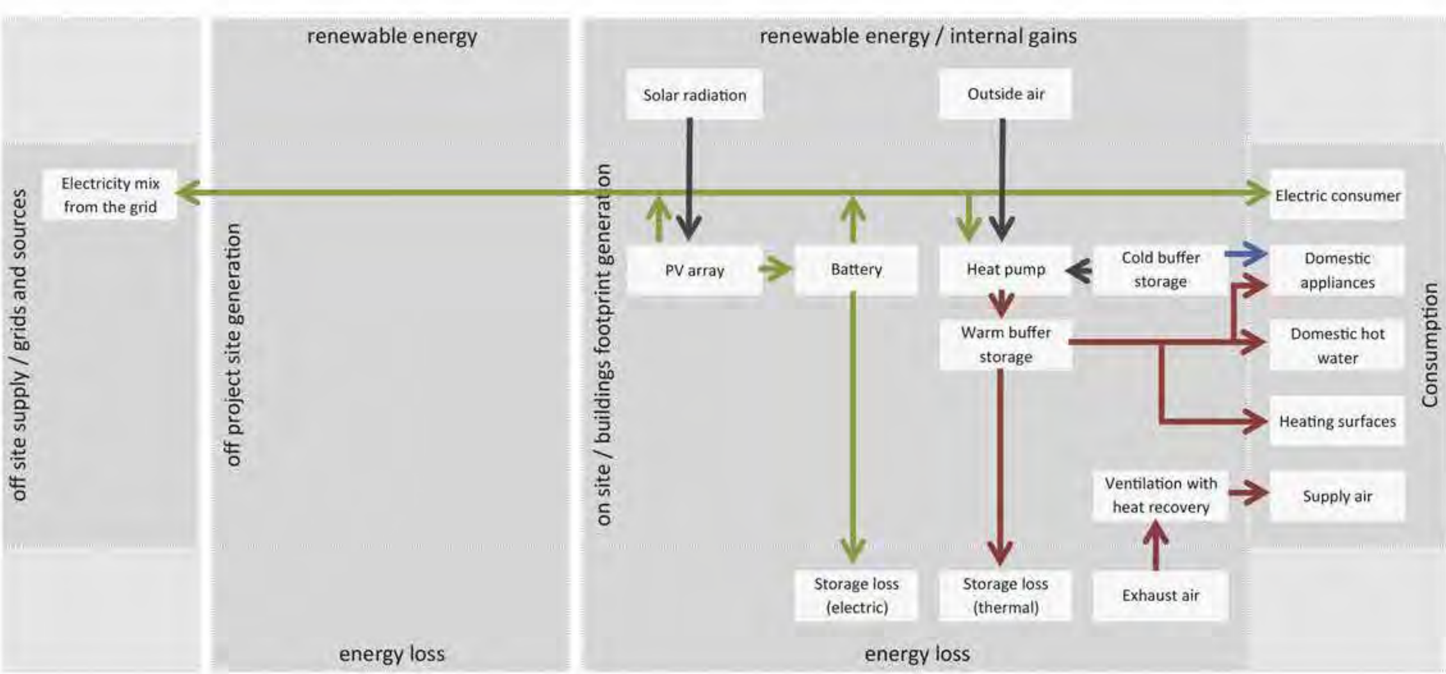
In the common area of the climate envelope, underfloor heating (130 W/m²) and curtains create heat islands with different temperature levels. All (hot) consumers and PV systems are linked to heat as well as battery storage via load management in order to optimize self-supply and self-yield utilization.



Concept energiBUS system

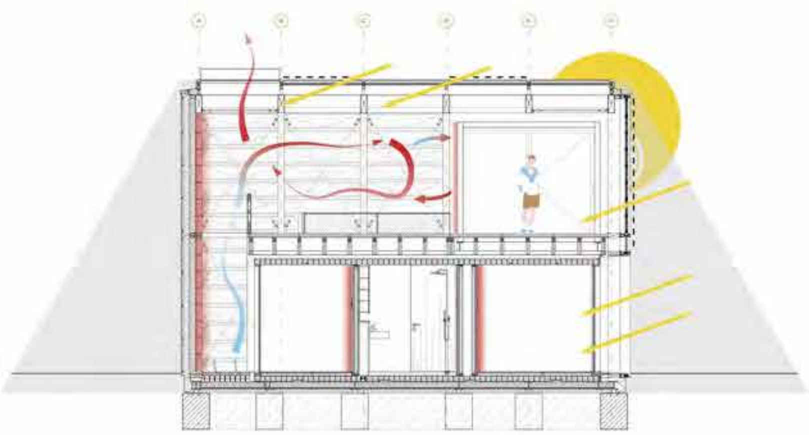


Energy concept for entire building

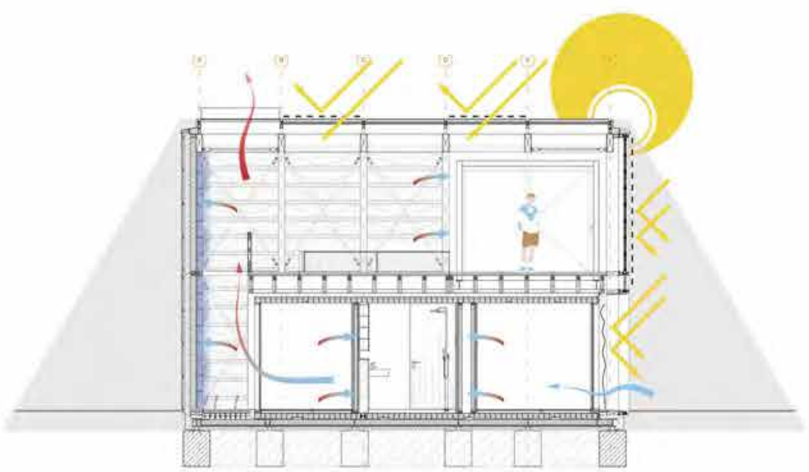


Energy Supply Diagram

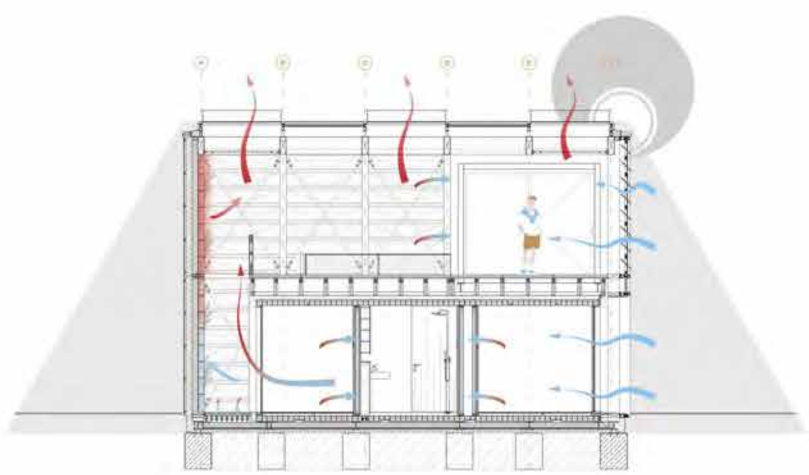
indoor climate dc and hdu



Passive ventilation winter day HDU



Passive ventilation summer day HDU



Passive ventilation summer night HDU

The louvers of the climate envelope are motorized and open automatically as needed. When the temperature inside the HDU reaches a certain level, the louvers of the facade open to generate natural ventilation and exhaust inside the common area. The north facade is made of clay blocks, which stores the heat of the day and releases it back into the room at night. The living module is thermally separated from the rest of the climate envelope and has a wall heating that maintains a constant living temperature in the cold winter days.

© Marvin Hillebrand, MIMO / SDE 21/22

key figures, team and sponsors

MIMO

Further project information:
https://mimo-hsd.de/

Public funding

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Landesbetrieb Wald und Holz Nordrhein-Westfalen

Landeshauptstadt Düsseldorf

ZIES - Zentrum für innovative Energiesysteme

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SONOS, Inc.

Weidmüller Interface GmbH & Co. KG

ZinCo GmbH

TEAM NAME | TEAM IDENTITY

EFdeN | ION

UNIVERSITY

ion mincu university of architecture and urbanism bucharest bucharest, romania

TASK

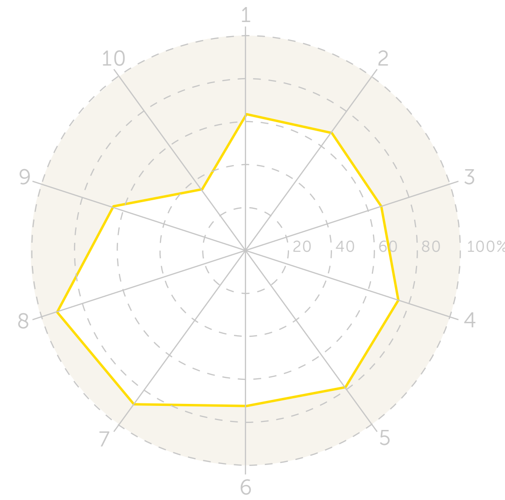
renovation and addition of storey

LOCATION OF DC

wuppertal

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	2835 m²	95 m²
	3	1
		43 m²/p

Since 2013 EFdeN has been helping students and young professionals find a sense of direction while providing an environment to apply their creative energy through a trial and error process. Facilitated by the Solar Decathlon competitions, the team has attempted to be at the forefront of everything related to sustainability, from law & policymaking to education and development of our cities.

The EFdeN name comes from the mathematical function f[N] - where N is Nature. Nature is at the core of everything the team does as they try their best to protect it and bring it closer to people so that they are much more considerate towards it. The story of EFdeN is unique.

What started as a singular project 8 years ago, with the occasion of the participation in the Solar Decathlon Europe 2014 competition, is now the most important sustainability NGO in Romania and the only one in the country to develop solar homes for educational and research purposes, along with sustainable products and educational modules for students, specialists and the general public. After two previous participations in the Solar Decathlon competition (SDE 2014, Versailles & SDME 2018, Dubai), team EFdeN is tackling the most important challenge so far, in a disruptive way, designing a new prototype - EFdeN VATRA - for urban revitalization. The team is composed of around 50 young people, mildly experienced professionals, coming from 8 universities, 20 faculties, studying in more than 10 different domains.

Lately, the team has embarked on a mission to articulate their organisational culture. This is relevant due to the fact that the mission and objectives are the core principles upon which the EFdeN VATRA is built. EFdeN Vision: “We believe in sustainable communities where educated people are living a high quality life.” EFdeN Mission: “We are committed to designing, executing and implementing models of good practice in accordance with nature. We are an emergent hub for professionals and projects.”

urban context and mobility

Besides designing an intervention to suit the characteristics and needs of the targeted group, our project seeks to give something to the community and the city. To provide interaction spaces for the neighbourhood, we designed the outdoor public space to fit the necessities of all the users in the district, where kids could play, adults could meet or just enjoy a nice evening in the sun.

As the revitalisation of urban building stocks is the key focus of the SDE21/22, the VATRA design strategy consists of four different modules that could be combined to suit the three typical European urban scenarios, also present in Wuppertal and Mirke: renovation and extension, closing gap or renovation and addition of storey.

The Vatra mobility hub

Starting from the frequent problem for many European cities, the lack of parking spaces, we developed THE VATRA MOBILITY HUB. It is a multi-storey structure featuring a rotary system that can be seamlessly integrated into the current building stock to accommodate parking spaces. Also, it provides charging stations powered by renewable energy for electric vehicles and car-sharing options while freeing the ground and helping biodiversity with the green facade. The façade is also improving the air quality and regulating the microclimate.

Providing Renewable Energy

As the green mobility hub is a multi-storey structure, we are installing photovoltaic panels that will work as a roof. The charging stations have a bidirectional power flow to make it possible to charge the batteries in the daytime and to use a fraction of it, when the car is parked, in the evening and night for grid services.

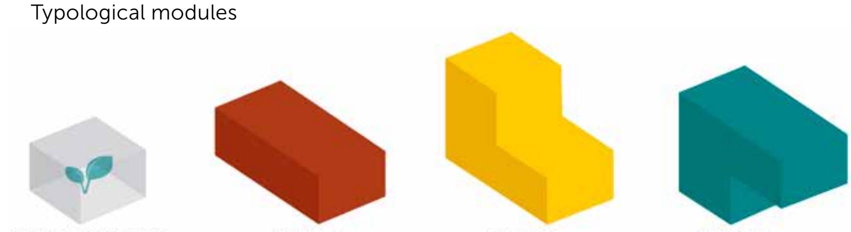
One of our objectives is to reduce eWaste. Our solution is to give a second life to used EV batteries converting them into custom residential energy storage systems.

The Pocket Parks

An attentive approach towards commonly used routes in the city could become the basis for creating other similar links and shortcuts. This would help link cultural spaces, as well as make common trips to work or marketplaces more comfortable, thus increasing the residents' quality of life.

As public and green spaces are of utmost importance in a city, residual areas from within the compact residential structures can be reused as pocket parks or local courtyards.

Typological modules



design challenge (dc) overview

General architectural concept

EFdeN VATRA aims to create a sustainable and affordable housing model that empowers single-living people by forming a community.

Vatra Design Strategy

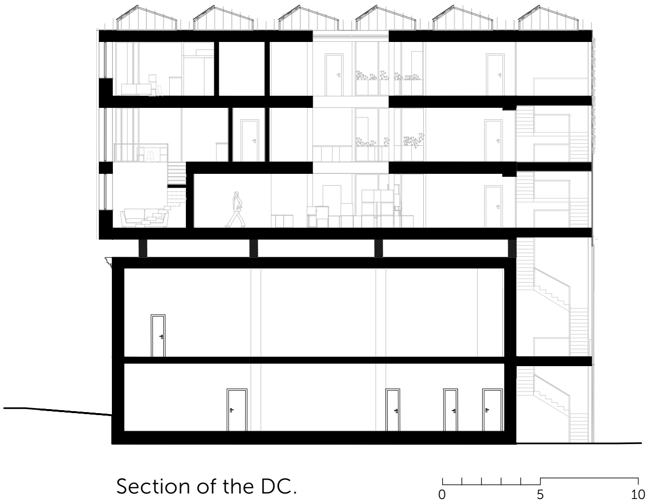
... to combat resource scarcity
The design aims to maximize the amounts of living units whilst at the same time providing adequate comfort conditions for each resident. The principles that guided all of the design decisions were scalability and resource efficiency.

... to adapt to today's social structures
According to a survey by Eurostat, single adult households without children rose by 20.3 % between 2021 and 2020.

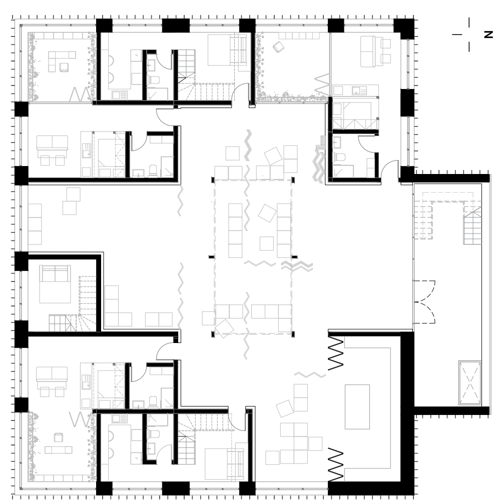
Three typological modules are single-living apartments. The last module is a private greenhouse that is to be attached to each individual living unit.

... to regain the sense of belonging
Data from the European Commission in 2018 shows that 30 million European adults reported frequently feeling lonely. That is 7% of Europe's population.

In response to the epidemic of loneliness in Europe, EFdeN VATRA proposes revisiting and reinterpreting the concept of the Romanian hearth. VATRA (Romanian "the hearth") is the core of our concept. It is the space wherein a traditional Romanian house the family gathered, a place full of joy, dance and stories. Thus, the VATRA layout is organised into public and private spaces. The latter one consisting of individual living units is arranged peripherally on the layout, around the common spaces, inspired by the hearth.

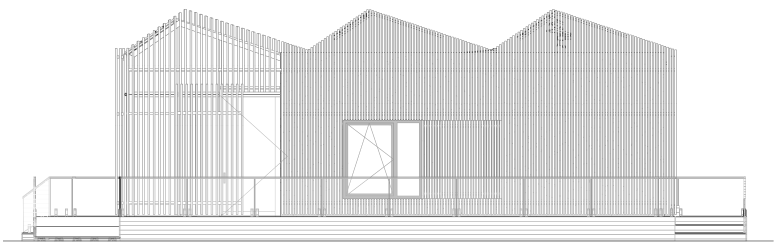


Section of the DC.

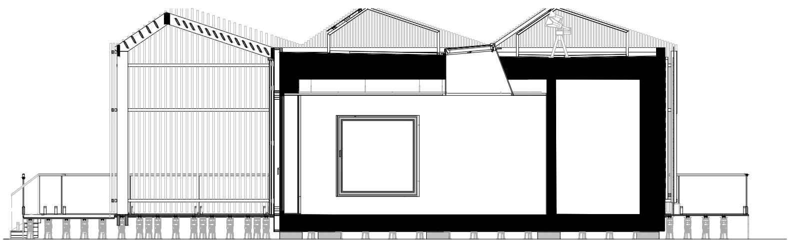


Floorplan of the Design Challenge with a central common space surrounded by apartment modules, with the access attached.

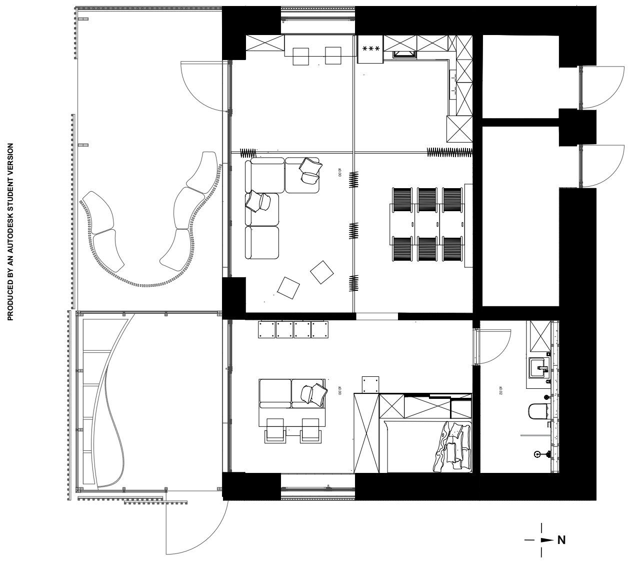
house demonstration unit (hdu) overview



A vertical South-North facade of the House Demonstration Unit. We can see the eastern face of the prototype with the apartment's window and the secondary exit.



A vertical South-North section through the House Demonstration Unit. We can see the apartment module with the bathroom, and the attached greenhouse which can be opened into the interior of the house.



EFdeN VATRA prototype integrates into its plan the most important features from the Design Challenge, so in its composition, we find a one-level apartment module- adapted for people with disabilities, a greenhouse- with the possibility of extension into the outdoor terrace or into the apartment, the electrical and mechanical rooms, and the common room- which can be divided into four different spaces.

As the HDU has become the representation of the concepts presented in the building design, the aim is to showcase at the competition a cohabitation system and its benefits and to do this we are researching many possibilities, from gimmicks, mirrors to VR technology.

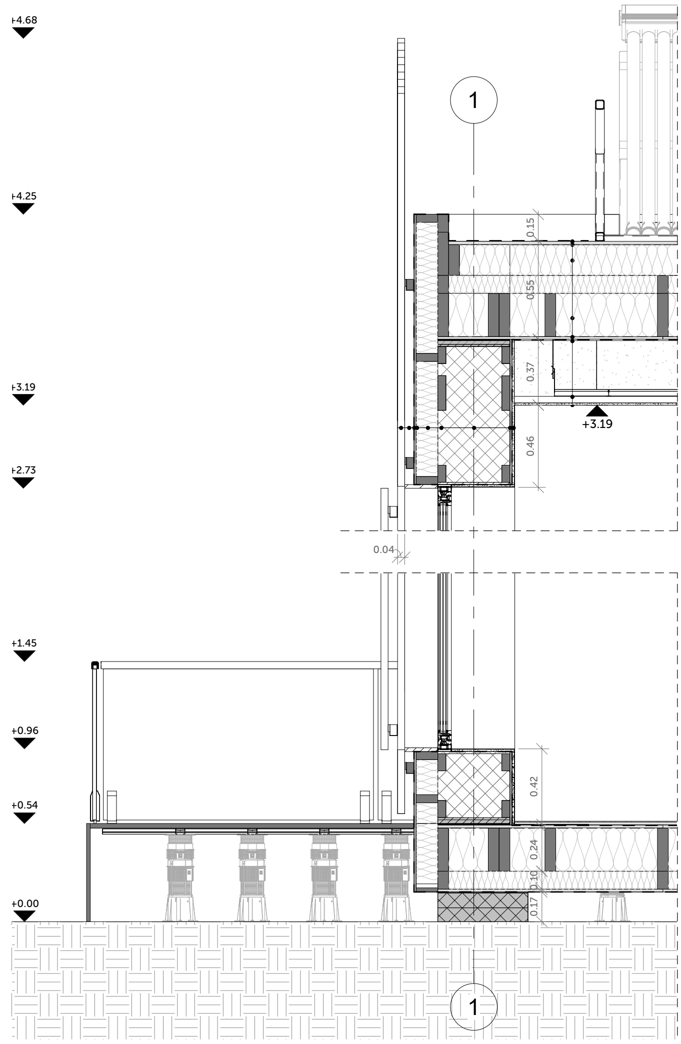
Regarding the construction, an off-site timber frame manufacturing method reduces costs, accelerates project timelines and improves overall predictability. The goal was to achieve an entirely dry assembly process, reducing carbon emissions from transportation, better waste management, and overall lower construction costs stemming from fast fabrication and assembly, reduced costs for heavy-duty equipment rental and the workforce.

For efficiency, the prototype features technical solutions from the use of optical fiber for indirect natural lighting and an automated blade system for the facade that controls direct light. Electricity comes from bifacial photovoltaic panels that produce energy using both sides. Furthermore, the excess energy will be stored in second life batteries from electric cars. Of course, technology plays an important role, but traditional solutions and materials are intensely used: the structure of the house is made of structural straw wall panels, with additional thermal insulation and wool, also inside, to cool the house in summer a clay wall is integrated.

house demonstration unit (hdu) details

One of the most interesting structural detail of our prototype is the timber structure wall. To achieve the optimal insulation requirements we combined a structural timber box structure filled with compacted straw blades with a custom system of wood boxes filled with cellulose. To optimize as much as possible the repeated assembly and disassembly process the upper and lower boxes are detachable. Therefore, the structure walls and floors can be assembled without completely taking down the insulation layers. As a result, we achieved a versatile structure, that answers to the rigorous technical requirements and functions as a support for different types of finishings.

To maximize the surface area of our roof we use bifacial photovoltaic panels. As to improve the solar intake we elevate them on custom timber structures and use a special white bituminous slate as hydro insulation. This heavily influenced our facade design, which integrates the volumetry of the wood structure into an integrated shape.



The joint between all structural elements, the west window system and the decking system.

Upper Floor Structure	
Waterproofing Membrane Bytum Slate 350 white	1 mm
Selective Permeability Membrane Rothobaast NET SD40	1 mm
Support Surface OSB	18 mm
Thermal Insulation Cellouse	510 mm
Roof Structural Wood Panel, made of three layers ofbidirectional Wood Beams	60x240 mm, 30x50 mm
Support Surface OSB	18 mm
Vapour Barrier Membrane Rothoblaast TRASPIR EVO 160	1 mm
Technical Ceiling Steel Bracket Structure with Aluminium Framing	600 mm
Interior Finishing Gypsum Board	12,5 mm

Exterior Wall Structre	
Facade Finishing Vertical Timber Cladding	40 x 40 mm, 40 x 60 mm
Wind and Rain Barrier Membrane Rothobaast NET SD40	1 mm
Support Surface OSB	12 mm
Thermic Insulation Cellouse	120 mm
Wood Box Support Structure, wood elements	45 x 120 mm
Thermic Insulation Straw Bales	400 mm
Structural Box Ecococon System, wood elements	45 x 95 mm
Support Surface OSB	12 mm
Vapour Barrier Membrane Rothoblaast TRASPIR EVO 160	1 mm
Drywall Gypsum Wallboard SaintGobain Activ'Air	12,5 mm
Interior Finishing White Plaster	

Inferior Floor Strucure	
Interior Finish Lynoleum	5 mm
Vapour Barrier Membrane Rothoblaast TRASPIR EVO 160	1 mm
OSB	18 mm
Thermal Insulation Cellouse	340 mm
Structural Wood Panel, two layers of bidirectional beams	60 x 240 mm, 60 x 100 mm
Support Surface OSB	15 mm
Selective Permeability Membrane Rothobaast NET SD40	1 mm

West Window System:	
Schuco AWS 75 Aluminium Profiles	
Triple Glazed Glass System with 90% argon	

West Window System	
Deck Finishing Merbeau Wood	20 x 100 x 2000
Deck Structure Aluminium Profiles	42 x 65 x 2400 mm
Deck Fundation Footing	h = 548 mm

solar system

As previously described, for our intervention on Cafe Ada, the roof shape has the role of providing the best angle and height for the bifacial photovoltaic panels. It carries the role of keeping the image of an industrial building roof in the collective memory.

Through the utilisation of bifacial technology, the number of photovoltaic panels is reduced facilitating a smoother integration.

The key objective for the HDU is to have a positive annual balance as the LBC certification requires us to supply one hundred and five per cent of our project's energy needs, while in the case of the Design Challenge the objective would be to have optimal interaction with the local electrical grid.

Rooftop with PV modules © Steinprinz / University of Wuppertal

Economy of installation

Cost reduction is also pursued. The cost of this solution is comparable with the one of a mono facial system, but because the gain is significantly higher the Levelized cost is lower. With the same amount of surface used, the gain is 24% higher. It means that the cost of installation is lower, fewer cable meters and materials are used for manufacturing the structure for the PV panels, and last but not least, we have to provide maintenance for fewer panels.

Additional Properties

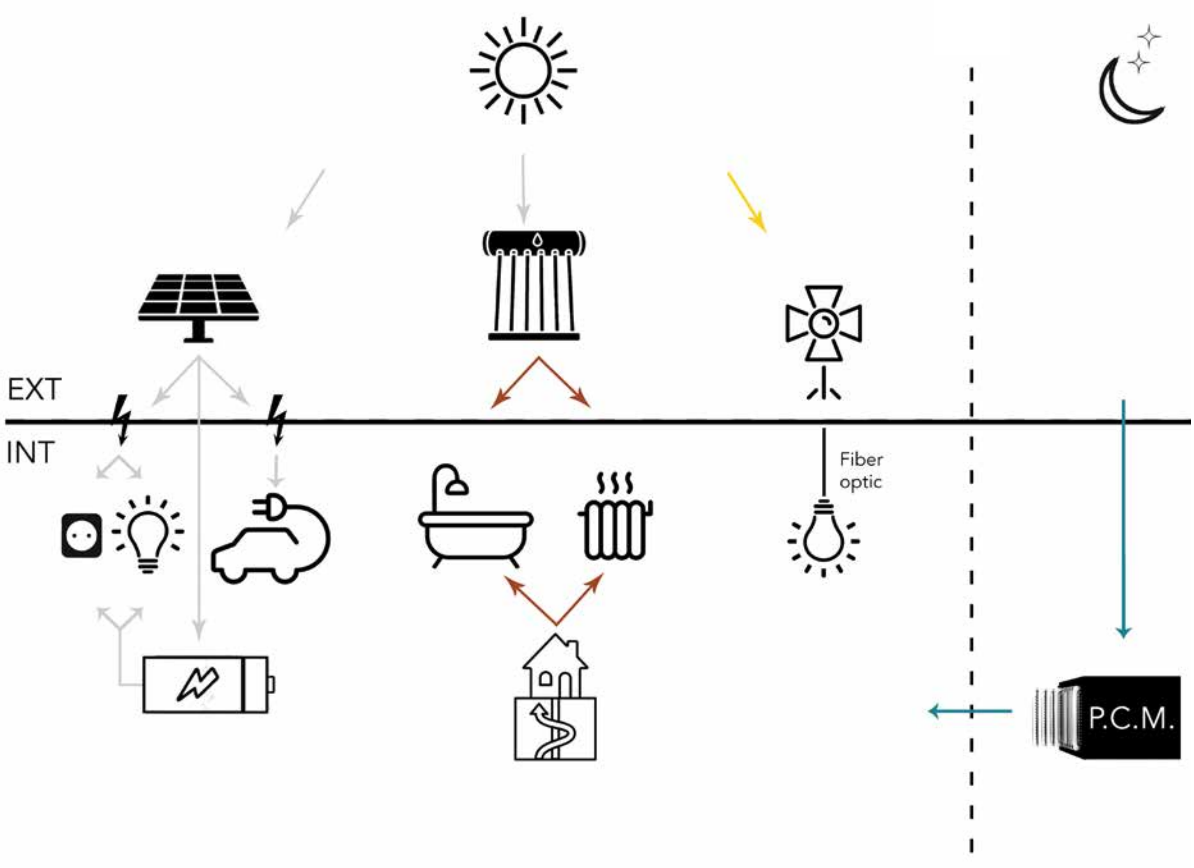
With this bifacial solution, the posterior of the panel is heated through the reflection and energy gaining process, transmitting the heat to the superior face and facilitating snow melting in the winter. This results in an increased energy gain during winter.

energy supply

From May to July our power generation system should entirely cover the electrical energy consumption. The annual energy production is around 20 MWh. In our pursuit for clean energy the main challenge is to cover the heating and cooling demands only with electricity, to overcome this we are focused on using biogas and geothermal energy. This way our project lowers its electricity demands.

Considering the 3 kWp limit for the HDU, 10 panels and a dedicated roof area of 17 sqm would be required. An automation system is being considered for the tilt angle, as the annual optimal tilt angle range varies between 16 and 76 degrees. At this point our prototype is not fully independent of the grid. For the post competition life and the LBC certification we take into consideration to extend the installed power to 5,5kW.

The brain of the system is Cerbo GX. It allows the user to monitor and control the system from anywhere in the world via VRM Portal. Furthermore, it performs diagnostic checks and could resolve problems remotely. The main goal of the control strategy is self-consumption, storing the energy into the batteries during the day, for use later on when there is no sun available. The major obstacle in such a system is that power generation times do not match with the actual times of power use. This results in a system being forced to import energy from the grid and export it when there is a surplus.



indoor climate dc and hdu

The energy required to maintain a comfortable interior environment is greatly reduced by the smart integration of phase changing materials. Just like a thermal battery, they store the night's coldness and use it to cool down the warm outside air entering the house during the day, reducing the need for energy intensive air conditioning.

The skylight helps clean the air of CO_2 and remove formaldehyde, benzene, and other common indoor pollutants from the environment by using natural ventilation and vegetation can create sensations that mimic natural environments.

In correlation with the idea of hearth and traditional materials, we used clay as an interior finish, which also has the purpose of thermal mass, with the role of regulating the interior humidity, reducing the maximum cooling load from 0.48 kW to about 0.35 kW.

key figures, team and sponsors

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Further project information:
https://efden.org/

TEAM NAME | TEAM IDENTITY

RoofKIT | KIT

UNIVERSITY

karlsruhe institute of technology karlsruhe, germany

TASK

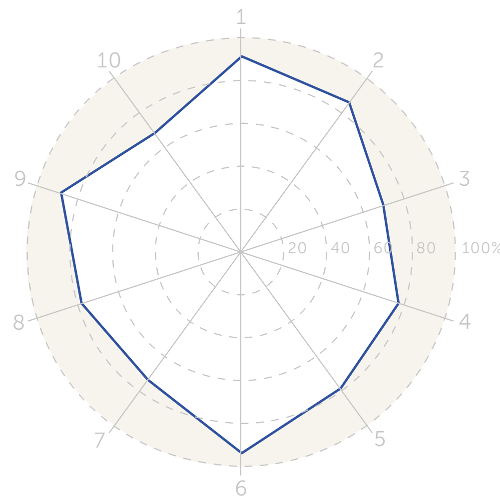
renovation and addition of storey

LOCATION OF DC

wuppertal

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© RoofKIT, Zooey Braun / SDE 21/22

our vision

	1771 m²	54 m²
	5	1
		27 m²/p

We believe that our current cities have a huge overlooked potential of building ground and energy harvesting areas: rooftops. According to investigations of the Volkswohnung GmbH in Karlsruhe, rooftops are the biggest asset in the portfolio of the company, and we believe that this is not only the case in Karlsruhe but in many cities worldwide. It is a reserve that we should start to address. Moreover, we believe, that with the current boom of prefabricated houses, those two questions could and should be combined: how to design module-based prefabricated light-weight housing structures for roof top settlements? Here we see a huge potential for the future. And an impact not only in a technical sense, but also in a social sense: providing housing in inner cities for all levels of society. On top, we see also the benefit for the existing structures, as they achieve an upgrade in programmatic and functional services, as it is the goal to incorporate new community space types within the roof-top structures and understanding the additions as energy producers for the whole neighbourhood.

Design

In addition to the renovation of the building, the uses in it are rearranged and supplemented by a hotel and apartments. The current dance hall will be moved from the first floor and will act as a link between the café and hotel in the old building and the residential units on the upper floors. Externally it is recognisable as a recessed, glazed mezzanine floor with a surrounding open-air terrace.

Lightweight

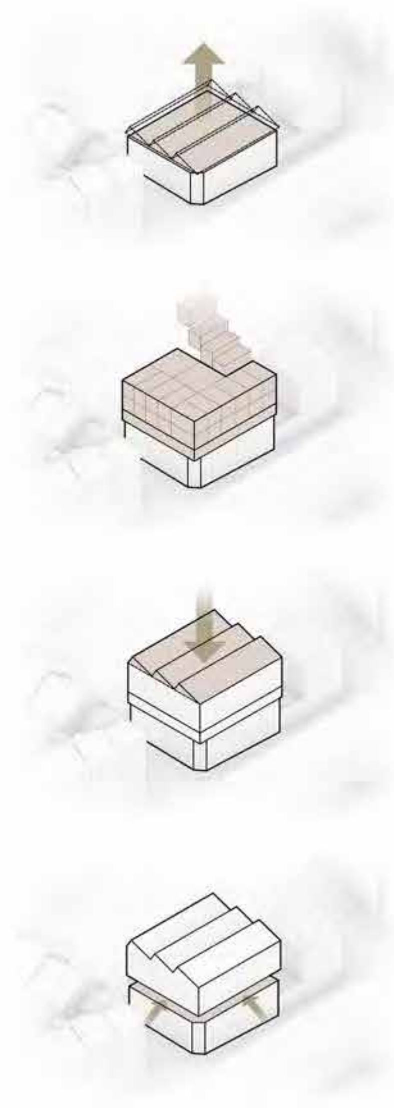
60 to 70% of the bound CO_2 can be found in the supporting structure. For this reason, we continue to use the load-bearing structure of the existing building and saddle it with a lightweight modular timber construction. With its energy concept we focus on all the energy resources available on and in the building: solar energy, waste heat and biogas.

Urban mining to material storage

Many materials in the design already had a life cycle: door handles and fittings are reused from old buildings, wooden elements come from demolition sites and metal plates from former roofs. All this is combined with biological recycled products: Wood from sustainable cultivation, insulation material made from seaweed and fungal mycelium, as well as other innovative products from KIT research.

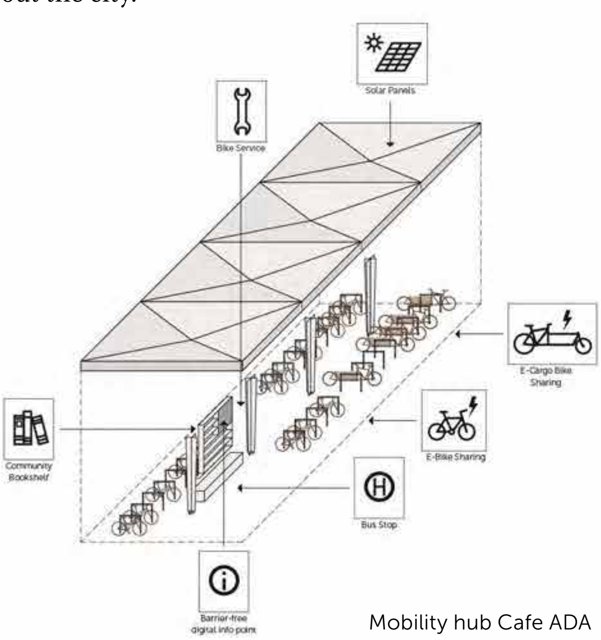
urban context and mobility

Site plan and urban mobility concept

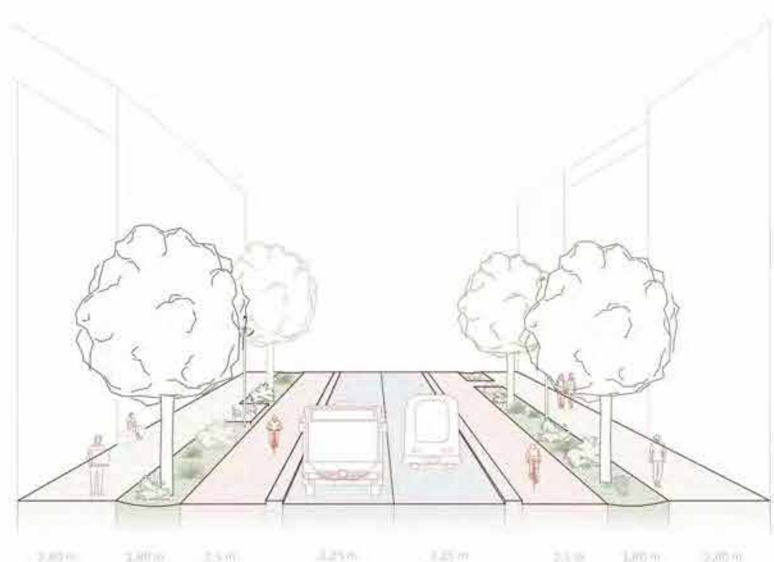


Design concept

Our main objective is the transformation from an individual to a collective system. We plan to implement a cable car connection between the residential district and the main station. Mobility hubs will establish a network of important points to change the type of transport throughout the city.



Mobility hub Cafe ADA

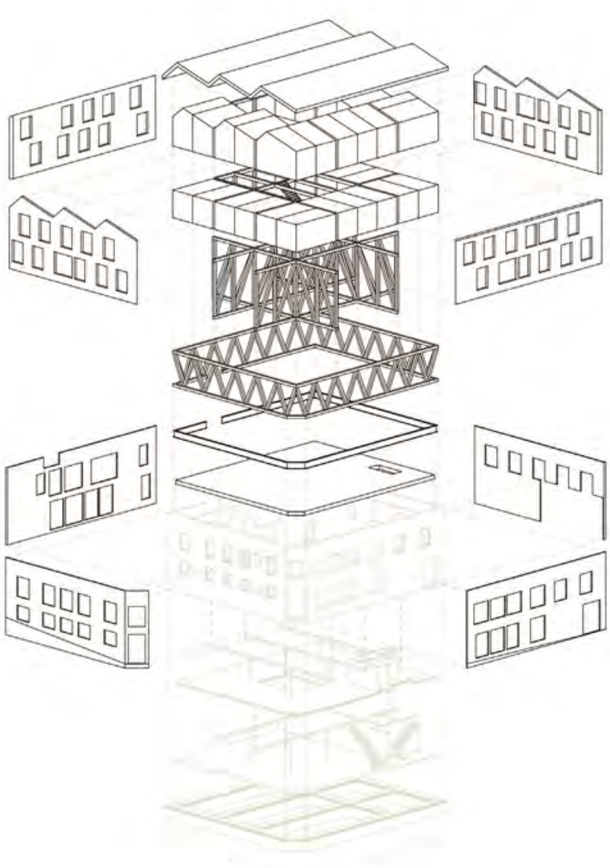


Bus street future

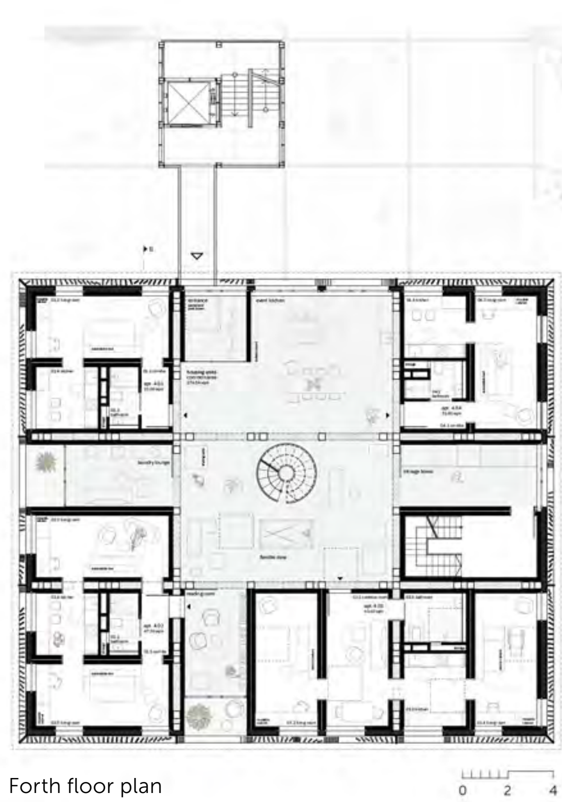
To counteract the high average space consumption per person our extension works with the concept of shared spaces, that help to reduce the individual provided space while still maintaining a high comfort. The individual living units are arranged around a public atrium open for interaction.

design challenge (dc) overview

Section

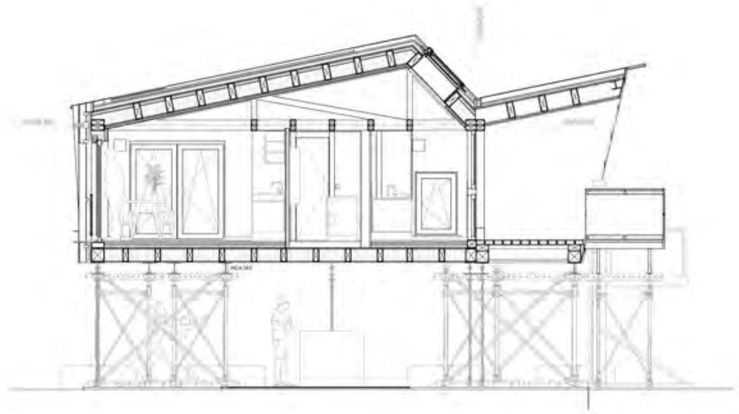


Isometry structure design



Forth floor plan

house demonstration unit (hdu) overview



Section

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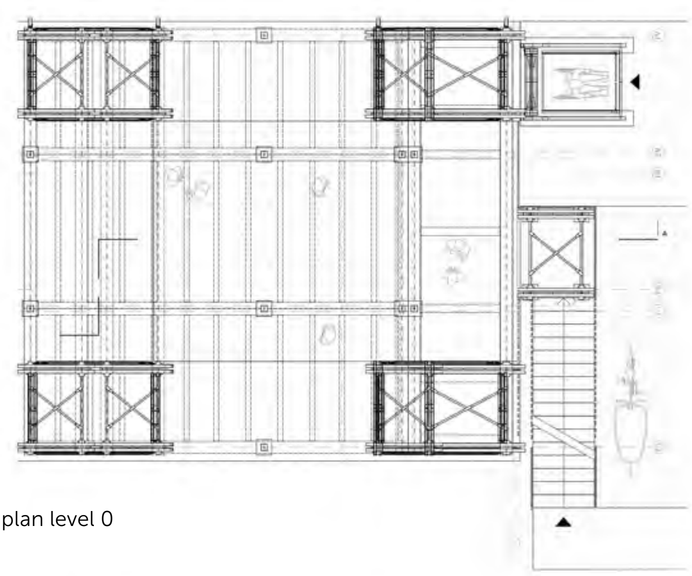
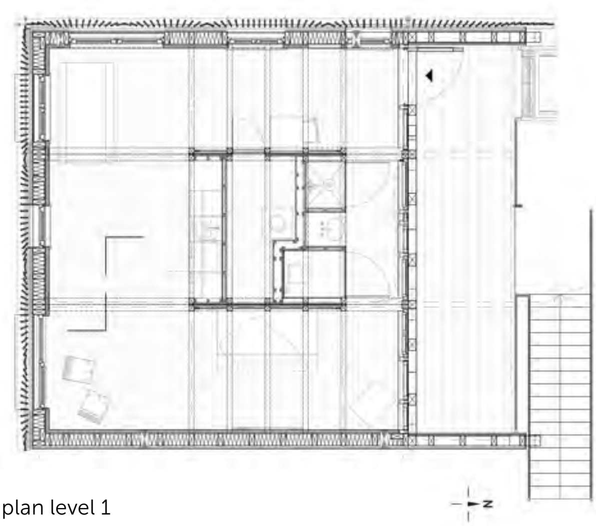


Floor plan level 0



Floor plan level 1

The HDU is perceived as a two-story structure that represents the residential units and the urban gap. The urban gap is portrayed as an exterior area below the HDU. It serves as a waiting area for the tours, a place to relax and interact, but also as a dance floor. As in the overall design, the HDU is built in modular timber construction and consists of four modules. The interior design in the form of custom-made furniture, allows flexibility and is space-saving at the same time. The open floor plan allows high space efficiency since no pure traffic zone exists. A functional core in the centre contains all the sanitary facilities, as well as the technical building equipment to keep the supply lines as short as possible.

house demonstration unit (hdu) details

roof

-	photovoltaic-thermal collector
0,7mm	copper sheet covering
30mm	shuttering
60mm	counter battening
-	roof underlay AMANN Sucotecto 0.8
24mm	diagonal formwork
240mm	wooden beams with seaweed insulation NEPTUTHERM
60mm	supporting wooden battens with insulation NEPTUTHERM
24mm	diagonal formwork
-	PE vapour barrier ECOVAP blue
26mm	installation area
15mm	ceiling panelling ECOR lightcore
2mm	felt covering

exterior wall and facade

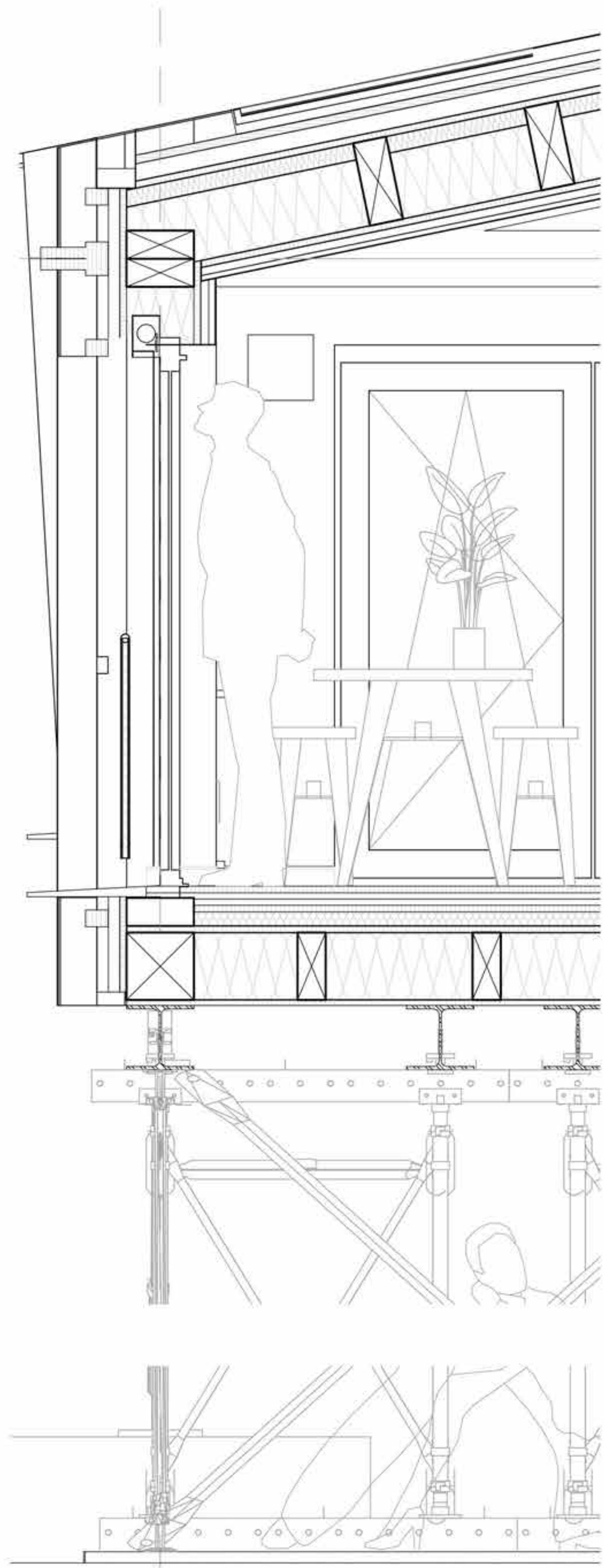
2mm	clay finish plaster
3mm	clay under plaster
22m	clay panel CLAYTEC Lemix
26mm	installation area
-	PE vapour barrier ECOVAP blue
24mm	diagonal formwork
240mm	wooden beams with seaweed insulation NEPTUTHERM
24mm	diagonal formwork
-	facade membrane DOERKEN delta 50
110mm	supporting wooden battens, myzel-based coating black
140mm	wooden slats, reused sunburnt wood

floor

25mm	wooden floorboards, partly reused wood
22mm	clay panel CLAYTEC Lemix
22mm	clay panel CLAYTEC Lemix
25mm	wooden formwork with underfloor heating
50mm	installation area
-	PE vapour barrier ECOVAP blue
24mm	diagonal formwork
240mm	wooden beams with seaweed insulation NEPTUTHERM
-	wind sealing TYVEK soft
20mm	diagonal formwork, partly reused wood

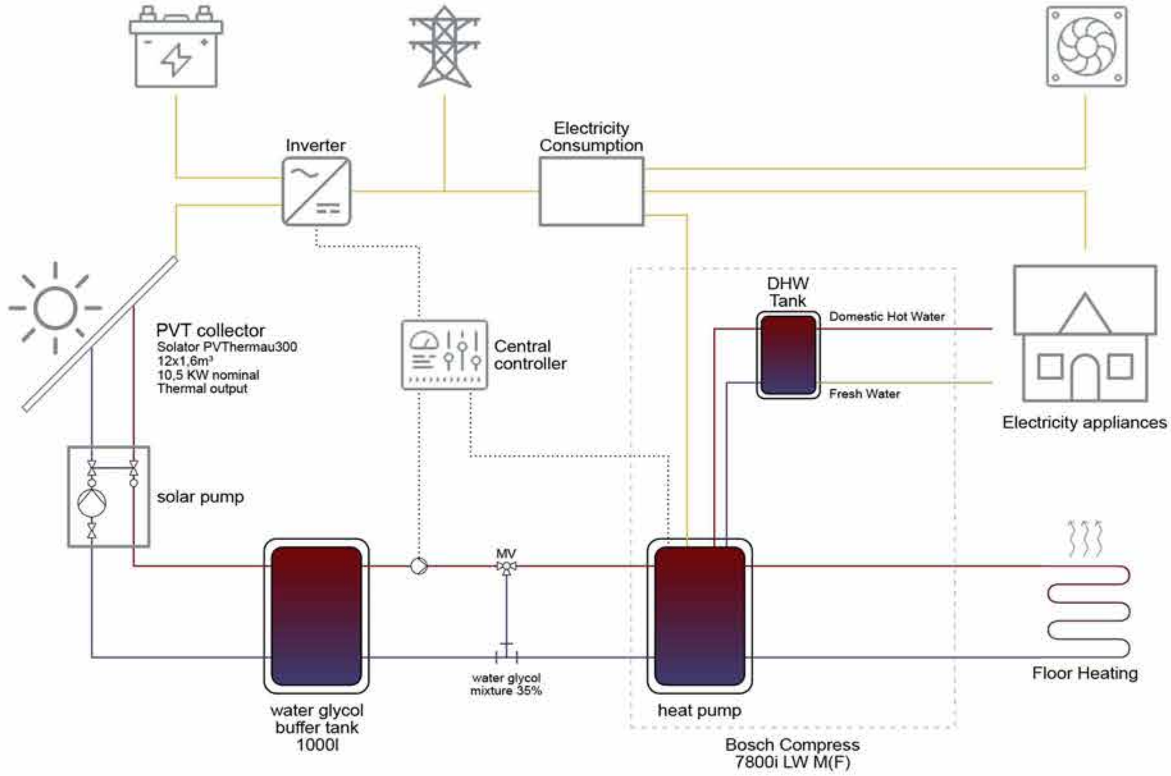
scaffolding

-	scaffolding DOKA STAXO 100 towers, steel



HDU constructive section

solar system



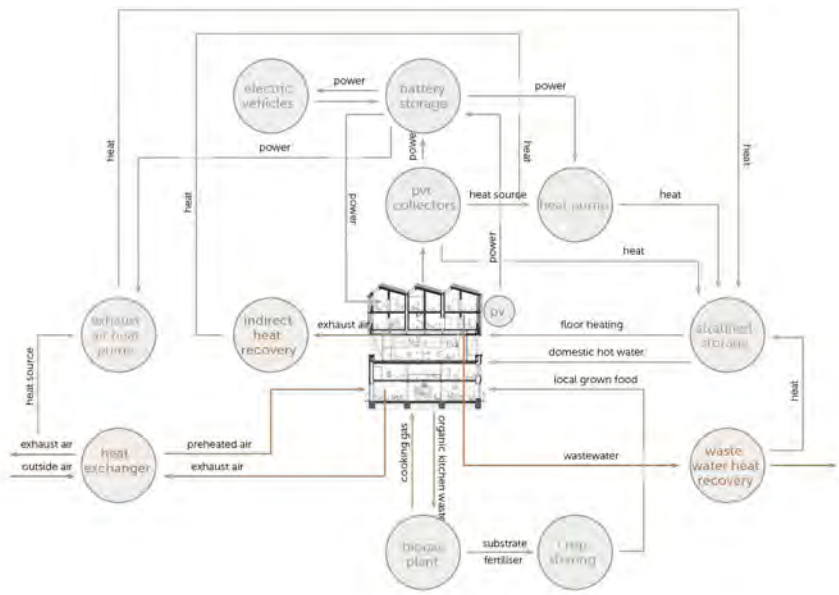
Schematic solar system

Team RoofKIT proposes an extensive use of the available surfaces on the House Demonstration Unit to be utilised for solar harvesting with the main approach of multifunctional use. On the south oriented sloped roof, a building integrated photovoltaic thermal (PVT) collector system is installed. The solar thermal collector serves as heat source for a high-efficiency brine-water heat pump that provides heat for the floor heating and domestic hot water production. The photovoltaic panels generate electricity to be consumed in the HDU.

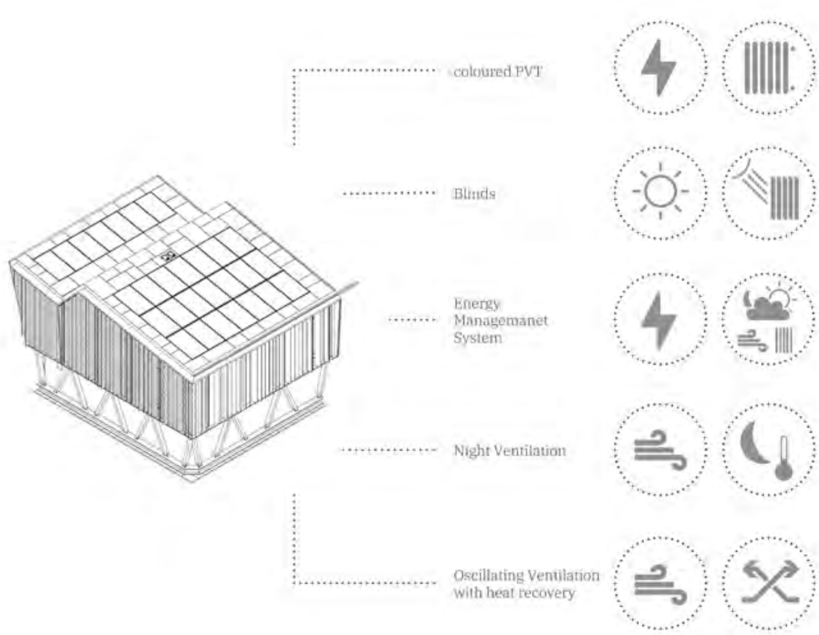
Any electricity surplus is stored in the battery system, or eventually fed into the grid. The PVT collectors are coloured in red, as part of the aesthetic integration in the roof. This double use of electricity generation and solar water heating would not be necessary for the HDU where photovoltaic and thermal collectors easily could be placed next to each other. As RoofKIT aims for solutions for urban contexts with less surfaces compared to the floor area, this innovative and multifunctional PVT system is used also in the HDU.

Exterior of the House Demonstration Unit
© RoofKIT, Zooey Braun/SDE 21/22

energy supply



Overview of the different technical systems and their interconnection



Concept of the HDU with its main innovations

Energy supply

The approach is a unit which does not need active cooling, especially during the contest period. To improve the energy performance of the house demonstration unit, in-depth dynamic simulations are performed to evaluate design decisions.

Envelope Thermal Properties:

As the House Demonstration Unit is mounted on pillars and therefore connected to air on all six sides, the envelope needs to meet the requirements for a passive house not only with its walls and roof but with its floor as well. To achieve this, the timber frame construction of the modules receives stuffing natural insulation with Neptutherm, which offers a comparatively good λ-Value of 0,046 W/mK. This insulation layer is applied all around the unit to prevent thermal bridges, especially in the range of the supports of the steel beams below the building. Another special feature of the HDU are the windows – here so-called stock windows, i.e. windows from or for other construction projects, are re-used for the HDU. The windows are triple glazed and have a U-value of 0.6 W/m^{2}K, minimizing envelope heat losses during winter.

Solar Harvesting:

The electricity generated by the PVT system as well as the façade photovoltaic system is used to cover the whole demand of the HDU during competition (heat pump, household electricity, mobility). The hybrid use of the PVT collectors is also beneficial as it increases the efficiency of electricity generation by cooling the PV cells with the brine circuit of the heat pump on sunny days. In order to distribute the harvested solar power to the consumer most effectively, RoofKIT uses a concept which distributes everything from the core of the unit. This allows to keep the electrical installation as compact as possible and makes the building process of the HDU much easier. Therefore, most of the sockets and lighting outlets are placed in or right next to the core. According to the yearly simulations, the HDU generates over 95% of the energy that is consumed by the building, almost achieving a net zero energy building.

indoor climate dc and hdu

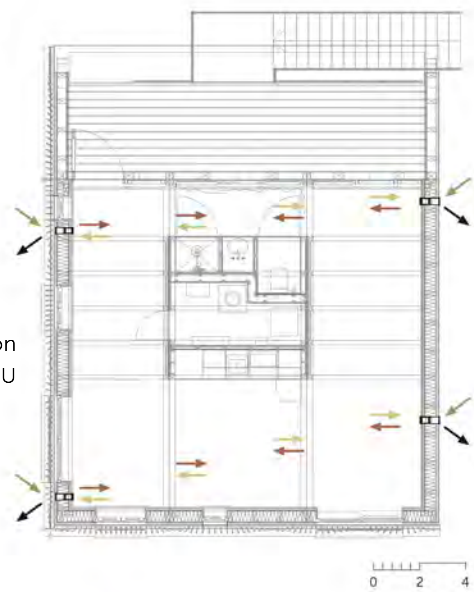
Concerning indoor climate, we took a closer look at the room temperature, air relative humidity and CO_2 concentration over the year. The implemented passive measures cater for an average room temperature of 22°C. In summer the integrated thermal mass stores the excess heat to stop the room from heating up further (clay boards are integrated into the inner wall surfaces as well as in two layers in the floor). Another benefit of clay as a building material is its sorption characteristics, which allows it to regulate air moisture by balancing out variations and peaks.

Natural ventilation at night ensures that the stored heat is emitted and transported out of the building so that the next day the thermal capacity is restored. Whereas in winter the thermal mass can contribute to buffer temperature variations, in order to prevent the room from cooling down too much. The building management system controls the night ventilation strategy, optimizing the opening of skylights and operation of blinds to achieve an acceptable indoor environment in summer.

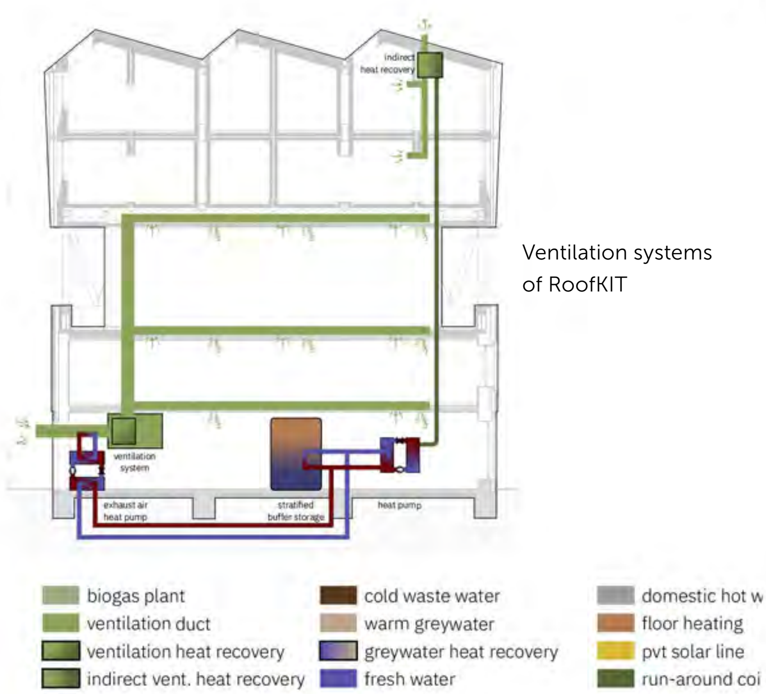
Due to the generous window areas compared to the rather compact building volume, the windows can generate enough cross-sectional area for ventilation when in tilted condition. Nevertheless we still recommend making good use of natural ventilation during nighttime to make the best possible use of the integrated thermal mass. As an additional action to regulate the CO_2 content in the best possible way, a decentralized ventilation system with heat recovery is installed that provides controlled air exchange rate in winter, without increasing significantly the heat losses due to ventilation. Therefore, using low-tech solutions with natural building materials and their positive characteristics a high level of comfort can be achieved in the house demonstration unit.

Mode of action thermal mass

Night ventilation strategy in the HDU



Decentralized ventilation systems in the HDU



Ventilation systems of RoofKIT

key figures, team and sponsors

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Miele

Others
Carstahl
Implenia
Lasten Velo
nimbus
RIBAG

RoofKIT

Further project information:
https://roofkit.de/de/

TEAM NAME | TEAM IDENTITY

VIRTUe | TUE

UNIVERSITY

eindhoven university of technology eindhoven, netherlands

TASK

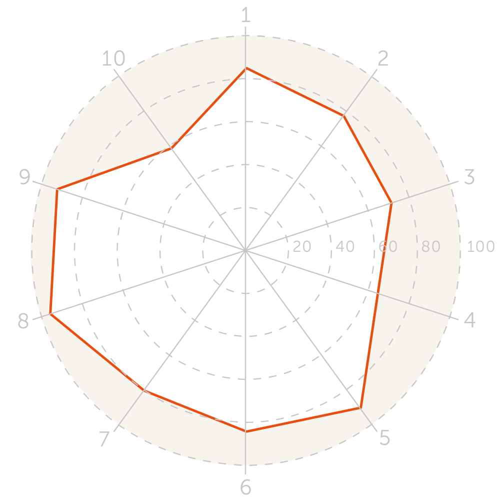
renovation and addition of storey

LOCATION OF DC

wuppertal

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	$1135\ m^2$	$63\ m^2$
	4	1
		$19\ m^2/p$

VIRTUe is a multidisciplinary student team at the Eindhoven University of Technology, working to drive the transition towards sustainable cities. The construction and operation of buildings are responsible for 39% of the CO_2 emissions. While the demand for new homes in the cities keeps growing, the building industry uses obsolete methods and materials. Meanwhile, people consume large amounts of space, power and materials. Humanity is stuck in a destructive loop where neither industry nor individuals give sufficient incentives to each other to change. VIRTUe aims to break this loop through an integrated approach to sustainable building and living, with the following goals:

1. Future-proof buildings

2. Normalisation of low-impact living

“Ripple” is inspired by the ripple effect. Like a drop in the water, the project creates a ripple of influence in buildings with a public function. Ripple can be applied universally whilst being tailored to the context of each city and can create a growing impact.

To future-proof buildings, the “Ripple” philosophy introduces design in three layers: fixed, flexible and free. The fixed structure has the longest lifespan and allows the façade and the bathroom and kitchen modules to be adaptable. The free layer of furniture, bio-based materials and reused wood makes the building circular. The façade has a “solar belt” to accommodate customised PV Thermal panels. Situating solar panels on the façade frees up space on the roof for biodiversity and the residents.

We normalise low-impact living by creating smart communities. The “Ripple” design approach differs from the typical building block by replacing corridors with communal rooms to share appliances and activities. One modular unit contains two small yet comfortable apartments and a communal room to encourage social interaction among neighbours. This room houses EQUI Librium, an interactive display that bridges the gap between energy production and consumption by running appliances at the optimal time of day.

urban context and mobility

The first application of Ripple is designed for Wuppertal, characterised by its hilly environment and an abundance of trees. Nowadays, Wuppertal is a car-dominated city in a network of many neighbouring cities.

VIRTUe plans to reduce the capacity for motorised traffic in Wuppertal to reclaim space for active and shared mobility, promote social engagement and make sustainable travel behaviour easy and obvious. To do so, transit stations of varied sizes and purposes are built throughout the city to provide the infrastructure needed for the transition to active and shared mobility. The space gained by removing the cars is returned to green spaces, animals and people.

The urban plan also focuses on social sustainability and how public spaces can be designed to encourage social interactions. Social hubs on public squares accommodate functions for the local communities such as day care centres and flex offices. We have developed a 20-year vision in which the urban mobility plan is rolled out in three phases to eliminate car dependency and replace it with solar-powered public transport.

Mobility Map of the Mirke area

Design Challenge Context Plan

Mobility station impression

design challenge (dc) overview

VIRTUe renovates the existing building of Café Ada and integrates the residential block as a vertical extension, using the roof space available in cities. The modular design follows the tessellation shape that offers many possibilities to create a larger apartment block without repetition of the same space.

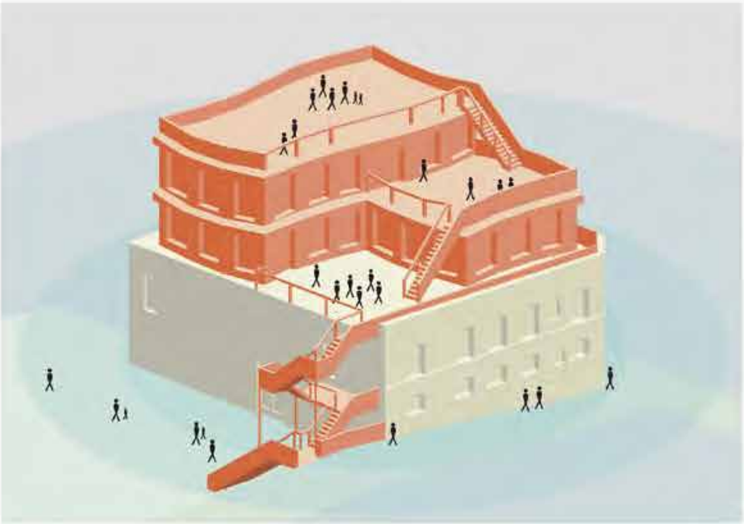
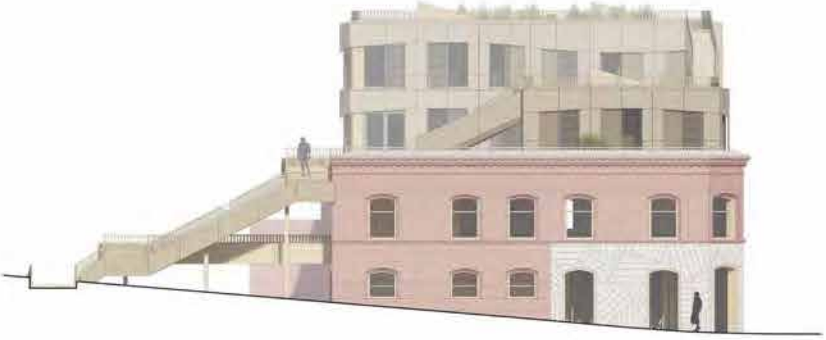
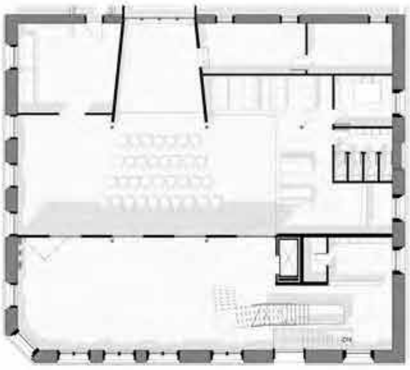


Diagram of our Design Challenge concept

Floorplan of the First floor of the Extention

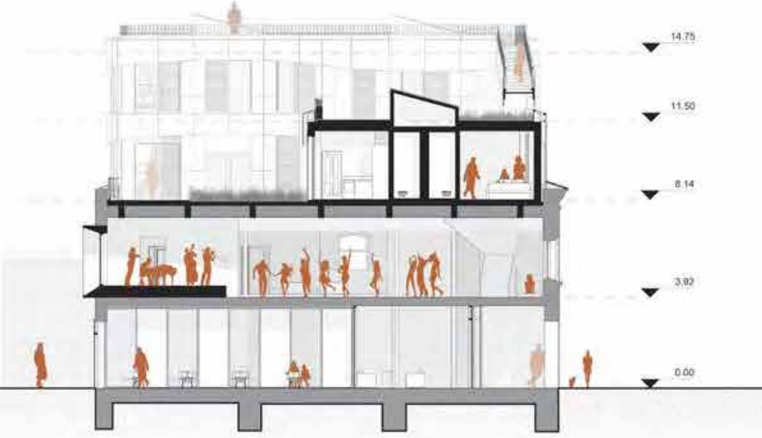


Elevation



Floorplan of the first floor of the renovation

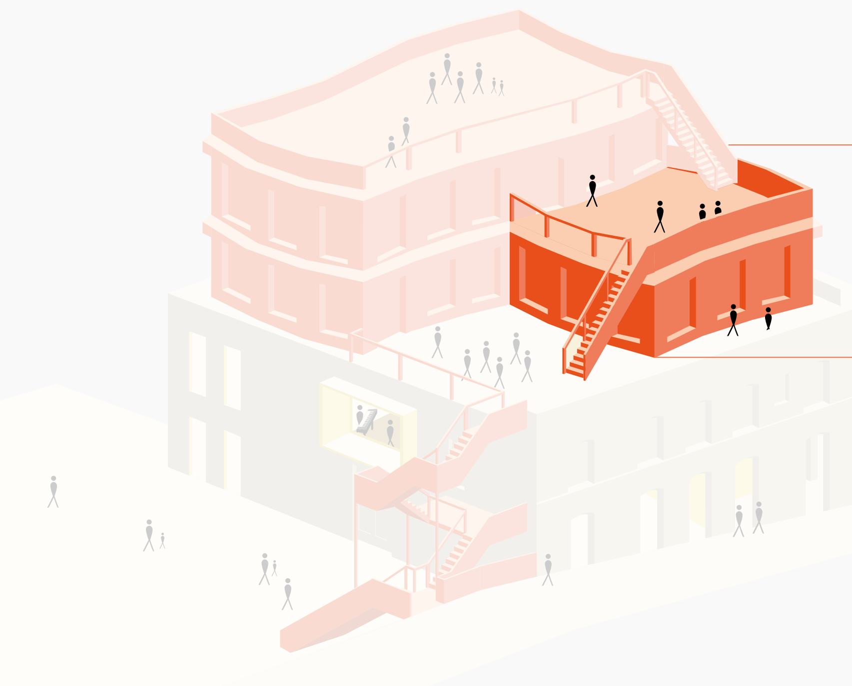
Section east to west

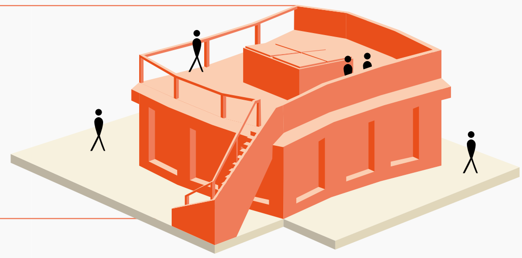


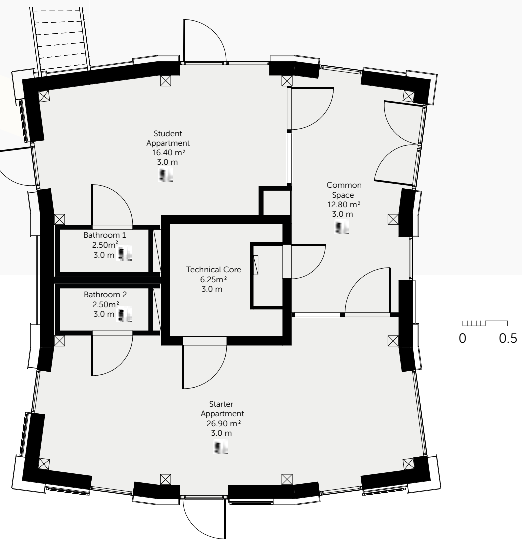
Section north to south

house demonstration unit (hdu) overview

RDU Representation







RDU Floorplan

RDU in context of the competition

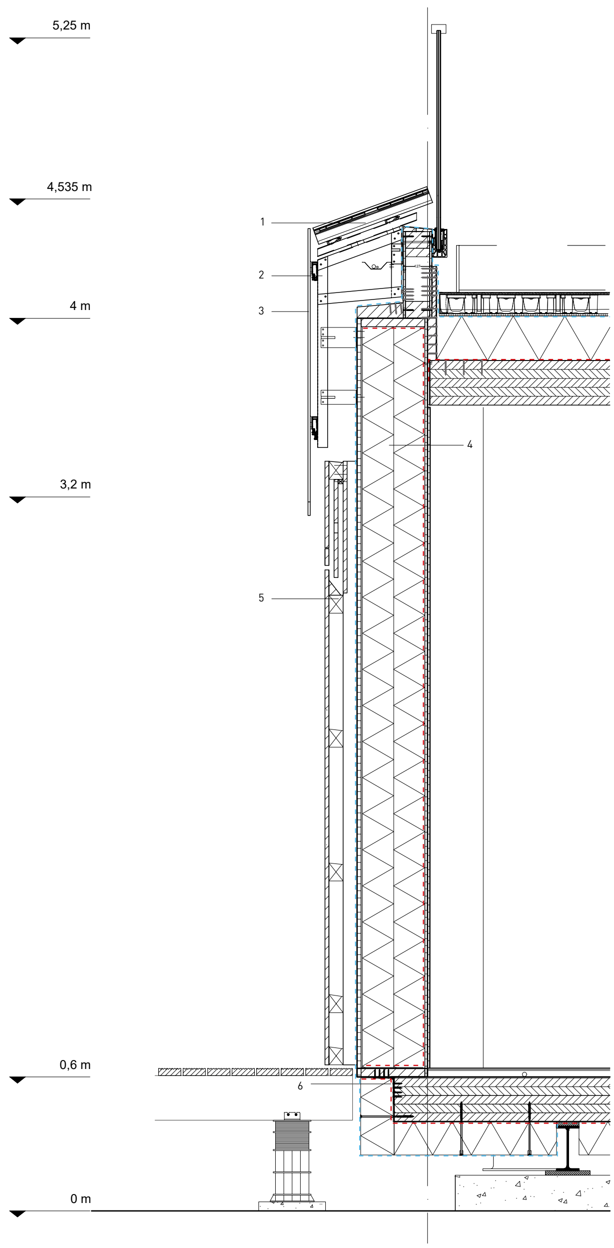
The ripple concept becomes reality in the Ripple Demonstration Unit (RDU), a highly efficient living unit for two households, where circularity coexists with innovative technologies.

The RDU is designed in layers to maximise circularity and adaptivity. The central core containing all the installations is controlled by the residents through EQUI, a smart interface in the communal room. This shared space and a green roof encourage low impact living by sharing resources and inspiration. The attractive façade is wrapped in a customised solar belt catching the sunlight throughout the whole day. The urban concept is represented on the platform of the RDU through collective solutions, such as urban farming and shared mobility.

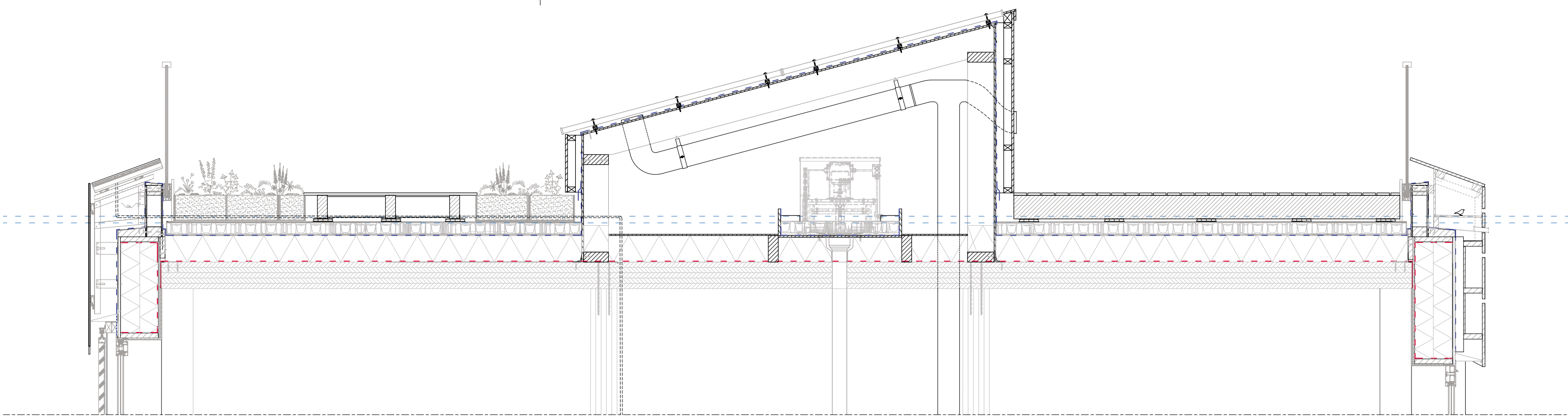
house demonstration unit (hdu) details

It is on the detail level that the concepts of ripple are worked out. The approach of designing in layers, as well as the necessity to make the house fully demountable, posed challenges in the façade and roof design, requiring a new mindset in detailing.

The RDU is designed in layers, so that every element can be separated and reused. Examples showing the design in layers are the build-up of the roof and the floor.



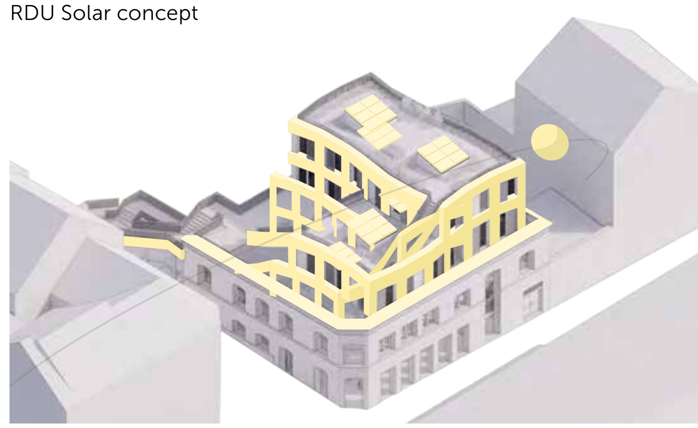
1. Colour Blast Solar Panel with PV
2. Aluminum Substructure
3. Colour Blast Dummy Panel
4. 12 mm Multiplex
   12 mm OSB Vapour Retarder
   286 mm Isovlas Insulation
   18 mm Multiplex
   Damp Open Foil
   210 mm Aluminiumsubstructure
   Colour blast glass panels
5. Shutter
6. Aluminium Window Frame
7. L-profile



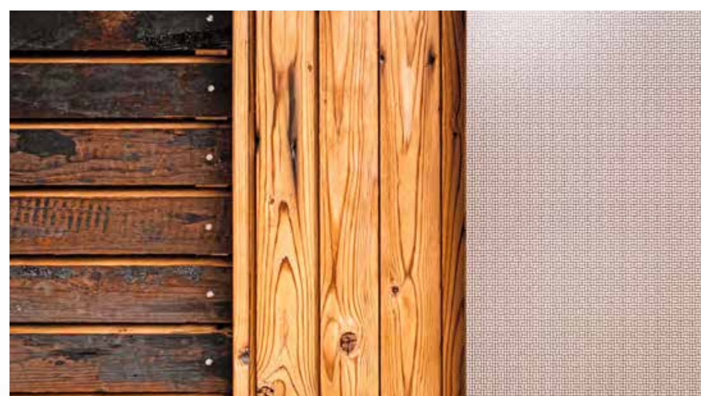
solar system

The Ripple Demonstration Unit is ‘wrapped’ in a solar belt (on the upper edge of the house), which is integrated into the design of the façade on three sides and thus catches sunlight throughout the whole day. The north side of the façade instead hosts a bird hotel. The attractive solar façade allows the roof to be usable space for the residents and welcomes greenery, stimulating biodiversity. The innovative colour-matching technology used and the unique tessellation pattern reproduced on the PV panels allow the solar system to integrate with the wooden façade.

RDU Solar concept



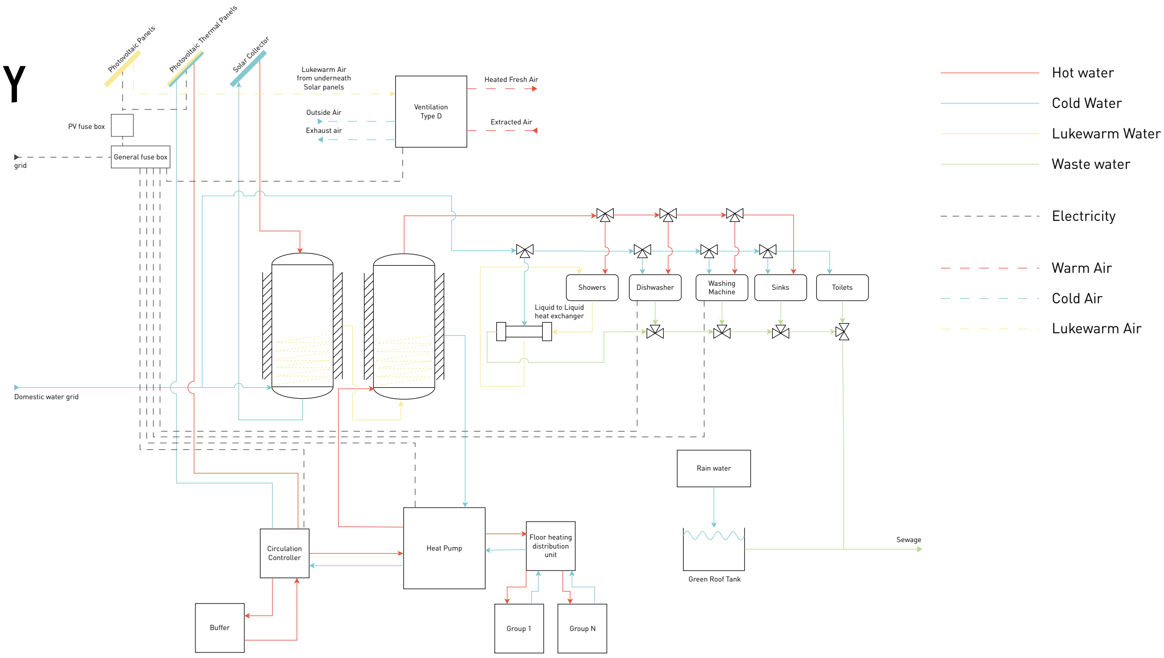
Design Challenge solar panel arrangement



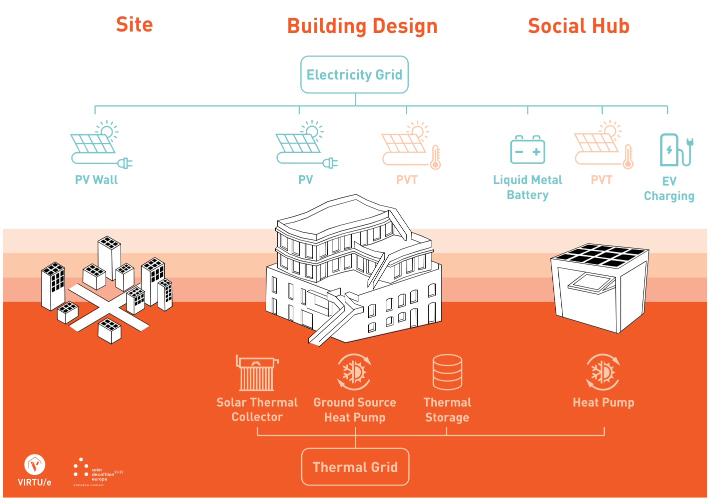
Solar panel materiality

Design Challenge solar panel arrangement

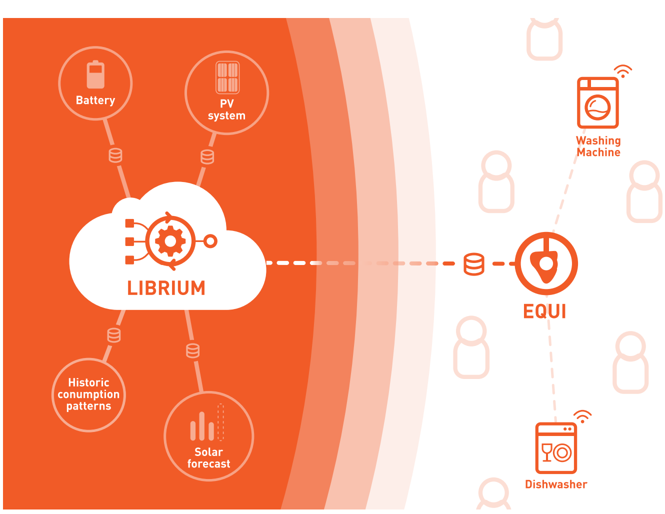
energy supply



RDU systems diagram



Energy concept



Equi, managing electrical apliences to maximise solar energy usage

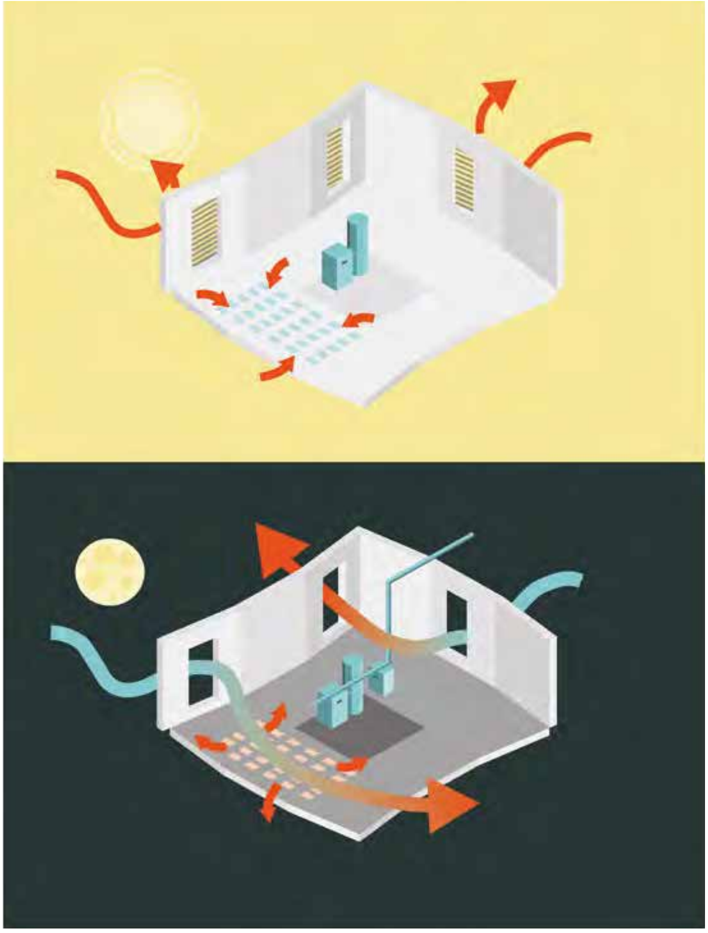
The Ripple Energy Concept reduces the energy demand, achieves energy positivity, and decarbonises the energy supply. The energy concept covers electrical and thermal energy production, storage, and management while being linked to our urban mobility strategy. The energy demand is reduced through a combination of active and passive solutions. Decarbonisation can be achieved by reducing the energy demand, through the smart management of the energy and by reaching energy positivity.

Thermal energy is generated through PV Thermal, solar boiler, and ground heat pump, while the energy demand is reduced by hot-fill appliances, heat-recovery dynamic ventilation and shower, automated shutters and tiny living.

The energy demand is furthermore reduced through user behaviour. For this, we have developed EQUI Librium. EQUI is a smart home interface that helps users monitor their energy consumption and schedule appliances. Librium is the brain behind the energy system, which bridges the gap between energy production and consumption by scheduling appliances at the optimal time of the day.

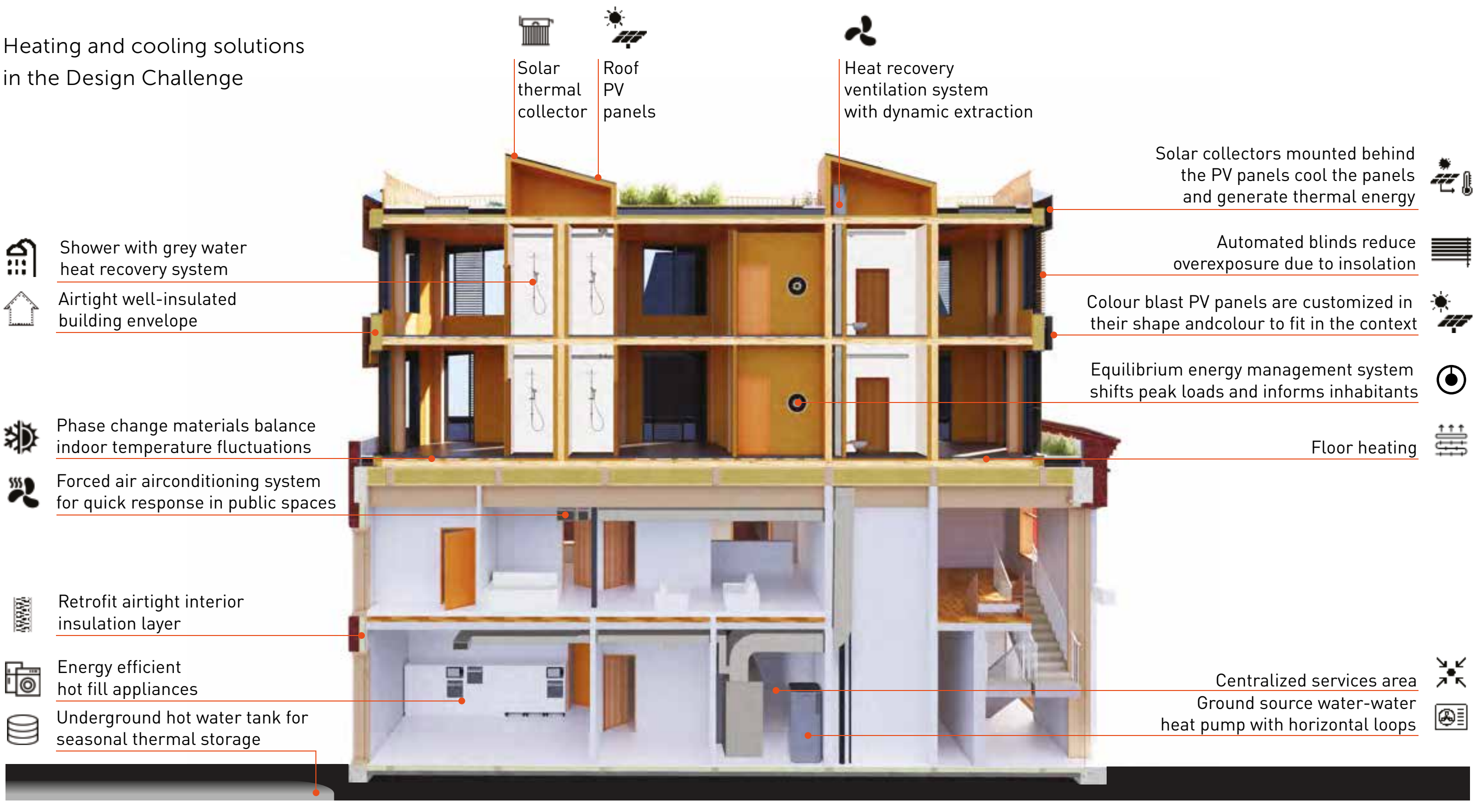
indoor climate dc and hdu

The indoor climate is controlled by ventilation, PV Thermal and floor heating, which also contribute to reducing the energy demand. Some of the measures taken to achieve this are a highly insulated and air-tight building envelope, heat-recovery dynamic ventilation and automated shutters for shading. Because the wooden building has a low thermal mass, Phase Changing Materials are used in combination with floor heating to balance and reduce the heating needs and to stabilise the indoor temperature passively. In this way, the outdoor conditions can be taken advantage of, and they do not necessarily interfere with the living conditions. Instead, they are optimally used to ensure a comfortable indoor environment.



Ventilation Diagram

Heating and cooling solutions in the Design Challenge



key figures, team and sponsors

VIRTU/e

Further project information:
https://teamvirtue.nl

Main sponsors:
Eindhoven University of Technology (TU/e)
Stam De Koning Bouw
JONGEN Bouw
De Volksbank

Project consultants
Count & Cooper
Holland Innovative
Kenneth + Smit
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Bex*

Transportation & travel
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Orange Climate
Zehnder
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Solar Crew
HVP Duurzaamheid
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Building envelope
Heko
Rothoblaas
Isovlas
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WEBO
Faay
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Exterior / interior finishes
Hamwells
De Houtgroothandel
Kameleon Solar
Steinfort Glass
Bernhagen Natuurkeukens
Sunshield
Reynaers Aluminium
Mosa Tegels
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Vlakglasrecycling
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Innodura
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ASW
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Vermeulen
Sustonable
Galvano Metaal
Hoppenbrouwers
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ATAG

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Stactics
Bureau Moeilijke Dingen
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Van Hees
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Provincie Noord-Brabant
Technobroker
Omines
Team CASA
Brainport Smart District

Events
Boels
De Zwarte Doos
RGB Silent Disco Lab
Mobile Stories
Greengiving

TEAM NAME | TEAM IDENTITY

Team Sweden | CHA

UNIVERSITY

chalmers university of technology gothenburg gothenburg, sweden

TASK

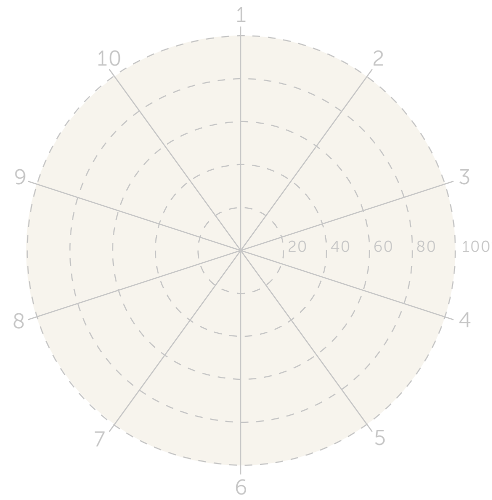
renovation and addition of storey

LOCATION OF DC

gothenburg

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	1716 m²	57 m²
	4	1.5
		32 m²/p

The C-Hive project is divided into two main parts – the Design challenge (DC) and the HDU.

The DC building is a commercial space with a high footfall containing a grocery store and a second-hand shop. By using lightweight cellulose-based and 3D printed constructions on the rooftops, the urban area can be densified in areas where space is limited yet valuable. 3D printing technology could also be employed in-situ allowing for customizable solutions and minimizing impacts from shipping.

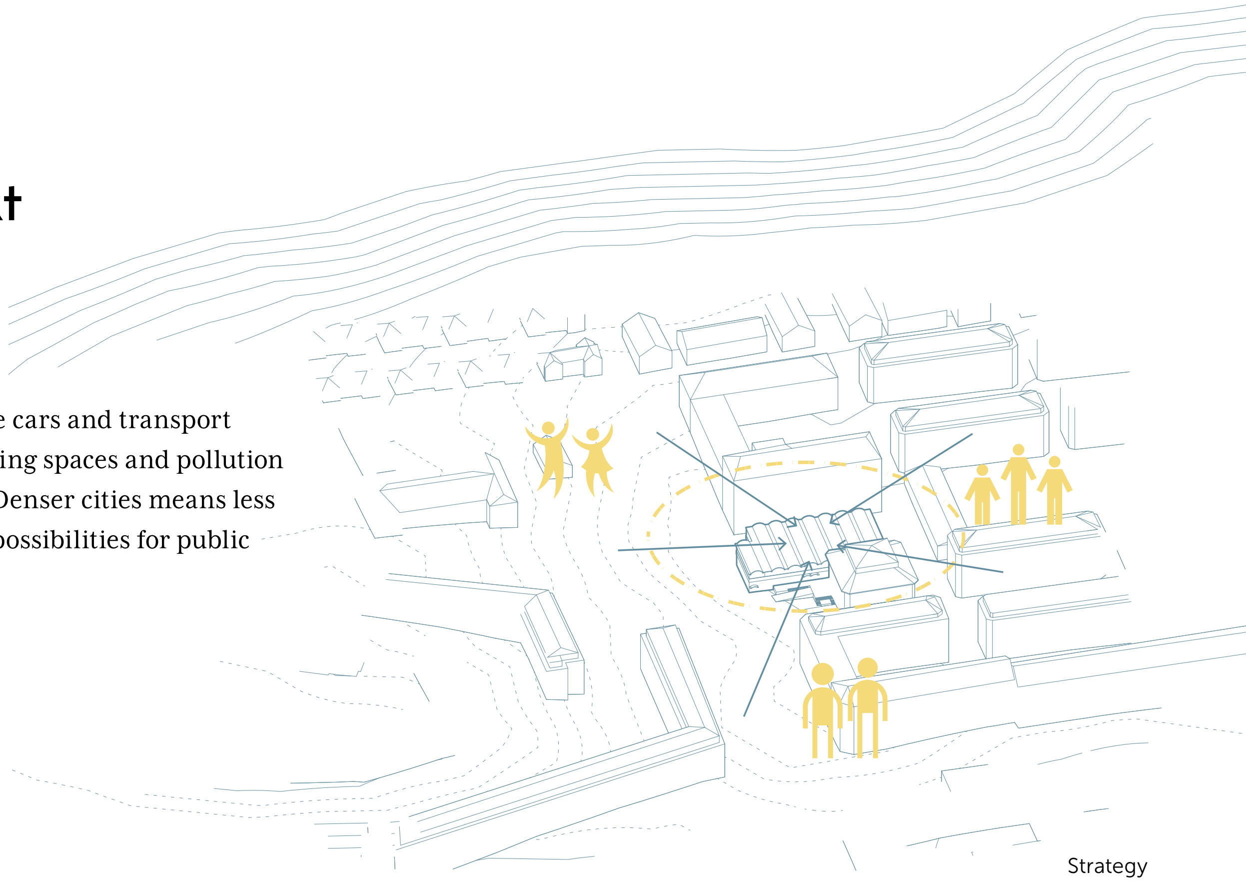
Extra floors would also be a way of financing the upkeep of the original building. Moreover, this would enable more people to live close to nodes where public transport, shops and services are more available.

Inside the DC building, we suggest a collective living space where spaces are shared with neighbours while still keeping the option of having private space. Living close to neighbours can have many benefits. Spaces like a gym, library, aquaponic garden or community kitchen could be shared and enjoyed by all residents.

Resources could be shared, especially those the residents do not regularly use, like workshop tools, cars or electric vehicles. Likewise, access to emergency services would be better. The same goes for exchanges of services. By sharing spaces, being alone becomes a choice and not something forced upon you by the conditions of the environment.

urban context and mobility

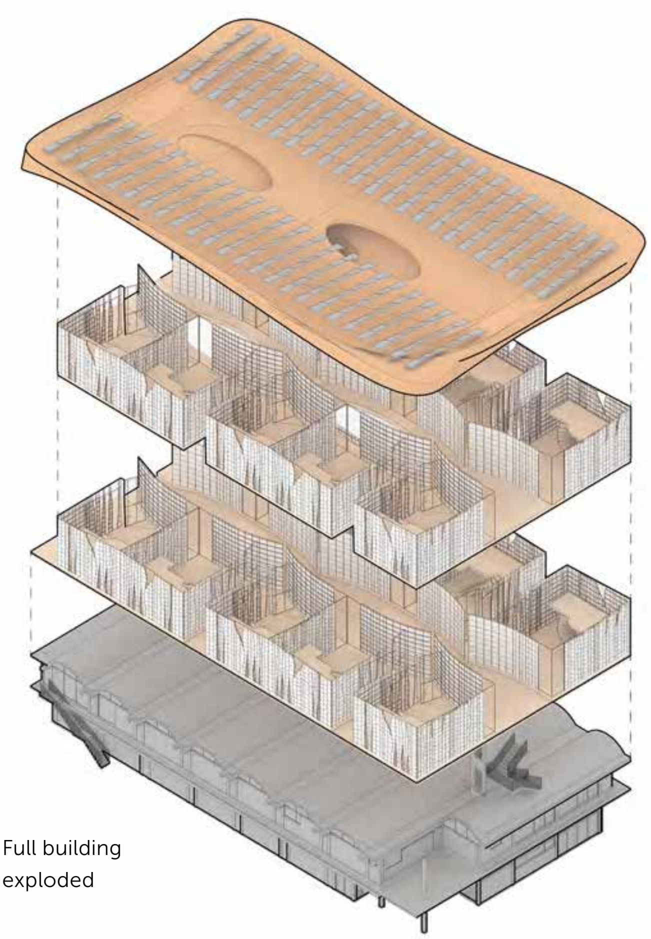
Sharing is caring. If more cars and transport vehicles are shared, parking spaces and pollution levels could be reduced. Denser cities means less need for cars and better possibilities for public transport.



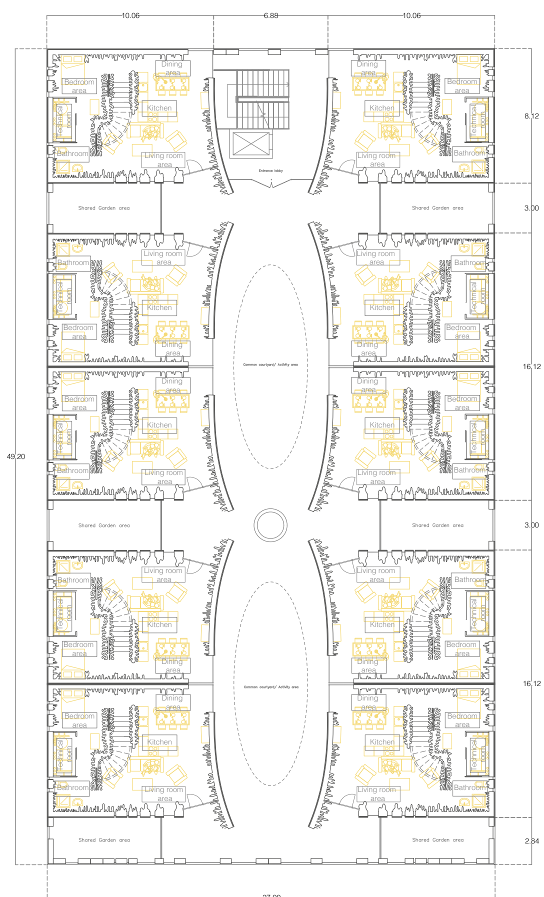
Strategy

Site context

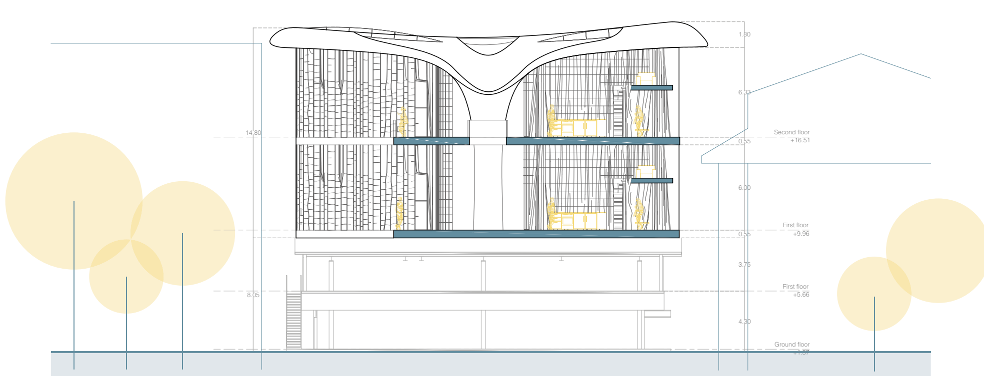
design challenge (dc) overview



Full building exploded



Floor plan



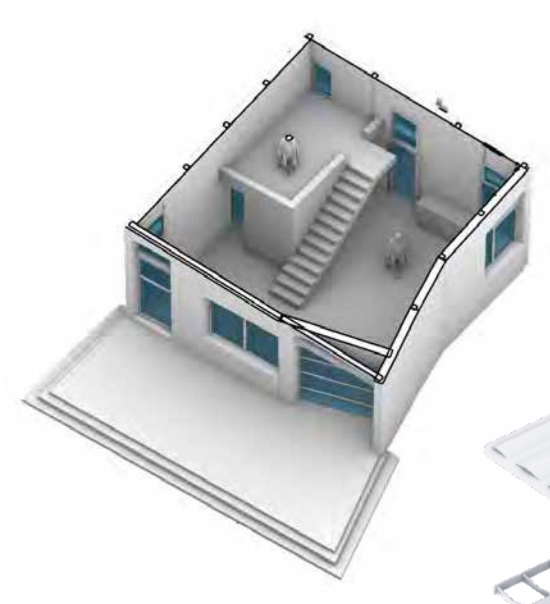
Section

house demonstration unit

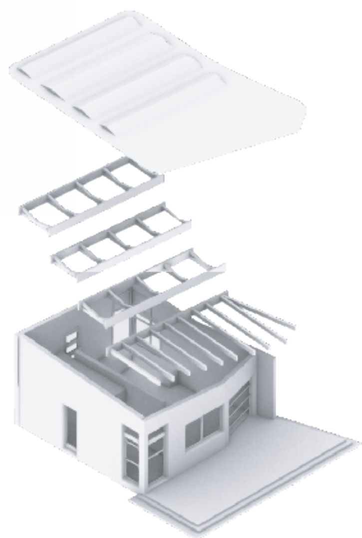
The HDU design has two main stand-outs. The first is an innovative use of cellulose and the second is the reuse and circular design.

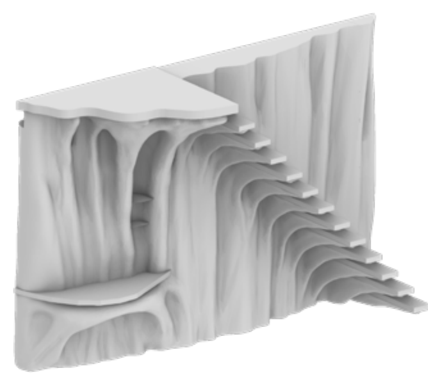
Engineered timber is used for the structure employing a newly developed construction method. 3D-printed cellulose will for the first time be used as both a facade material and a material for interior building elements. Green wood is used in the east facade in the interest of saving energy and making a double-curved facade which would be impossible with traditionally dried wood.

Many elements of the building are reused. This goes for the windows, doors, kitchen and flooring. All parts of the building are made with disassembly in mind so that the building elements can be reused.

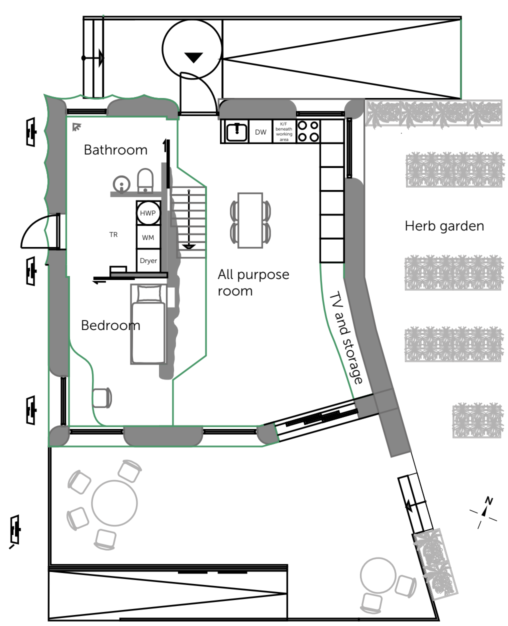


Axonometry of HDU





3D-printed wall



Floor plan

Detail construction

key figures, team and sponsors

Further project information:
https://c-hive.com/

Sponsors

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Pretec
Sweco
Circlab
Takcentrum
Montano
Moelven
Chalmers Students for Sustainability
ELBV
Unidrain
Göteborg Stad
Claytec

TEAM NAME | TEAM IDENTITY

FIRSTLIFE | CTU

UNIVERSITY

czech technical university in prague prague, czech republic

TASK

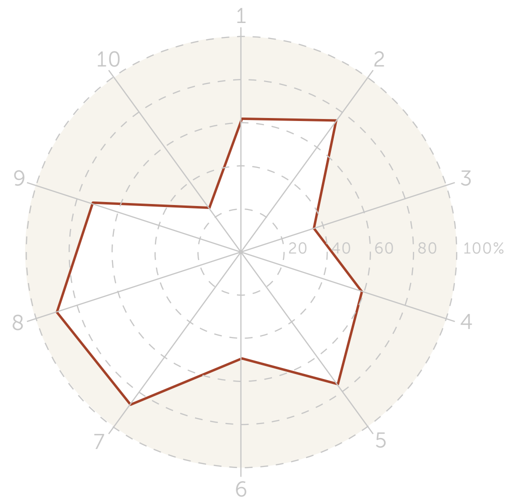
renovation and addition of storey

LOCATION OF DC

prague

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



Visualisation of the Design Challenge

DC

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	8252m²	68m²
	7	1
		66m²/p

There is a general lack of student accommodation in Prague. Rental living is too expensive and capacity of student dormitories is insufficient. Moreover, most dormitories were built in the 1960s and do not fulfil current living standards: tiny rooms usually for two persons with no option of variety, shared sanitary facilities and kitchen for the whole floor, hardly any services and generally outdated concepts. Besides this, only part of the buildings has been renovated and original building systems are inefficient.

Our vision is focused on following goals in order to make a corresponding upgrade with minimum negative impact on the environment:

→ increase student accommodation capacity and living standards;
→ improve the overall energy performance of the whole building;
→ solution applicable to a wide range of similar buildings, besides student dormitories;
→ solution adaptable to different uses, not only for student accommodation;
→ respect the architectural, urban and social context of the locality.

The interdisciplinary team consisting of students from four CTU faculties, supplemented by students from other universities, has developed a system for addition of storeys onto an existing building. Prefabricated elements reduce the assembly time and thus, minimise the inconvenience caused to the inhabitants from the existing building and its surroundings.

The model building is the Větrník dormitory in Prague, Břevnov district, built in the 1960s. Besides new student rooms, an important part of the design is its multifunctional community spaces like a communal kitchen/living space, habitable roof with pergolas as a part of the new storeys and a covered space in the yard for cultural events or study.

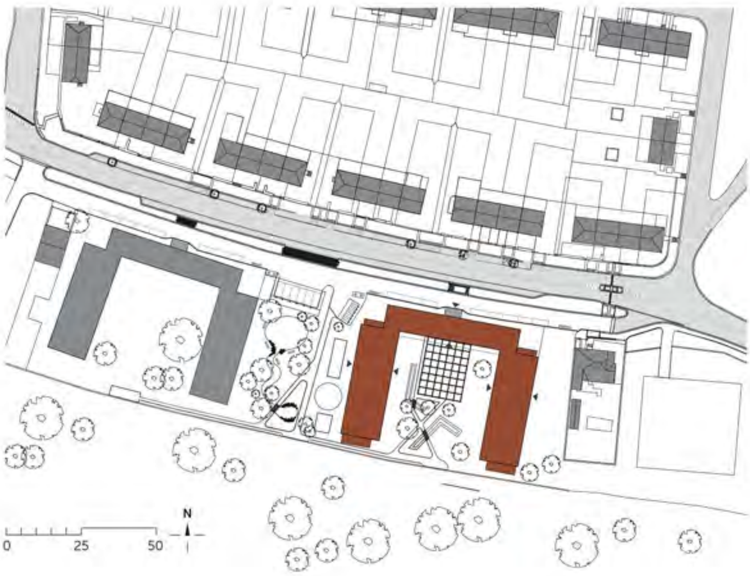
New roofs accommodate greenery and solar panels on shading pergolas. A new HVAC system supported by a smart measurement and control system is installed; a ventilation system with heat recovery for the heating season is being considered. Enhanced water treatment consists of a new rainwater management system and root waste water treatment plants.

Envelope improvements of the current building consist of insulating façades and window replacement. Room layout in the existing building is adjusted to increase living standard of the whole building.

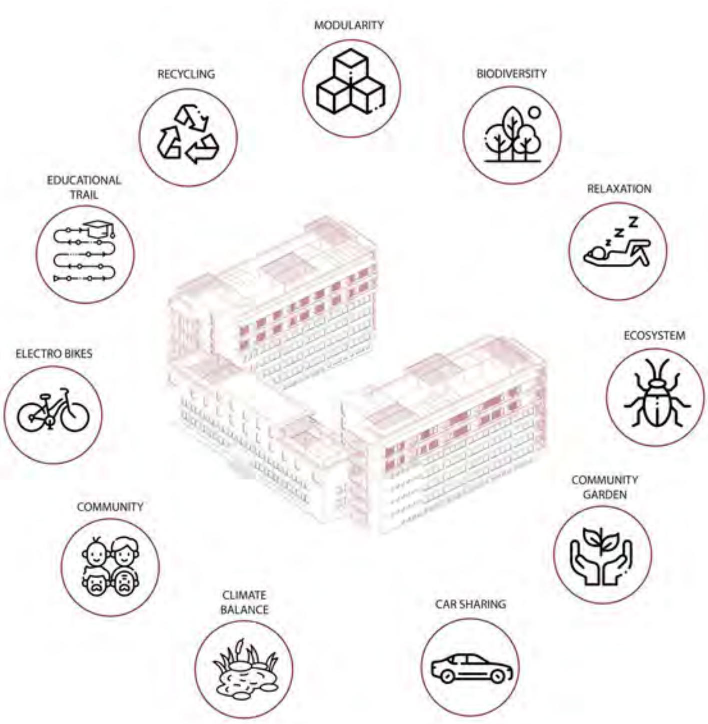
urban context and mobility

The design challenge location lies in the Petřiny district in Prague and is situated at the top of a hill. Its structure is a mixed urban neighbourhood. In part, it consists of homogeneous low to mid-rise residential buildings, usually family houses or villas with private gardens defined by fencing. The Petřiny district can be considered a compact urban space, with a close accessibility to public amenities and fantastic traffic coverage. The only aspect lacking to make it a working neighbourhood of short distance is the absence of an appropriate interconnection of public pathways and pavements, as well as lacking safety measures for cyclists.

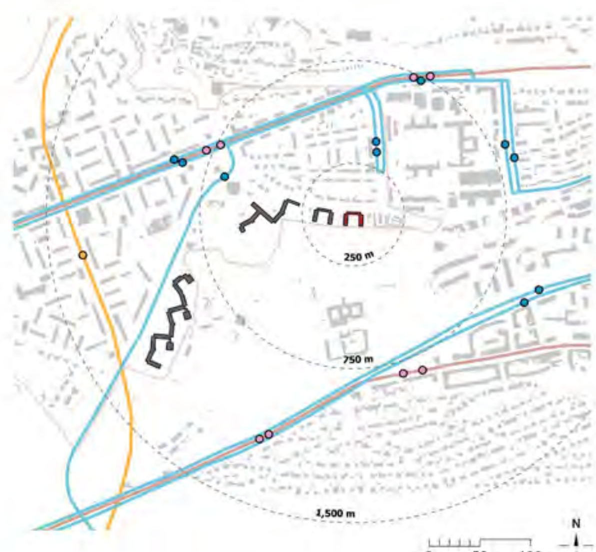
We focus on the comfort of the whole neighbourhood. To encourage more sustainable travel, we create a set of mobility hubs where the commuter would leave their car and use other means of transportation: parking spaces for shared e-bikes and e-cars on the site, bicycle pumps and associated services and informative panels to encourage more sustainable travel in the neighbourhood and to educate the general public.



Site map



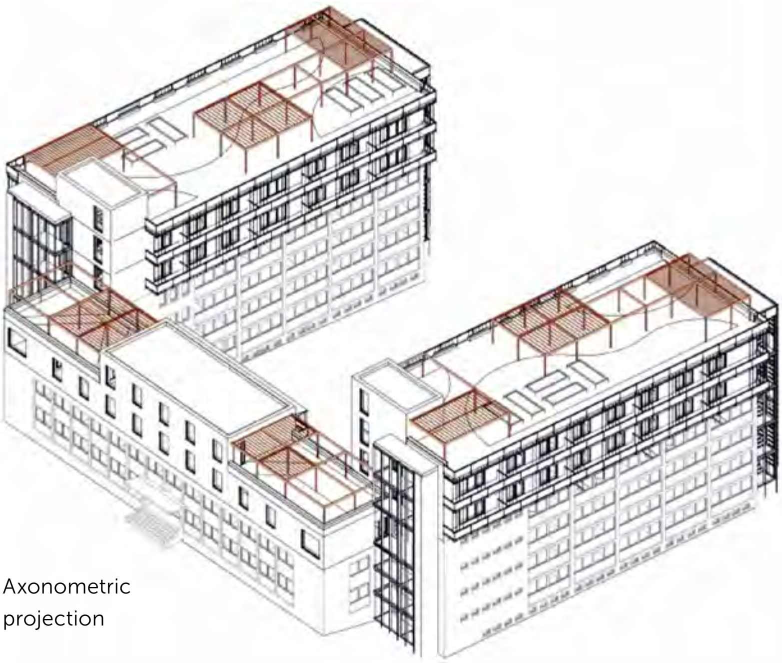
Site map key



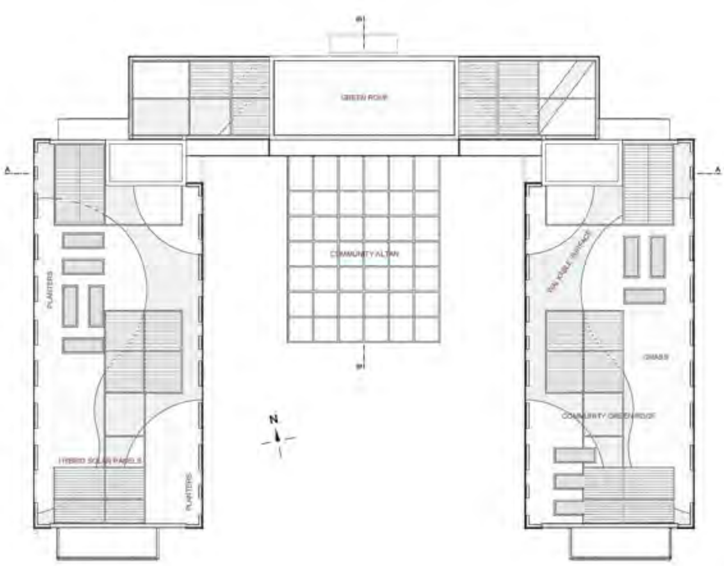
Locality plan and mobility situation

- bus stop
- tram stop
- metro station
- bus
- tram
- metro
- range rings
- other dormitories
- First life target building
- Petřiny district boundary

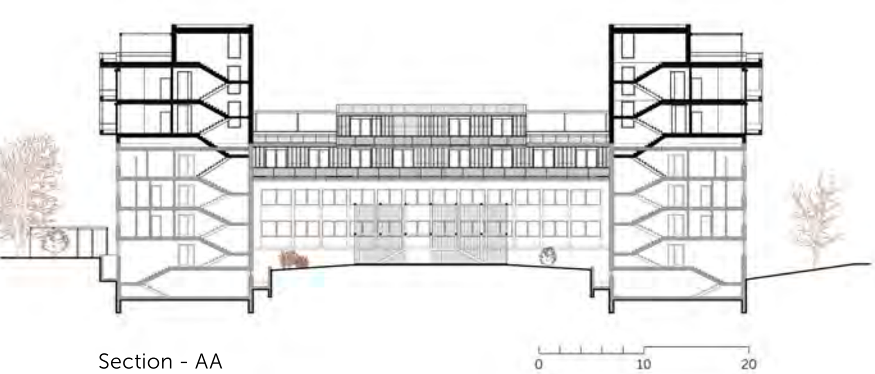
design challenge (dc) overview



Axonometric projection



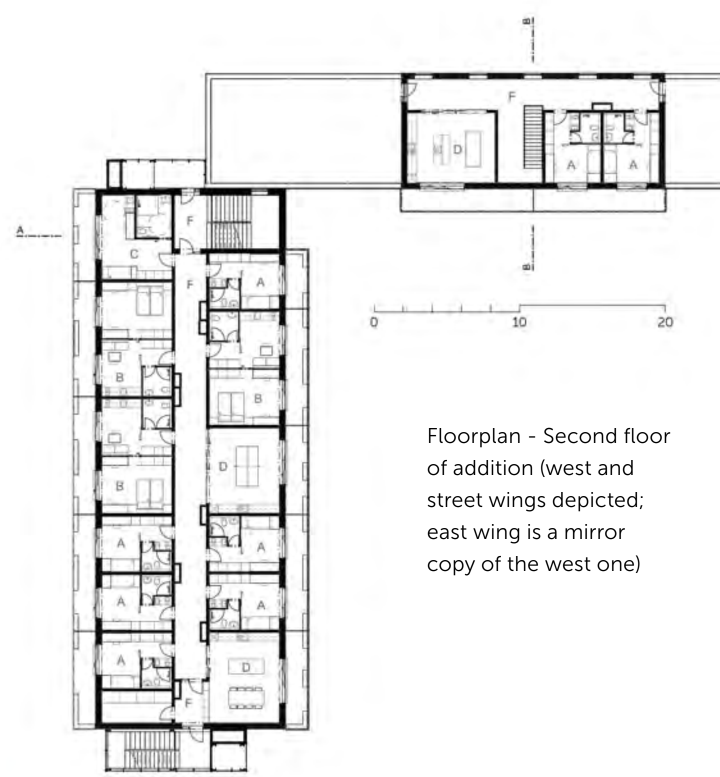
Roof plan



Section - AA

Additional storeys offer single- and double-bed rooms, from which some are barrier-free. Each room has its own bathroom, a kitchenette and access to lengthwise balcony. Multi-purpose community rooms equipped with in-built kitchens at each floor enable social life to thrive. Inhabitable green roofs with shading pergolas carrying photovoltaic and hybrid photovoltaic thermal panels serve as an outside community space. Insect hotels and herb and vegetable planting increase biodiversity and food self-sufficiency.

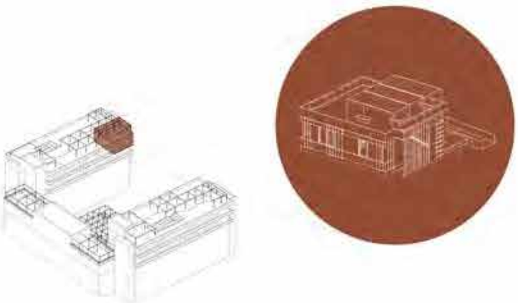
The load from the added storeys is transferred to the existing building via a wooden grid independent of the construction system of the existing building, making the solution applicable to wide range of buildings. The new lightweight timber structures supplemented with thermal insulation from natural materials minimise the additional load as well as the carbon footprint. External staircases accommodate a vertical root waste water treatment plant forming a pleasant green element. New covered space in the yard offers multifunctional communal spaces, providing space for study or holding events.



Floorplan - Second floor of addition (west and street wings depicted; east wing is a mirror copy of the west one)

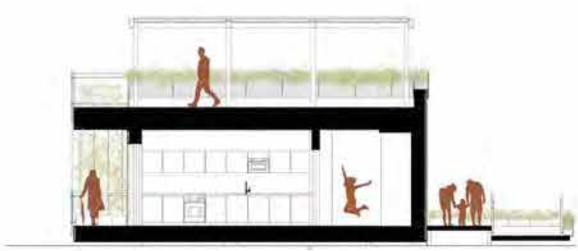
house demonstration unit (hdu) overview

In the HDU, a single student room and a community room are presented. The focus is on the variability of the space, which is shown through movable and expandable furniture as well as multi-purpose equipment. The rooms are connected by a balcony extending the interior living space and providing pleasant shade by a roof overhang. Climbing greenery shades the balcony during the warm period of the year. Building systems are concentrated in a technical module located inside the HDU in the corridor to minimise the amount of building envelope penetration. An exterior staircase leads visitors to an inhabitable green roof with shading pergolas carrying lightweight PV lamellae. The staircase structure bears a vertical root waste water treatment plant demo and hides the exterior heat pump unit and e-bike charging station behind a vertical assembly of wooden transport pallets, collected from all other competition teams to symbolise cooperation and circularity.

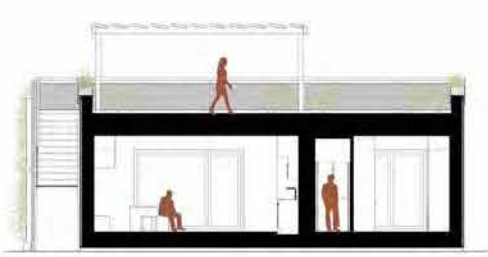


DC to HDU transformation

Axonometric projection

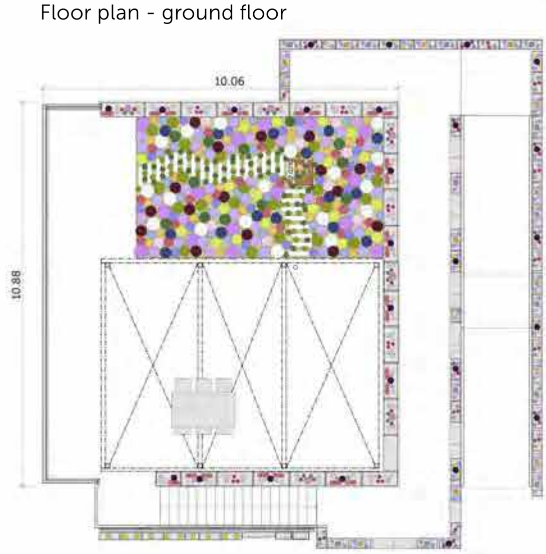


Section A



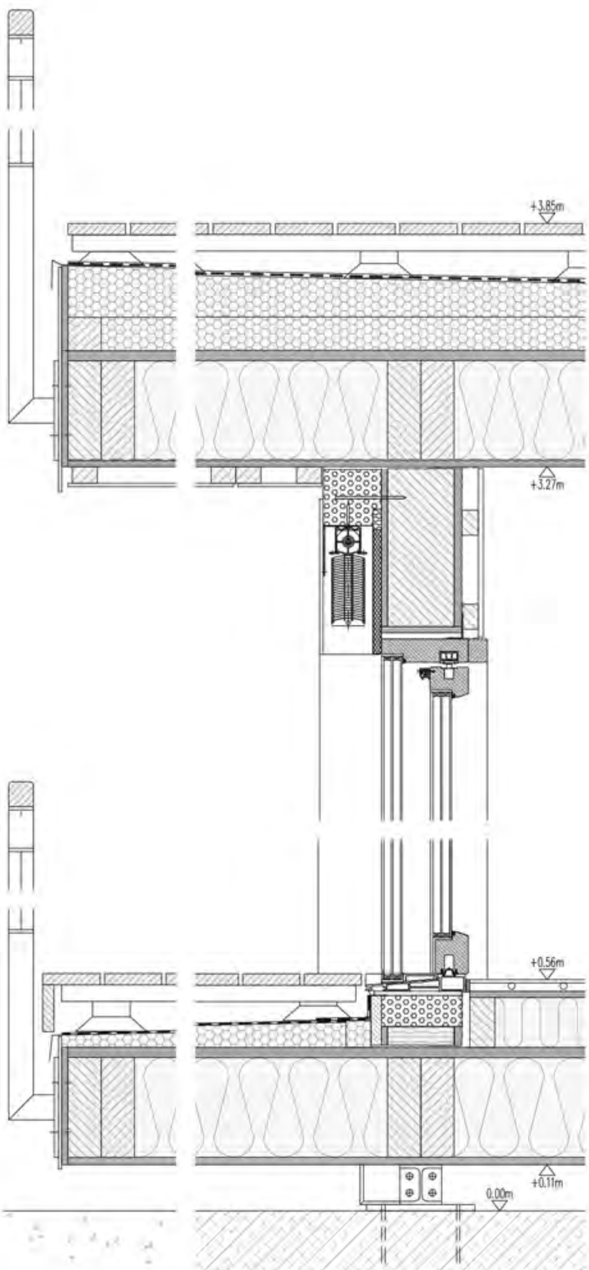
Section B

Floor plan - ground floor

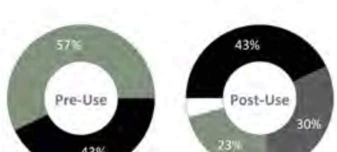


Floor plan - roof

house demonstration unit (hdu) details



Construction detail east façade



Urban Mining Index

Closed loop-potential (floors)

Prefabricated timber structures are supplemented with thermal insulation from mainly natural materials – blown cellulose and wooden fibres; polystyrene is only used in the roof and balcony for the purpose of moisture safety. The HDU comprises five floor panels, six wall panels, three CLT modules (student bathroom, kitchen in community room, building systems), five roof panels, and three attic panels. The building envelope and all the connection details are precisely sealed to ensure air tightness. For interior cladding, boards from recycled beverage cartons are used. Wooden furniture is embellished by rope fitting and 3D-printed accessories.

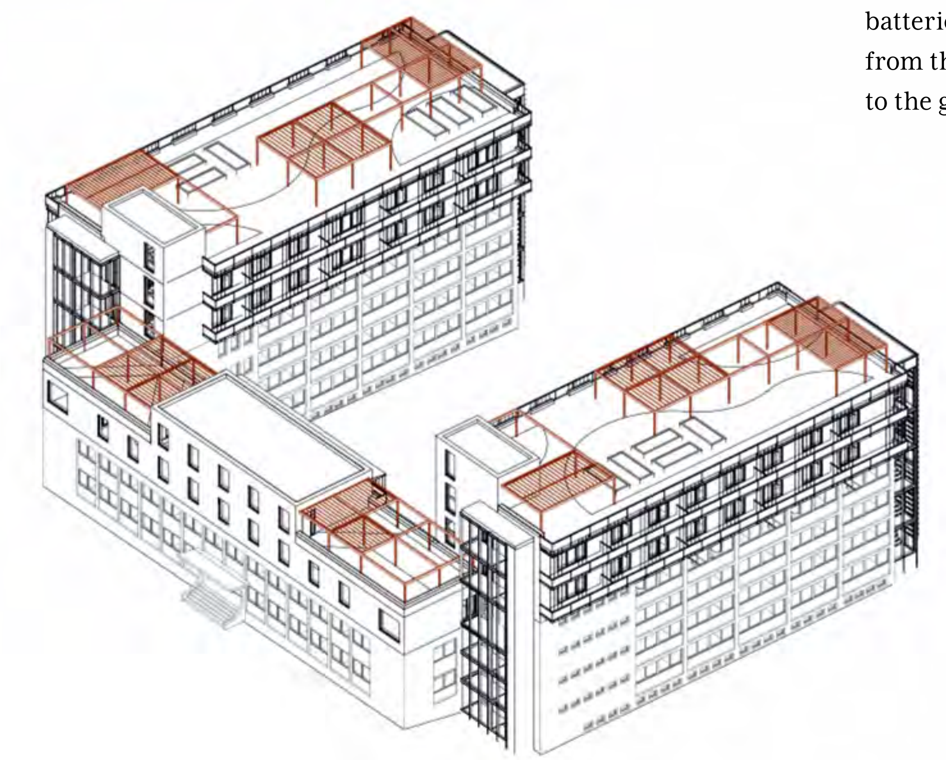
Roof	
Terrace thermowood battens, anchored by stainless steel screws	27 mm
Laths 40x70 mm, á 500 mm	40 mm/70 mm
Height rectification pad	35–115 mm
Geotextile	
PVC waterproof membrane	
Geotextile	
Sloped expanded polystyrene (EPS)	20–160 mm
EPS	80 mm
OSB	25 mm
Blown cellulose between solid structural timbers (KVH) 80x240 mm	240 mm
Vapour barrier	
OSB	15 mm

Façade	
Interior boards from recycled beverage cartoons	12 mm
Air gap between horizontal laths 40x60 mm	40 mm
OSB with sealed joints	18 mm
Blown cellulose between KVH 60x160 mm	160 mm
Vapour permeable wood fibre board (DHF)	15 mm
Soft wooden fibre thermal insulation between horizontal laths 60x100 mm	100 mm
Vapour permeable foil	
Ventilated gap between vertical spruce laths 40x60 mm	40 mm
Facade cladding fibre cement boards	8 mm

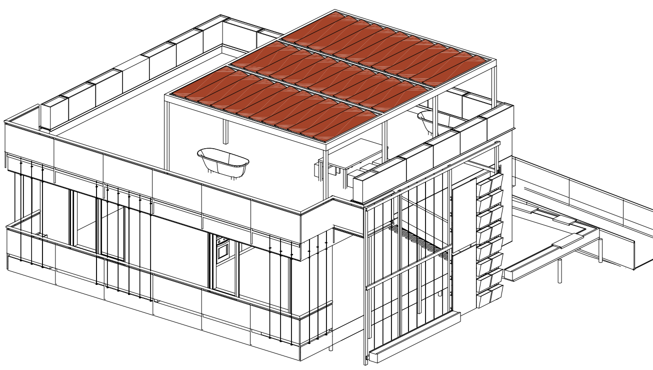
Floor	
Recycled PVC floor covering	5 mm
Polystyrene underfloor mat	2 mm
Protective boards	4 mm
System carton boards with floor heating pipes	20 mm
OSB	15 mm
Hard wooden fibre insulation boards	120 mm
OSB with sealed joints	25 mm
Blown cellulose between KVH 80x240 mm	240 mm
Waterproof plywood	18 mm

solar system

For electricity production, thin-layer photovoltaic films are used (total power of 2.7 kW_p). Respecting building integrated photovoltaics (BIPV) principles, the films are attached onto 32 lamellae forming lightweight shading pergolas on the roof. Generated electricity is stored in the batteries; the solar inverter can supply energy from the PV system to the HDU or feeds energy to the grid.



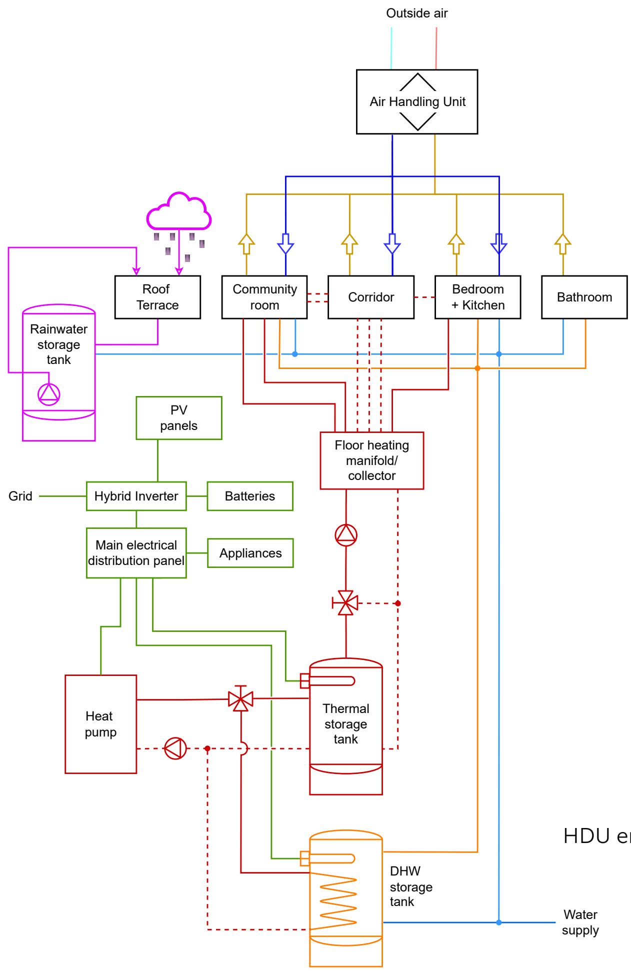
Based on a designed building use (student only, or mixed-use) and the expected occupancy during the summer, roof shading pergolas (red colour) accommodate either thin-layer PV films on lamelae only, or in combination with solar thermal collectors, or are substituted by photovoltaic thermal hybrid solar collectors.



Thin-layer photovoltaic films used on the roof pergola - axonometric projection

Thin-layer photovoltaic films on the roof pergola – photo from south-east

energy supply

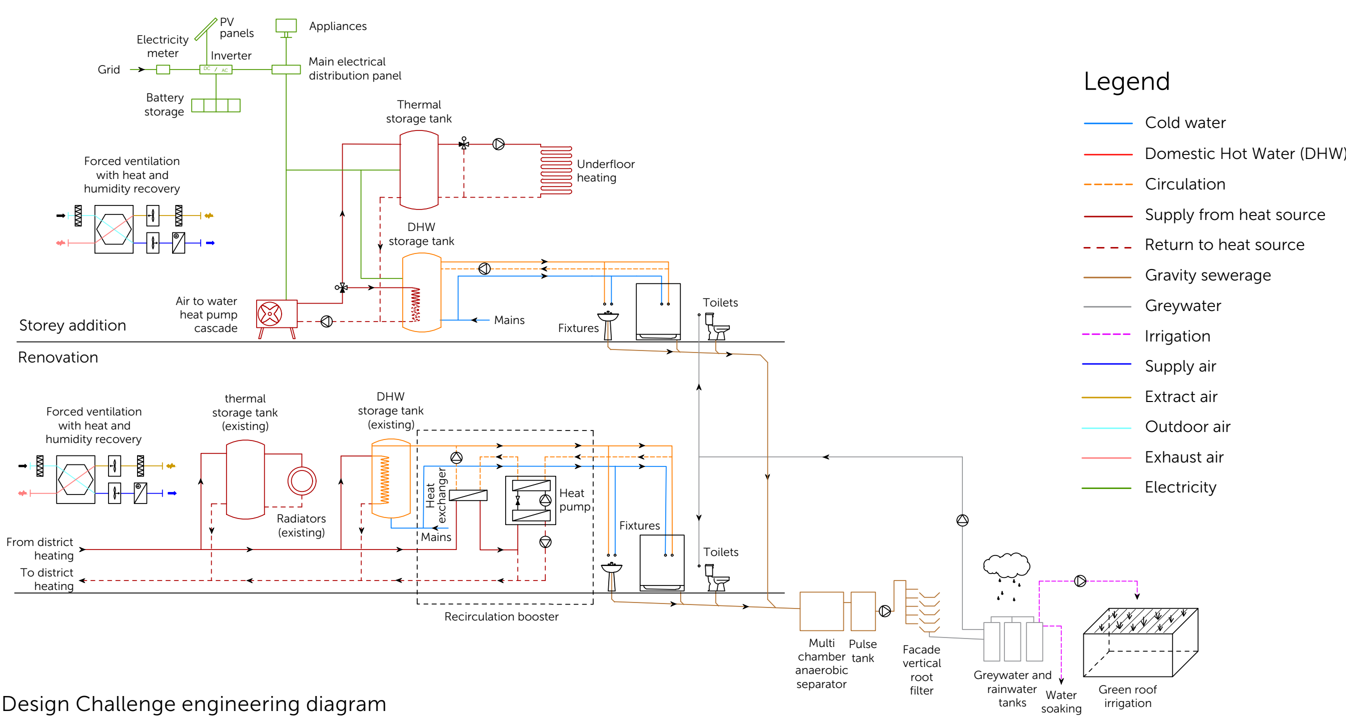


HDU engineering diagram

The main source of heat for the building is an air-water heat pump. It prepares heat for both the heating system and the domestic hot water preparation. There are two water tanks in the system; the first one is for domestic hot water preparation with a built-in heat exchanger and the second one is a thermal storage for the heating system. Heating cartridges are installed in both water tanks as a complementary (in the case of high electricity production of PV panels) and backup (in the case of heat pump malfunction) heat source.

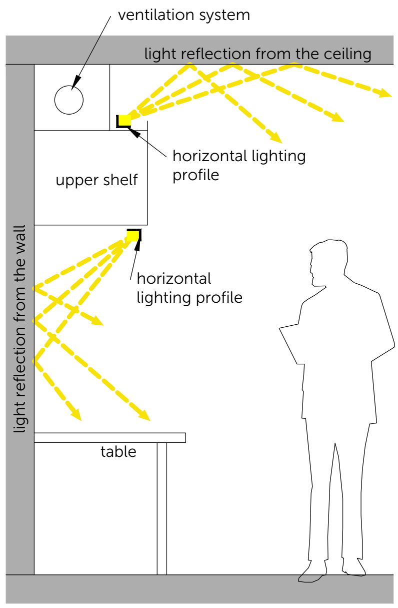
The building is heated by underfloor heating, divided into three branches: two for the community room and one for the bedroom and kitchen. There is a small electric radiator installed in the bathroom.

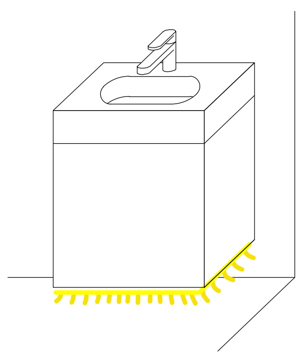
Building water management uses domestic water supply and rainwater. Domestic (potable) water is used for bathroom and kitchens; rainwater is collected in a tank inside the building and used for automatic irrigation of the green roof and planters.



Design Challenge engineering diagram

indoor climate dc and hdu





Lighting design – indirect lighting in rooms and night bathroom lighting

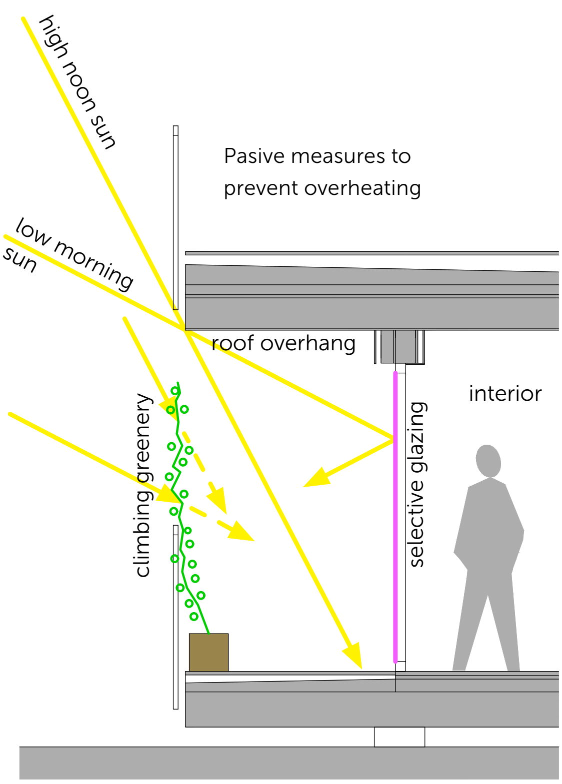
For heating, a radiant underfloor heating system is used, with the pipes laid in recycled carton honeycomb boards filled with sand to increase heat capacity. To utilise residual heat, returning pipes are led to heat the corridor space.

Equithermal control together with room thermostats are used for interior temperature control. Setpoint setting is accessible from both rooms and via an internet application.

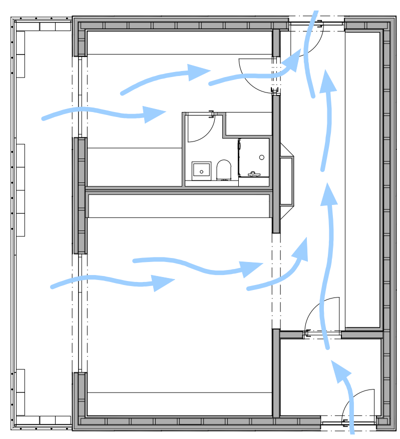
It is assumed that there is natural ventilation on warm days, while mechanical ventilation with heat recovery runs in the heating season. Intensity of ventilation is controlled by a CO_2 sensor in each room; user adjustments are possible via an application.

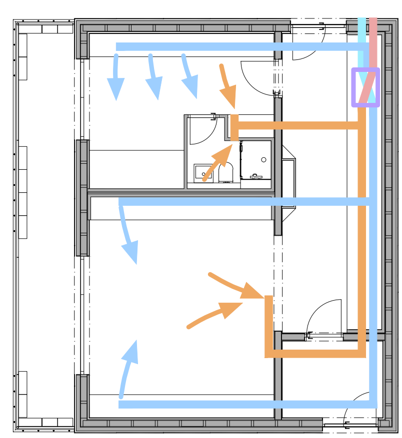
To prevent overheating, windows are shaded by a roof overhang and external blinds. Unwanted passive solar heat gains are further reduced by selective glazing, ensuring sufficient daylight at the same time due to a high light transmittance factor. As additional seasonal shading, deciduous climbing greenery (hops) is grown on the balcony.

For artificial lighting, biodynamic light sources are used in inhabitable rooms, designed as indirect lighting.



Pasive measures to prevent overheating





HDU natural (left) and mechanical (right) ventilation concept

key figures, team and sponsors

FIRST LIFE

Further project information:
http://firstlife.cz

Gold Partners

Metrostav, CIUR, Lindab, Dřevostavby Biskup

Silver Partners

Slavona, Kronospan, Zepris, Schneider Electric, Syner, Passerinvest, TTC, Doctus, PRE, Saint-Gobain

Bronze Partners

Wolf Bavaria, Unger Diffutherm, Casta, Berger, Bohemia, HAMAGA, Regulus, 2MAD, Pro Clima, Grohe, Centre of Advanced Photovoltaics, Propasiv, DEK, Cembrit, Dalux, Prakab, Strabag, Wienerberger, Packwall, AVC ČVUT, Hilti, Y soft, Abadia, TOPSAFE, ict expert, Püschmann, Fillamentum, Prusa Research, Wago, Vexta, Isover, Pipelife, Teco, Fitcraft Energy, Liko-s, Pivovar nad Kolčavkou

Auspices

CTU Rector's office, Charles University Rector's office, Czech Chamber of Architects, German-Czech Chamber of Commerce and Industry, Ministry of Foreign Affairs of the Czech Republic, Prague City Hall

Cooperation

Czech University of Life Sciences Prague, The Higher Professional School and The Secondary Technical School Volyně

TEAM NAME | TEAM IDENTITY

coLLab | HFT

UNIVERSITY

stuttgart university of applied sciences stuttgart, germany

TASK

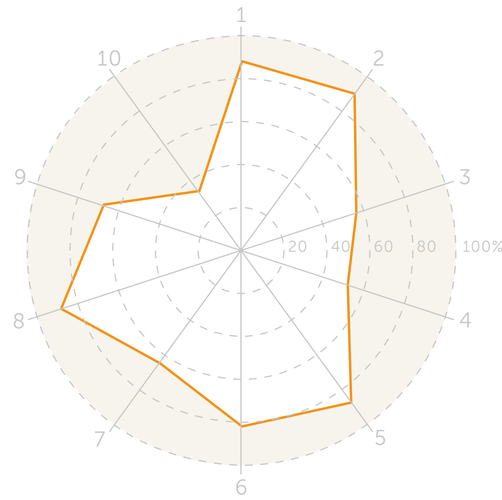
renovation and addition of storey

LOCATION OF DC

hft campus stuttgart

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	8382 m²	123 m²
	7	2
		23 m²/p

"CoLLab" means collaborative laboratory, which wants to offer new forms of living collectively in urban situations on small surfaces. Furthermore, coLLab describes an extension that enters into a symbiosis with the existing building and adapts to existing structures. Moreover, the project should not only have a positive effect on the environment, but implicitly take up the human as its scale and focus on the importance of common space and social networks. The main architectural concept of coLLab is a minimal and smart private living space and a maximised common space. In addition, the room itself should offer the residents space to adjust individually and also to let their creative freedom unfold in their own four walls.

Another important feature of the design is its transferability to other existing buildings.

Due to its structure, the selected existing building is considered a typical representative of its time and offers great potential to develop transferable solutions that can be used throughout Europe.

In the future, the building will not only be a place for applied science, but also a structure that is full of innovation, a place to exchange and for social interaction. By opening up the first floor and providing it for collaborative uses, such as open workshops and sharing cafes, many more user groups will come to the existing building to spend time on campus.

The vision of long-term use is a functioning community and the emergence of an intercultural village on the roofs of Stuttgart. On the top floor, students, pensioners, refugees, single parents with children, visiting professors, families and people in need are to be offered a home.

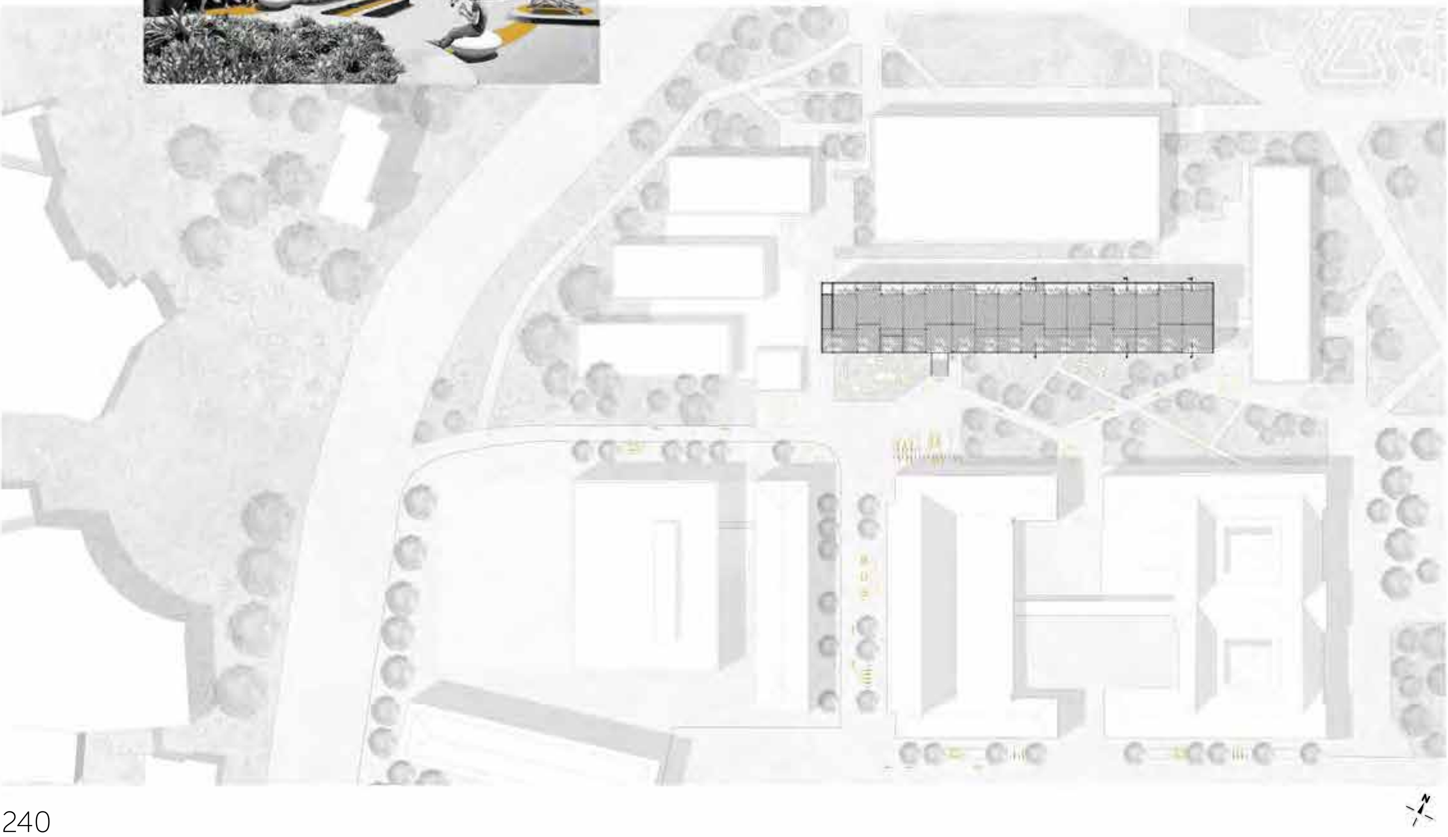
Through social mixing, we expect valuable social interactions and a growing community in the building. The campus with its transformation into a car-free zone, as well as the transformation and refurbishment of the existing office building should become a social meeting place for residents, university members and visitors and create a social togetherness.

urban context and mobility

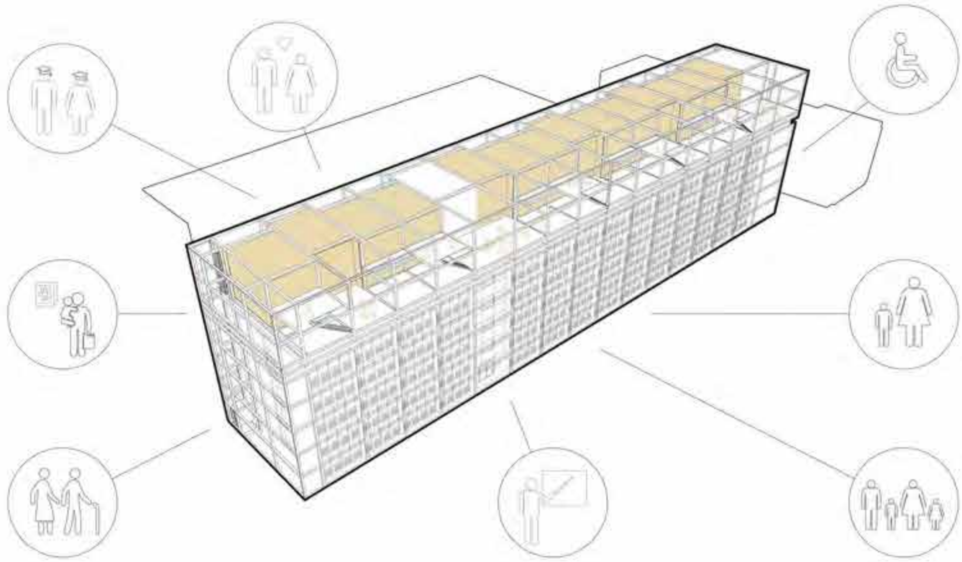
Mobility hub

The HFT campus can be described as an arrangement of different buildings, some of which create qualitative urban planning situations like an inviting city garden, while others are separated from each other by oversized streets and car parks. For the mobility concept this means to promote and supplement the existing public transport network by active mobility. By reducing the motorised individual traffic, the space given to parking will become available to create liveable public spaces or to build missing facilities. The aim is to turn the uninviting area with a lack of attraction into a place of urban identity. This also means changing the appearance of some buildings and opening up some of the ground floor as a public space or creating other forms of transparency and connections. It is also necessary to turn the unappealing and weather-exposed public spaces with a lack of seating into a varied space that makes visitors feel welcome. It is also intended to connect the university facilities and give a campus feeling that doesn't lead to isolation.

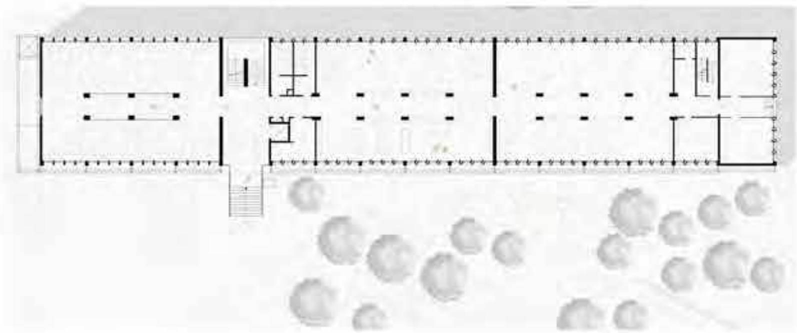
Location map – rooftop view



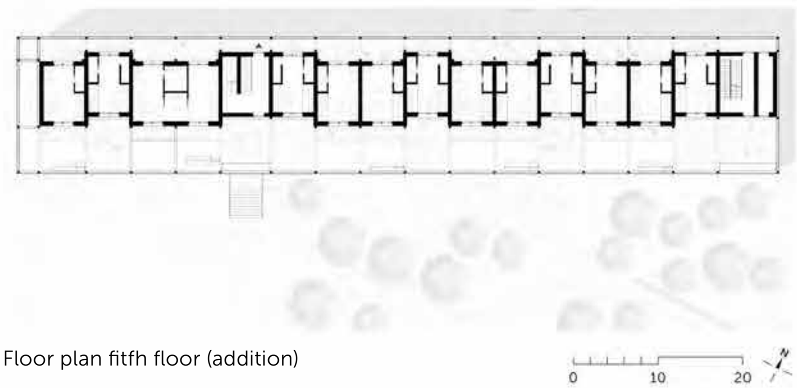
design challenge (dc) overview



Concept isometrics

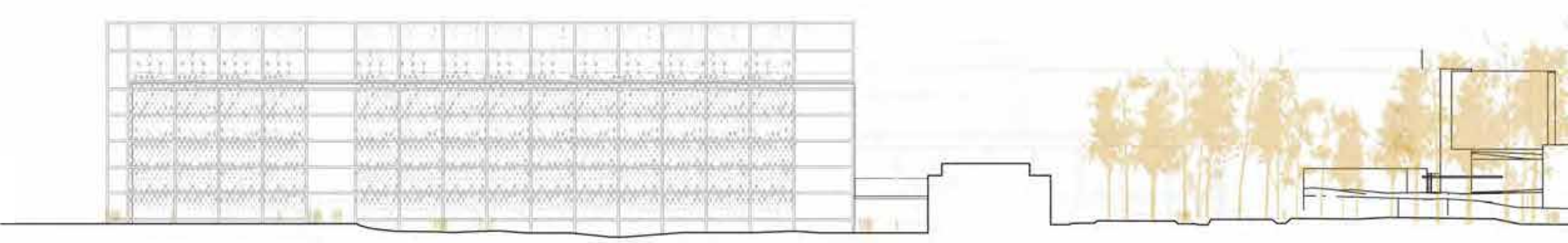


Floorplan ground floor (existing building)



Floor plan fitfh floor (addition)

Elevation south



In order to ensure the transferability of the concept to similar existing structures, various structural and energetic measures are applied, which can be validated primarily through parametrisation and simulation and transferred to other situations due to their high degree of modularity.

The addition is based on an adaptable timber skeleton, the so-called grid, which can be flexibly adapted to the underlying load-bearing structure and which, depending on the utilisation concept, is individually equipped with living and functional modules. Based on the grid dimension of the existing building, the grid not only forms the load-bearing structure of the extension, but is also continued along the existing façade to architecturally visualise the symbiosis between the existing building and the extension.

Based on the grid, the residential modules are formed by lining up function walls and accessed via an arcade in the north. In front of the modules are spacious common rooms for social interaction, which are framed by the grid and the façade.

The façade consists of diamond-shaped organic photovoltaic cells. Rather than hidden away, they determine the building's aesthetic value while also having several technical functions.

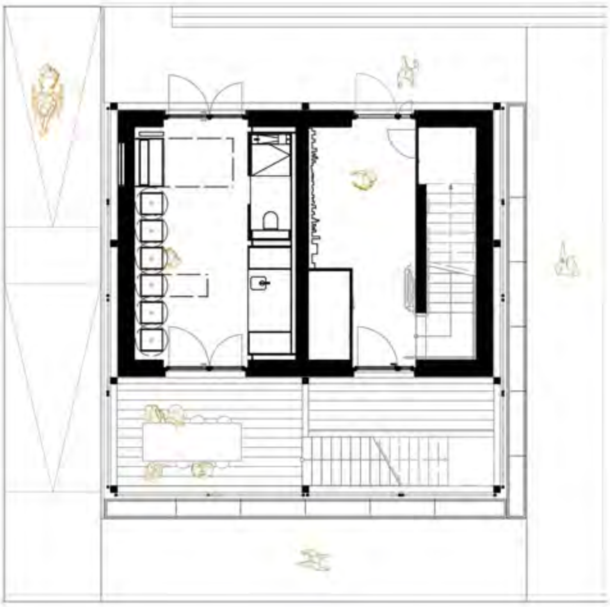
house demonstration unit (hdu) overview

Four individual units form the two-storey HDU. While three of the modules show an exhibition area, the last module of the tour is the actual living module. The frame is built by the constructive grid, which contains the modules, forms the exterior space, is the basis of the façade and provides infrastructure.

The interior is characterised by functional walls on both sides, into which smart furniture and technical components are built.

Around the modules the communal area is located on the south side. Visual relations, shadow plays of the façade and carefully detailed architecture turn the common rooms into qualitative places in which to meet and spend time with people.

The mesh façade with integrated organic PV supports the open space character within the HDU and the relation between inside and outside. Although the vertical façade greening is not used at the level of the extension, it is intended to demonstrate the architectural appeal of how the two structures are interwoven in the HDU.



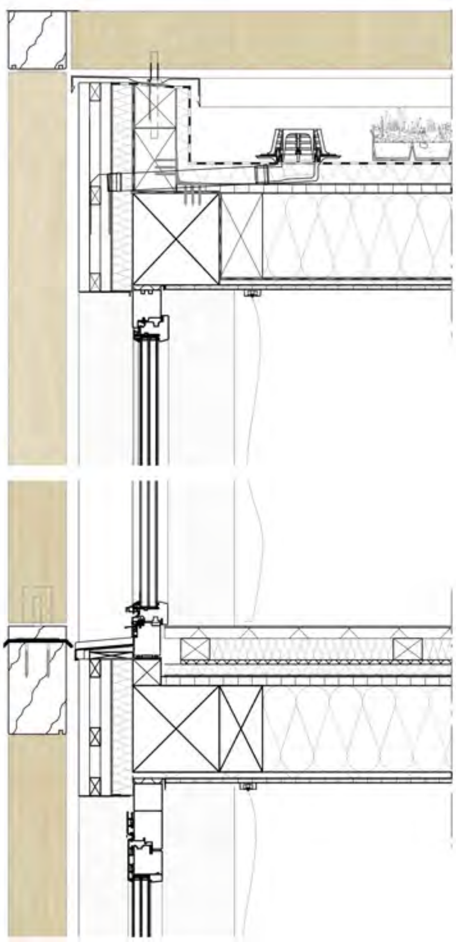
Floor plan ground floor

Floor plan first floor

Section

Elevation south

house demonstration unit (hdu) details



The HDU is built using a timber frame construction. Only certified wood is used and insulation made of wood chips chosen. The exterior façade is built from leftover wood from wooden façades at the university, which were collected to form a new composition.

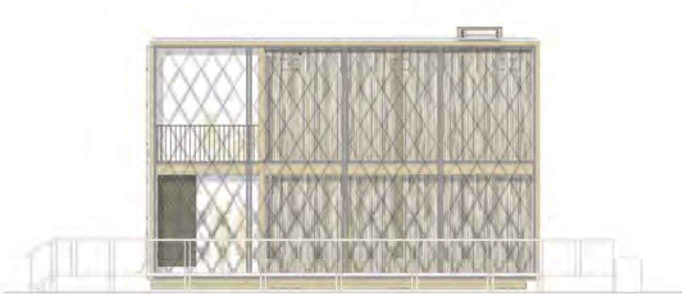
In order to conserve materials and save weight, the installation level inside the building is completely eliminated and all electrical wiring is surface-mounted. This also guarantees easy maintenance of infrastructure.

In addition, care was taken to ensure that only certified, recyclable, high-quality and pollutant-tested building materials were used. Furthermore, constructions material that cannot be further used is returned to the manufacturers and thus finds a subsequent use.

The result is an Urban Mining Indicator of 74%. Comparing the individual components with each other, it is noticeable that with the Closed Loop Potential (CLP), most components achieve a result of around 60-80%.

Roof	
Extensive green roof	85 mm
Flat roof foil	60 mm
Insulation EPS without slope	120 mm
ESB board	25 mm
Timber construction	240 mm
Woodchip insulation	240 mm
Vapour barrier	
Technical paper	
Plasterboard	12 mm
Battens	50 mm
Drywall	18 mm
Drywall	30 mm

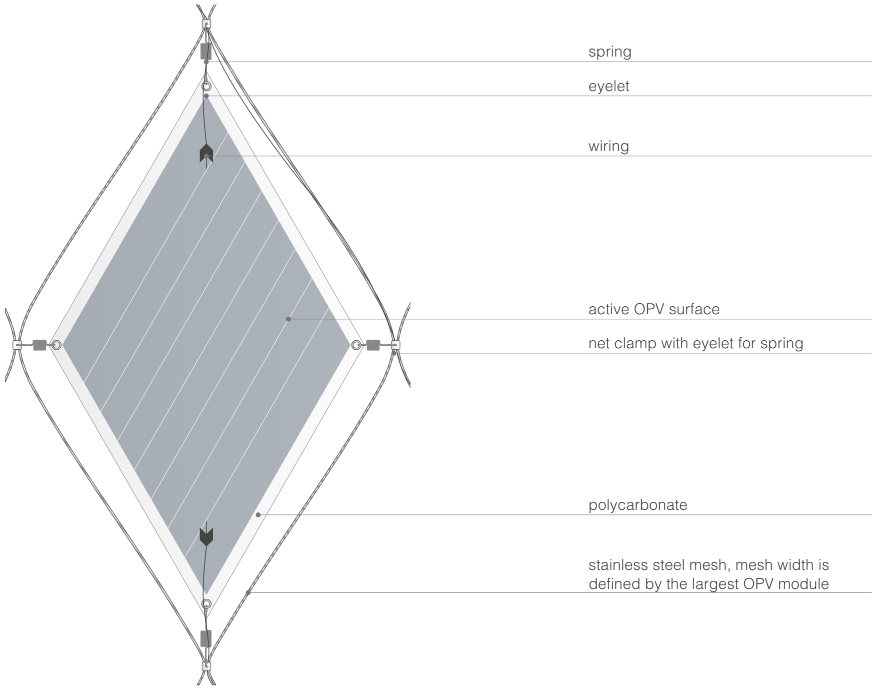
Ceiling	
Rubber flooring	15 mm
Dry screed, gypsum fibreboard	20 mm
Wood fibreboard	20 mm
Impact sound insulation	40 mm
GKB (constructively screwed)	12 mm
ESB-plate	25 mm
Technical paper	
Timber construction	240 mm
Woodchip insulation	25.8 mm
Drywall	18 mm
Drywall	12 mm
Battens	50 mm
Drywall	18 mm
Drywall	30 mm



Elevation east

Elevation north

solar system



Innovative organic photovoltaic (OPV) technology is being used on the façade and roof with individual, diamond-shaped OPV modules. These are set into the steel cable mesh attached on the outside of the grid structure that surrounds the whole building.

A simulation is used to determine the optimal placement of the OPV modules on the facade. The criteria for the placement of the shading elements for the existing building in Stuttgart are optimal shading of the windows in summer and at the same time allowing solar radiation to pass through for solar heat gains in winter.

The result shows the optimal placement of the OPV cells on the façade and roof, taking the criteria into account. The simulation and the resulting shading matrix are constantly updated as changes are made to the design or other parameters. One of the biggest advantages of this simulation tool is its transferability: with the right inputs, a customised, optimised shading model can be created for each location and project.

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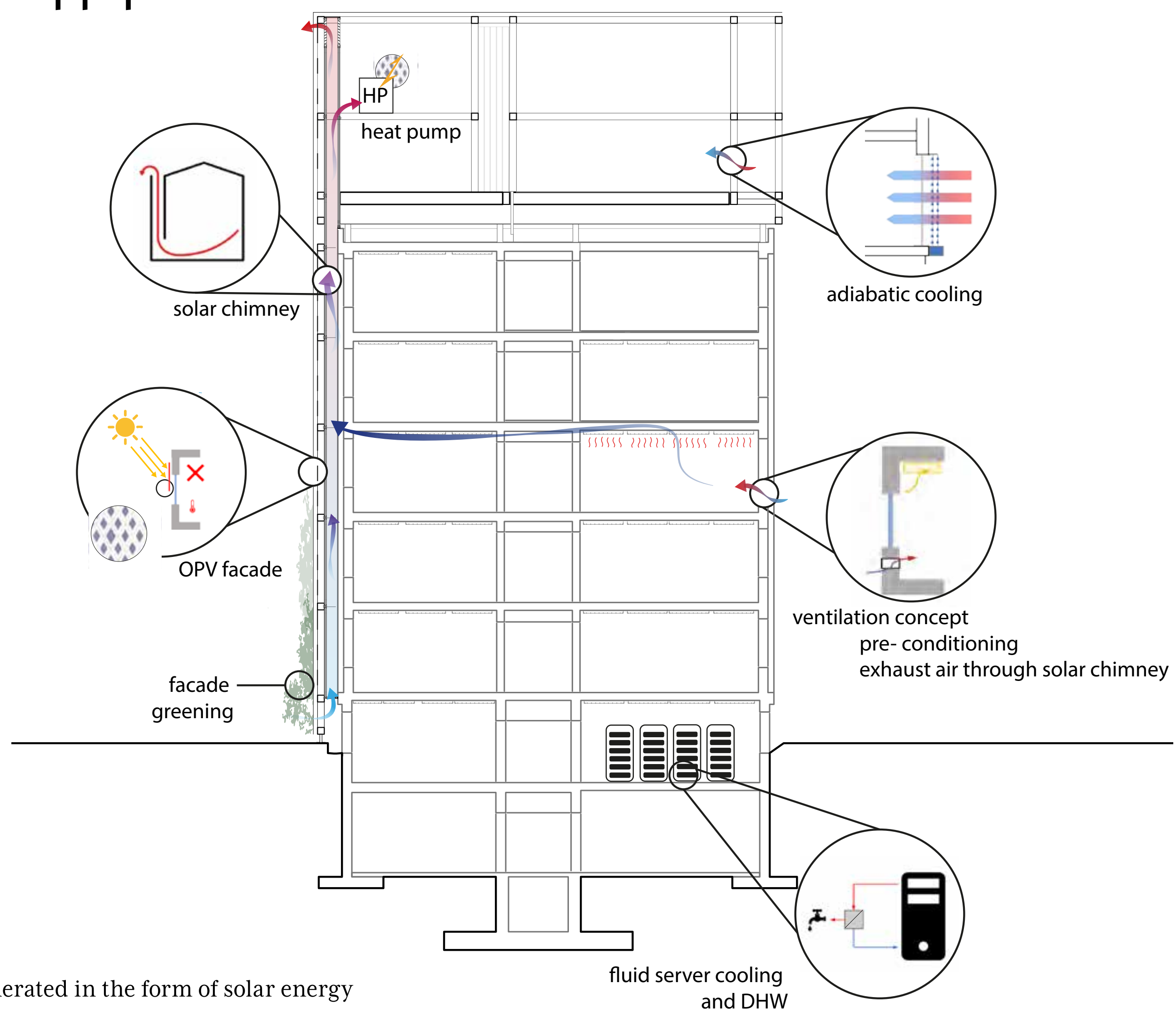
energy supply



Energy is generated in the form of solar energy via organic photovoltaic (OPV) modules. The OPV modules cover the east, south and west façades as well as the roof of the house demonstration unit.

The electricity is used for the HDU consumption needs and then powers the air-to-water heat pump for hot water generation. The electricity is then stored in a battery and fed into the grid.

Heat in winter is provided by underfloor heating and is supplied by a buffer tank. The buffer tank is operated by a hot water tank and the air-to-water heat pump. The warm air from the solar chimney is also used to heat the buffer tank via heat recovery.

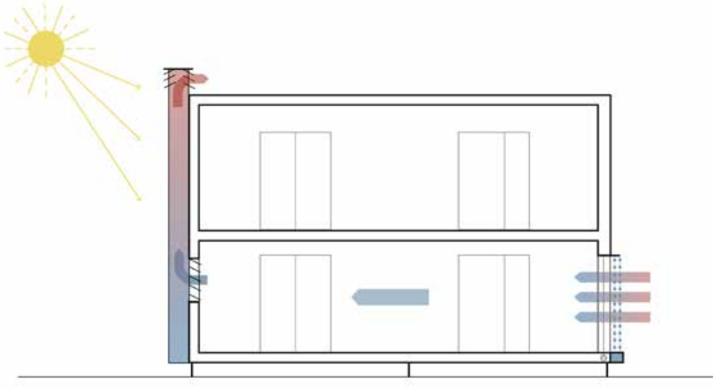
To keep the unit cool in summer, the passive system of adiabatic cooling is applied, together with the solar chimney.

indoor climate dc and hdu

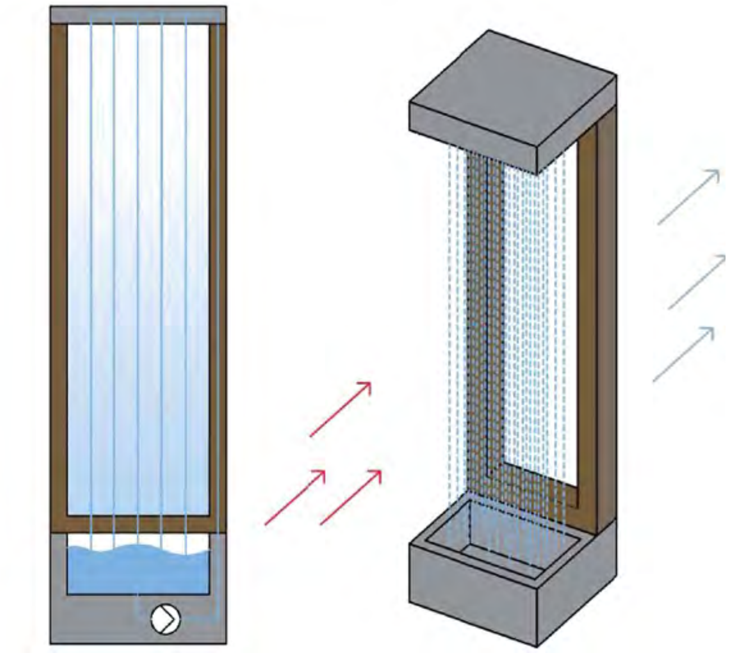
The low tech ventilation system of the HDU is composed of two basic elements – the adiabatic cooling element and the solar chimney. The adiabatic cooling is located in front of the opening sashes of the windows and cools the air located there via the evaporation of water. The solar chimney is an element located in the exterior wall, which is connected to the living space through a louvred window. Solar radiation creates thermics in the solar chimney, which, when the louvred window is open, creates a wind suction from the living unit. If the window in the area of adiabatic cooling is opened at the same time, this suction causes an inflow of precooled outside air.

For the concept of the existing building, the supply air is also provided by decentralised trickle vents. These can be used to preheat supply air in winter. The solar chimney also contains heat exchangers that can feed the heat from the exhaust air back into the building.

Moreover, the organic photovoltaic modules serve as shading and thus prevent overheating in summer, while at the same time allowing solar yields to pass through in winter.



Solar chimney



Adiabatic cooling

key figures, team and sponsors

Sponsors

Albrecht JUNG GmbH & Co. KG
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Bau-Fritz GmbH & Co. KG.
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VOLA GmbH
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XAL GmbH

coLlab

Further project information:
https://hft-stuttgart.de/

TEAM NAME | TEAM IDENTITY

Deeply High | ITU

UNIVERSITY

istanbul technical university & technical university of applied sciences lübeck turkey/germany

TASK

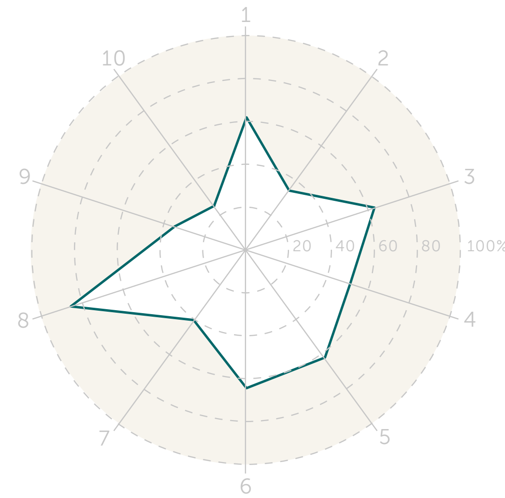
renovation and addition of storey

LOCATION OF DC

kiel

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	1148 m²	144 m²
	5	1
	40 m²/p	33 m²/p

"Deeply High" is an international, interdisciplinary student group from Turkey and Germany. We are **deeply** interested in **highly** sustainable building solutions and develop redensification solutions for countryside, border and city centre regions ("**Stadt-Land-Rand**"). We address socially responsible and inclusive, environmentally friendly and economically affordable project development. The Design Challenge and House Demonstration Unit show the solution for a vertical extension in the project location of Kiel and is an example for other such densely populated cities, but it can be adopted in other locations.

The architectural design is adapted in terms of **local traditional building materials** and architecture, sustainable and **recyclable building materials**, the integrability of technical building components and a **modern socially inclusive concept**. A timber frame construction with straw bale insulation and carbon flamed facade represents the most sustainable design for a project realisation in Northern Germany, but could be adapted according to geographical conditions and local availability in other regions. It is important to mention that the building technique is adoptable with relatively easy construction methods; our HDU was completely built by the student team.

Our architectural concept meets the conditions for barrier-free construction and is wheelchair-accessible. The walls of the interior spaces are designed modularly so that utilisation concepts can be flexibly adapted. The flat rooftop is accessible, **barrier-free** and designed as a meeting place for residents. We include **urban rooftop gardening** for the preservation of biodiversity, and use an aquaponics system and the recycling of biological waste through bokashi fermentation and worm boxes. The large conservatory offers the possibility for the integration of semi-transparent PV modules. Algaetecture (cultivation and use of microalgae in building components or facade system) is integrated and serves as innovative pilot project.

urban context and mobility

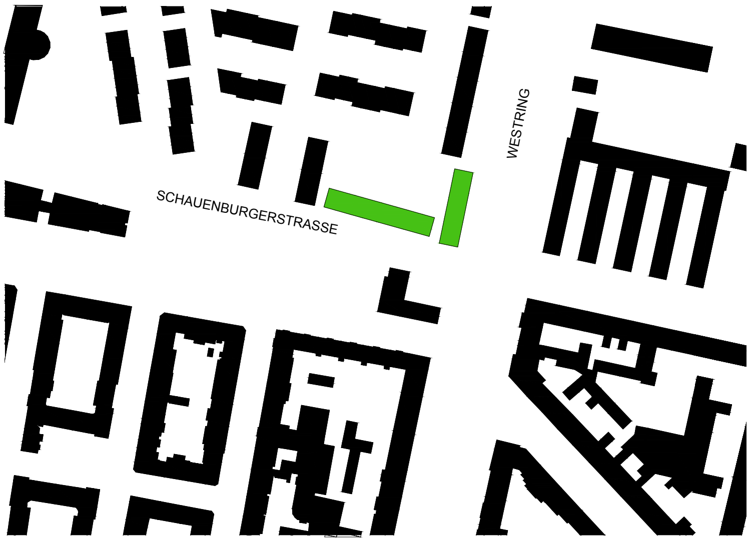
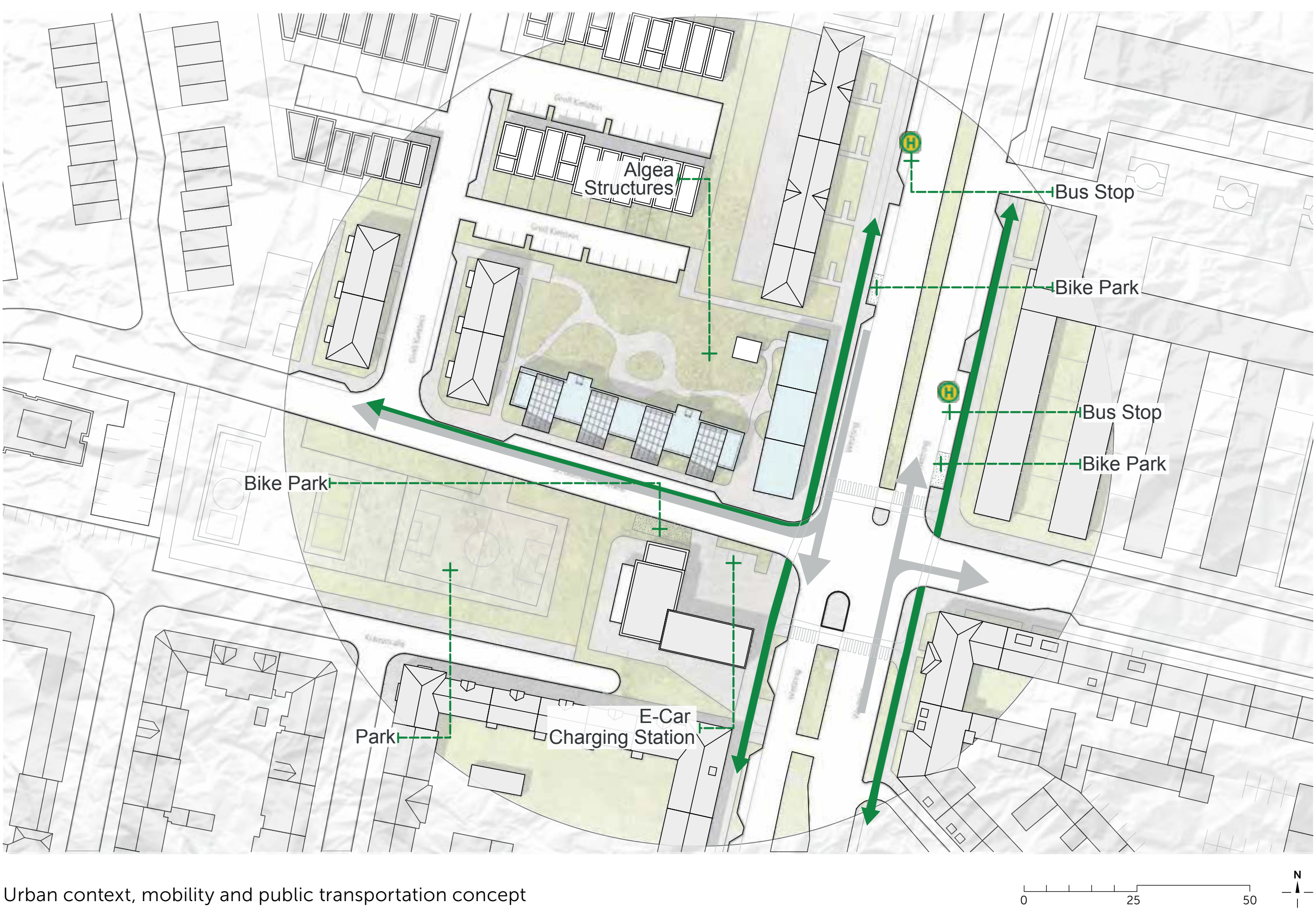


Figure ground plan with location of the chosen two existing buildings in Kiel

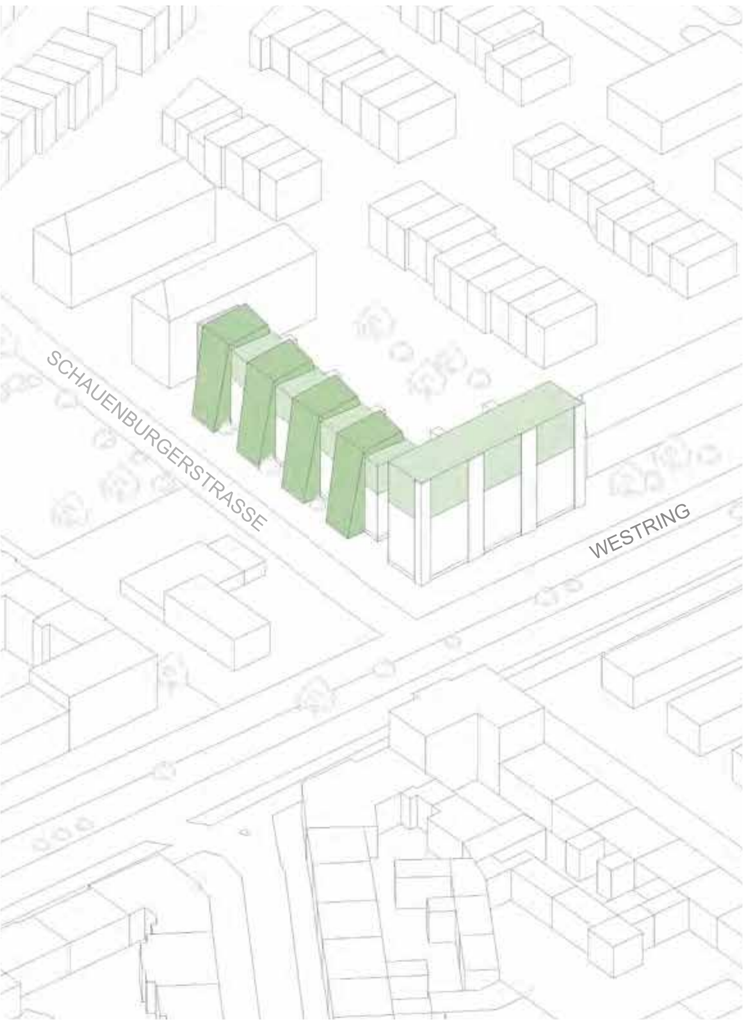
The project is located in Kiel, a densely populated city with a diverse community and potential for prospective green and social development. The vertical extension is planned for two buildings at an intersection; the L-shaped houses are part of the typical 1960s building with clinker brick façade. The Westring road is a main transport artery in Kiel, running from north to south. A park and a petrol station are close by.

Our urban mobility concept focuses on shared mobility systems such as public transport, bike-sharing, scooter-sharing, carsharing and ridesharing. Additionally, sharing systems for tools, facilities and other resources are supported for the residents and planned in an open, welcoming backyard of the residential area. Kiel has a relatively well-organised network of cycle paths. One cycle path connects the main transport artery (Westring) with the Veloroute 10, Kiel's first express cycle route. We propose an additional cycle park in proximity to the petrol station and also aim to convert the station into an electric vehicle charging station.



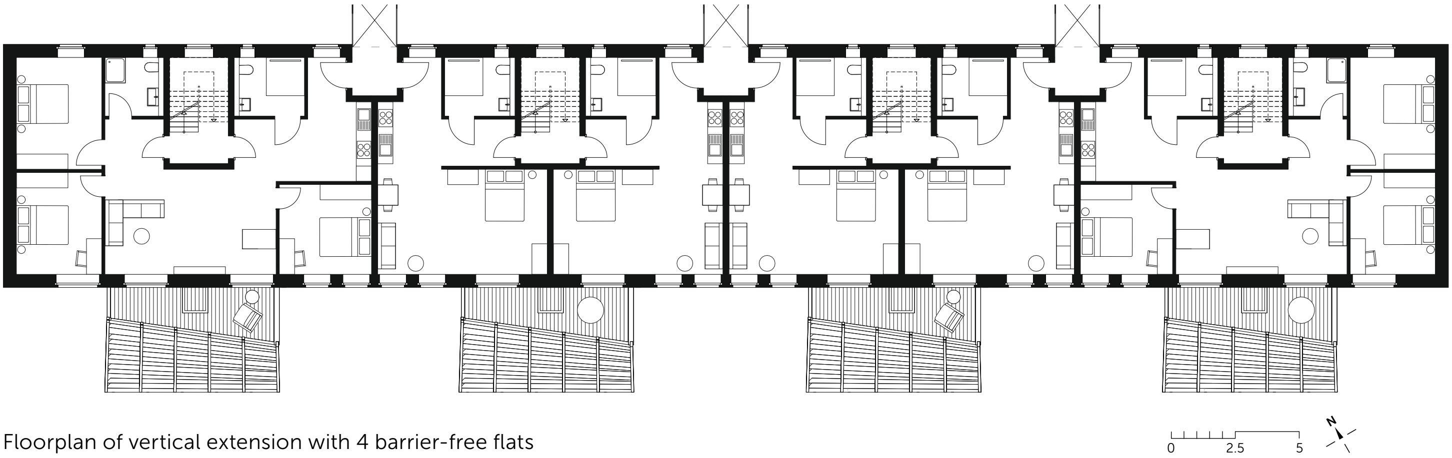
Urban context, mobility and public transportation concept

design challenge (dc) overview



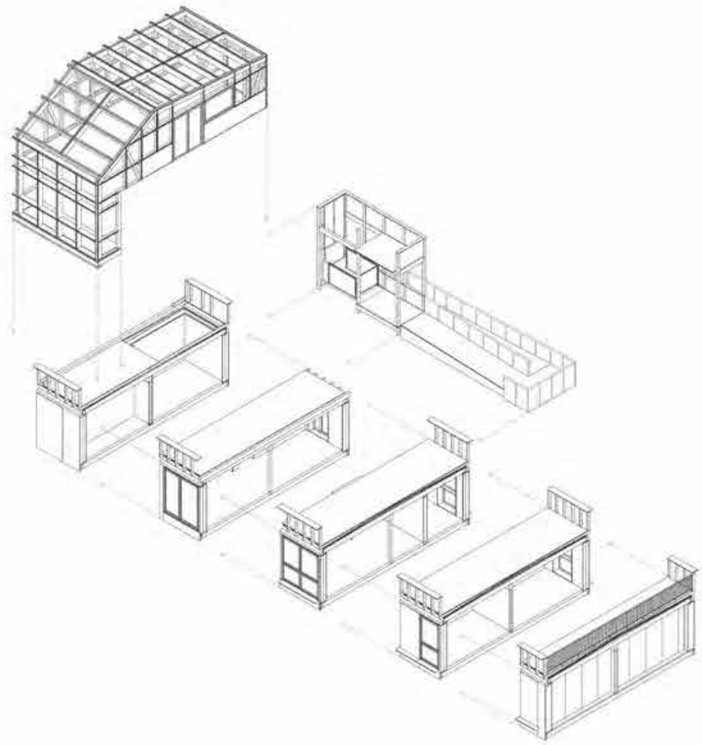
Isometry of building with vertical extension in Kiel

Our project proposes a general concept for environmentally friendly and socially viable life. This comprises of the challenge between modern and efficient house functioning and an affordable economic concept that does not divide Kiel's population but rather unites it. Thus, the architectural concept unites existing buildings and a vertical extension; it also creates open spaces for all residents. Renewable resources and modern technical equipment is used for the extension that goes hand in hand with a renovation of old flats. The DC consists of an energetically renovated existing building, the extension of two storeys and rooftop gardens with community spaces. Two storeys are added as a balanced compromise between economic efficiency and structural possibilities. The design of open spaces and a community rooftop are a particular point of interest. Economic affordability includes the use of recycled (and thus cheaper) building materials, but costly technical equipment requires an economic concept that is tailored to a social political concept.



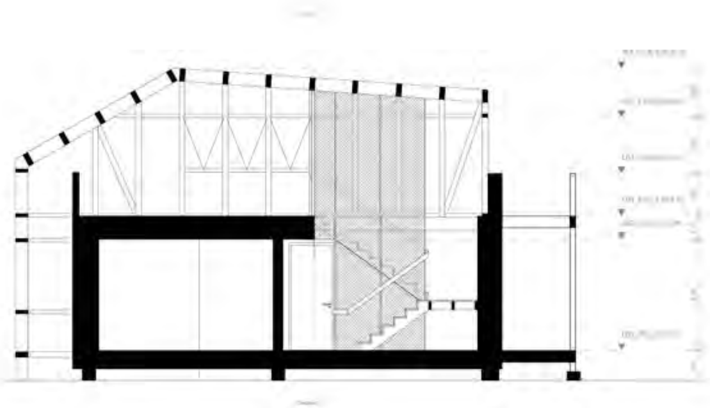
Floorplan of vertical extension with 4 barrier-free flats

house demonstration unit (hdu) overview

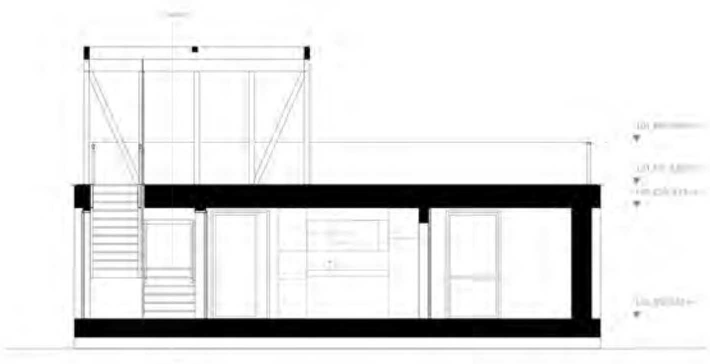


Transformation from DC to HDU

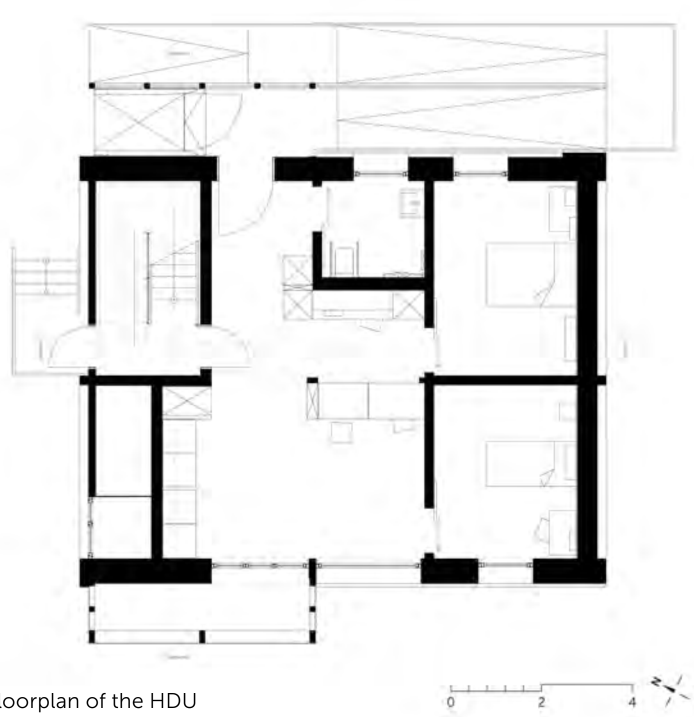
The HDU shows an excerpt of the design challenge. It comprises the barrier-free residential unit including the representation of a living room with an open kitchen, two bedrooms, the conservatory and rooftop area. A small technical room gives an impression on the technical equipment. The HDU is built on a small plateau to represent the connection from residential building to vertical extension and displays the second story incl. access to the rooftop. The raw building is a timber framework with straw bale insulation, carbon flamed façade and façade-integrated algaetecture. The interior design highlights include clay panels with clay-casein finish, modular and barrier-free lightning and modular furniture for maximum flexibility. An elevator provides barrier-free access to the community rooftop space with an urban gardening space. The greenhouse with integrated semi-transparent PV modules can be used as conservatory.



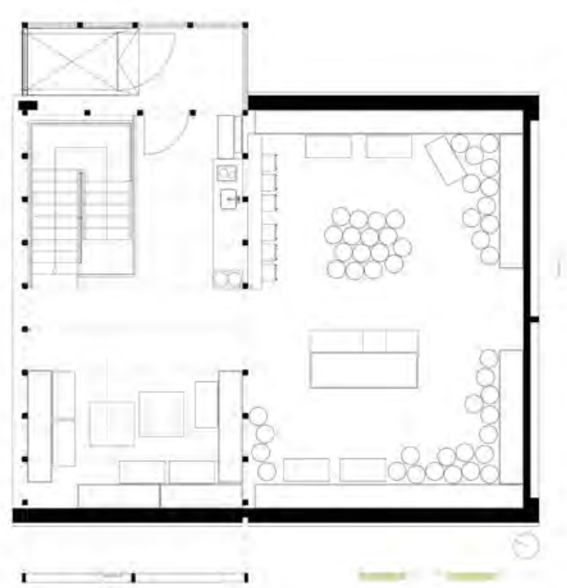
Section 0



Section 1

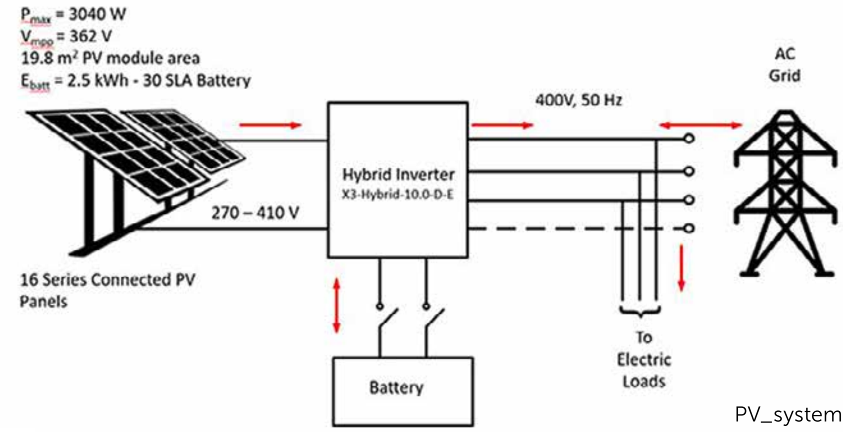


Floorplan of the HDU



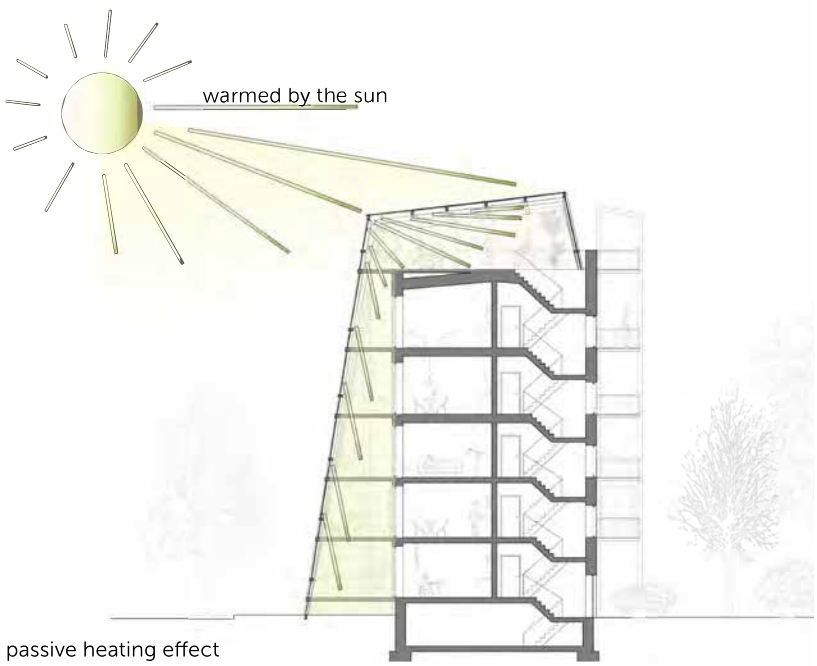
HDU rooftop floorplan

solar system



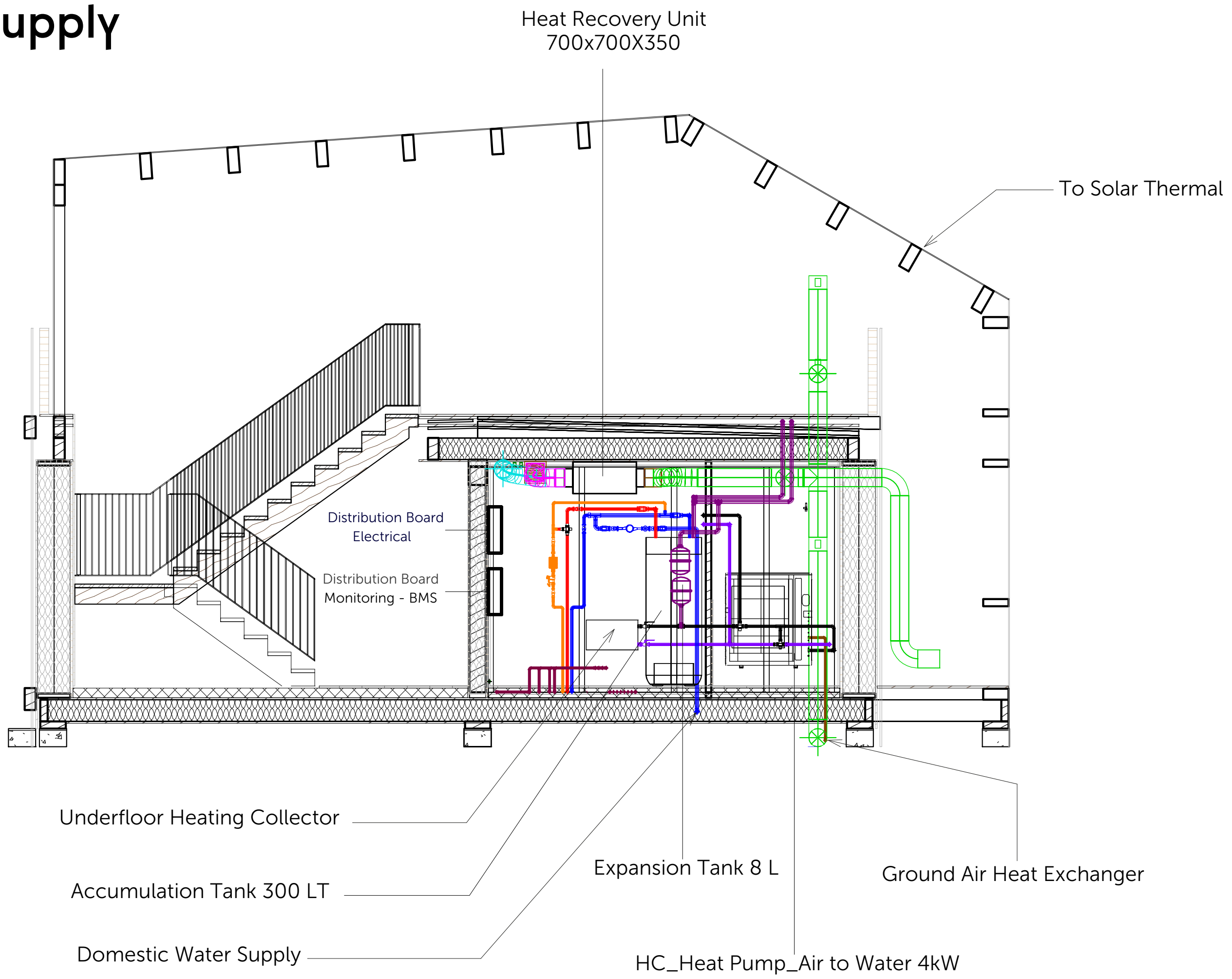
PV_system

Photovoltaic panels are built into the rooftop structure of the HDU's glass conservatory to produce energy. The PV system consists of main parts as 16 PV panels, a hybrid inverter and SLA batteries. The glass-glass PV modules are tilted at 30° to suit the site, the installed system power is exactly 3 kW. The energy demand is balanced by returning the excess energy generated by the system to the grid during hours of high solar irradiation. The battery has a storage capacity of 2.5 kW. The PV system shown in the HDU is also considered for the Design Challenge by the integration of semi-transparent PV modules that also allow shading of the rooftop and thus comfortable summer conditions for residents and plants. Research on dye-sensitised solar cells is ongoing. They produce energy in diffuse light and no longer need to face towards the south to be most efficient; vertically inclined surfaces or mounting in areas away from direct sunlight are also options. A test setup was implemented in the HDU.



House Demonstration Unit
© Steinprinz / University of Wuppertal

energy supply

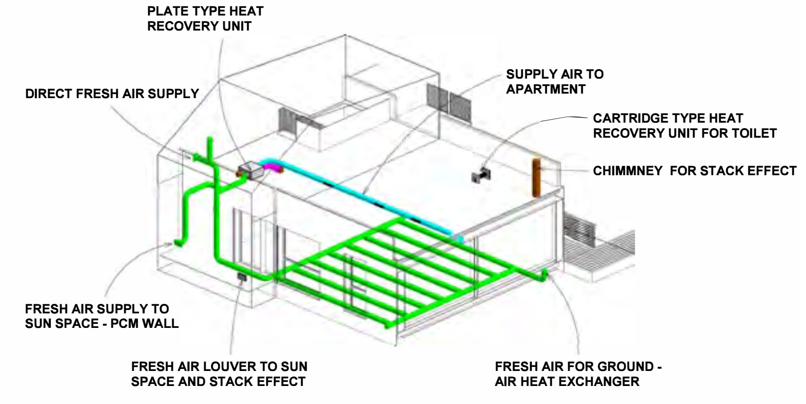


energy system overview

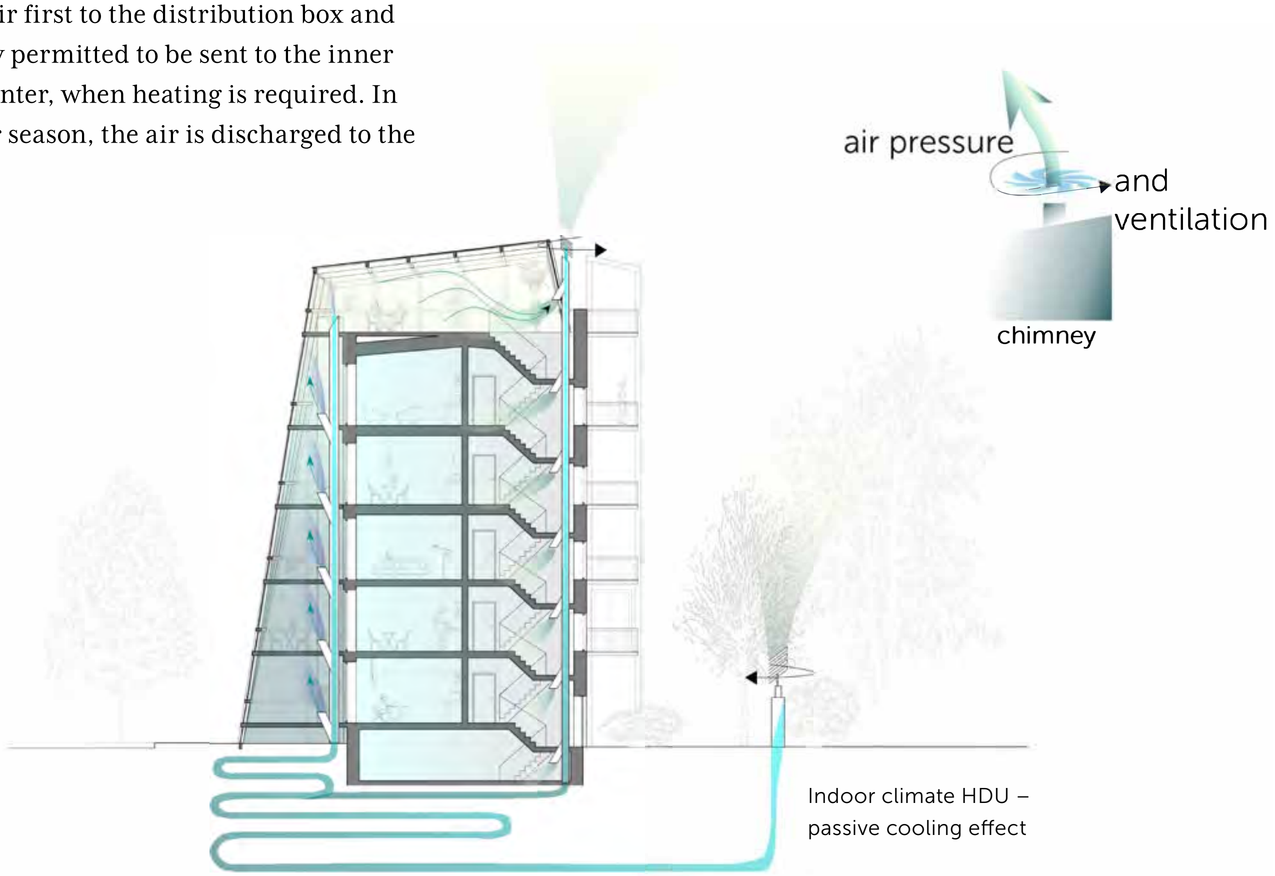
Photovoltaics are used to produce energy for the electrical system (see solar system). For water heating and cooling, energy demand is met through a solar collector and a heat pump. An air source heat pump functions in the mechanical room of the house to maintain the DHW needs of the inhabitants, and to heat and cool the house when needed. An accumulation tank is used to store heated water connected both to the heat pump and a solar collector situated in the energy garden of the house.

indoor climate dc and hdu

Fresh air circulation and air temperatures are mainly controlled through natural ventilation and sustainable heating concepts. A pipe system to control air flow is connected to a **ground source heat exchanger** which makes use from high and low soil temperatures in winter and summer seasons, respectively. Ambient air which is aspirated into the pipe network is ideally heated up or cooled down by the soil temperatures before the air is first fed into the air distribution box situated in the mechanical room. Smart monitoring decides how much air is supposed to be used within the living spaces and controls consequently the valve openings that exist at the end of the piping system. Furthermore, a **phase change material (PCM) box** collects solar irradiation and stores the energy during daytime. At night, it is released. The heated air is again led to the distribution box. Accumulating heat from the **greenhouse** is carried by air first to the distribution box and is selectively permitted to be sent to the inner spaces in winter, when heating is required. In the summer season, the air is discharged to the outside.



Climate Ventilation



Indoor climate HDU – passive cooling effect

key figures, team and sponsors

deeply high

Further project information:
https://deeply-high.eu/

Team Deeply-High

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architecte dplg, ceaa-terre - Faculty Advisor
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Mechanical Engineering - Faculty Advisor
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Orga/student Team Leader
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Katja Wickert – Communication coordinator
Paul Tschense, student –
head architecture/construction manager
Alexander Pfleiderer, student –
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Musa Kerim Karaca, student –
head water & energy system
Sebastian Pfleiderer, student – head static
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Marvin Martin, student – head BIM
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Selen Vardarlı, student – CESA
Ekim Öztürk, student – CESA
John Veicht, student – head interior design
Benedikt Pfleiderer, student –
head monitoring/IT

Partners and Sponsors:

Verband norddeutscher Wohnungsunternehmen e.V.
Baugenossenschaft Mittelholstein eG
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WARO MSR-Technik
HolzLand Klatt
Daikin
ins blaue
Schütt
Cedbik
Tischlerei und Innenausbau Witt
Akim Engineering
Kaulbach Transporte

TEAM NAME | TEAM IDENTITY

UR-BAAN | KMU

UNIVERSITY

king mongkut's university of technology thonburi bangkok, thailand

TASK

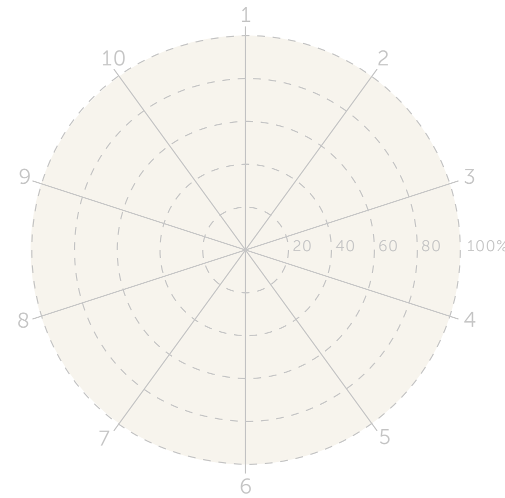
renovation and addition of storey

LOCATION OF DC

bangkok

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



Visualisation of the Design Challenge

DC

HDU

Visualisation of the House Demonstration Unit

our vision

	441 m^2	117 m^2
	3	2
		23 m^2/p

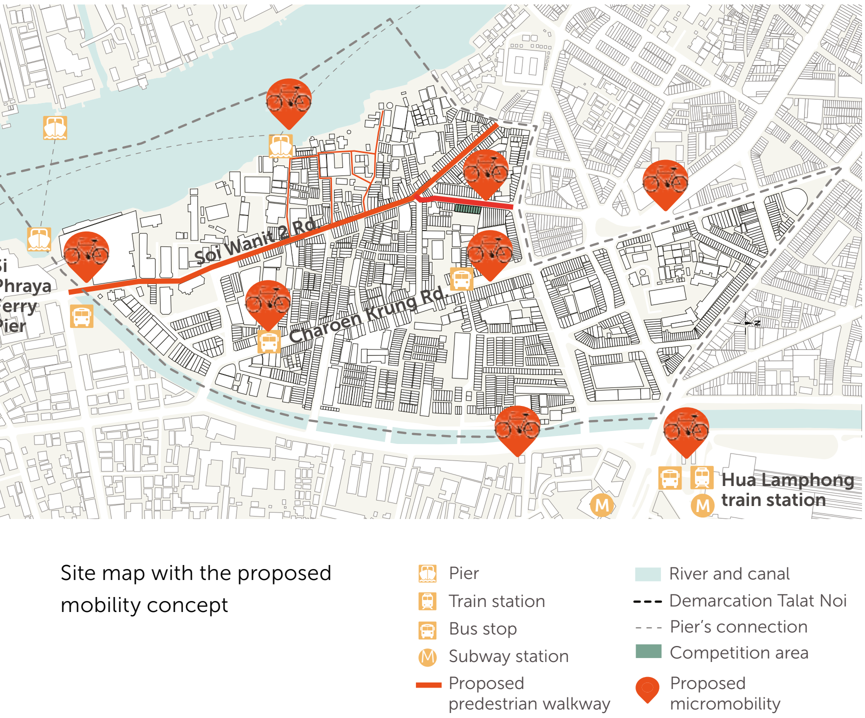
“Baan” is a Thai word for “home”. “UR-BAAN”, therefore means “home for the city”.

Team UR-BAAN comprises King Mongkut’s University of Technology Thonburi (KMUTT) and two partnering universities in Bangkok, Arsom Silp Institute Of The Arts and Kasetsart University, with over 70 students from various fields of study, including architecture, engineering, science and communication design who share common interests.

Our vision is to revitalise the most widespread form of building in Bangkok, namely the “shophouse”. Rapid urban expansion over the past few decades, with people migrating to the suburbs where land is cheaper, along with changing lifestyles and shifting trends in the housing market, has left blighted shophouses in old neighbourhoods, which have become less attractive places to live as a result. Project UR-BAAN has therefore selected the Talat Noi neighbourhood, a historic quarter in the heart of Bangkok, as the urban situation to tackle for the Solar Decathlon Europe 2021/2022 competition.

The team has borrowed the notion of the autoparts often sold by local businesses, adopting the methodology of “restomod” (restore + modify). The same approach as with a vintage vehicle that is restored and retrofitted with modern parts is applied to restoring an old building that wishes to keep its original appearance, enabling the residents, the locals and passersby to truly immerse themselves in the untouched setting of the neighbourhood. The new “parts” are not only meant to keep the existing building in shape but also to extend its life and enhance its performance.

urban context and mobility

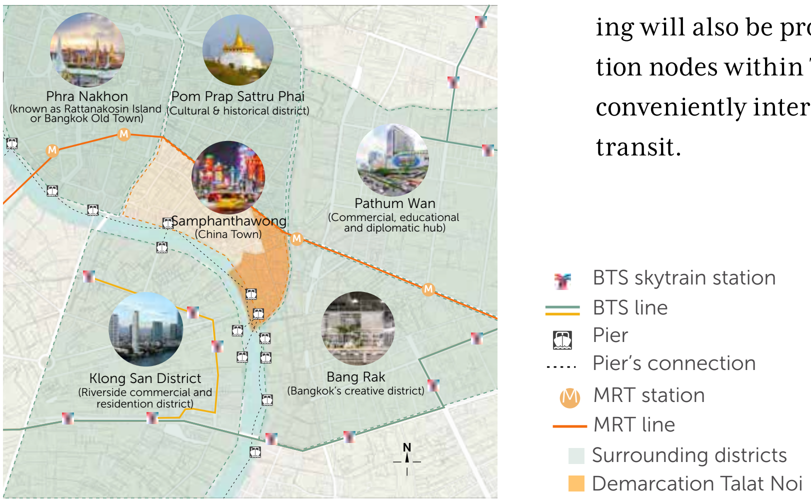


Site map with the proposed mobility concept

Talat Noi located in Samphanthawong district, next to the city's main river "Chao Pharaya" and many other cultural landmarks. Since the area is accessible via numerous public transportation such as express boats, buses, metro and sky train system, the area becomes an important tourist attraction and acts as a buffer area between the cultural and commercial quarters of Bangkok. One of the highlights is that the fine-grained urban fabric of Talat Noi offers a lot of opportunities for discovery and exploration by walking. Pedestrians are truly immersed in the cultural heritages as they channel through the neighborhood's tiny alleys.

The urban issues Talat Noi is facing involve a lack of green public space (averagely 0.4 sq.m. per person) and the invasion of big vehicles in narrow alleys, which worsen the experience of the pedestrians strolling around the neighborhood. Being a historic area packed with old underused buildings, there are barely enough space planned for green space. Therefore, the existing space behind shophouses that were intentionally left as a building setback is reutilized as a strategy to create pocket gardens throughout the district, allowing pedestrians to rest as well as becoming a community garden for residents in the rowhouses.

Soi Wanit 2, the main road that serves Talat Noi is proposed to eliminate every form of vehicle, except for bicycles, to make the neighborhood become completely walkable and reduce carbon emissions. Micro mobility such as bike sharing will also be provided at main transportation nodes within Talat Noi, allowing users to conveniently interchange with the city's mass transit.



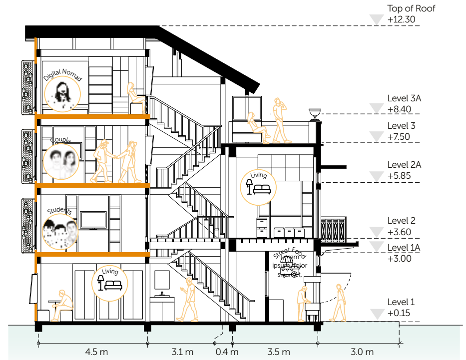
Talat Noi in urban context

design challenge (dc) overview

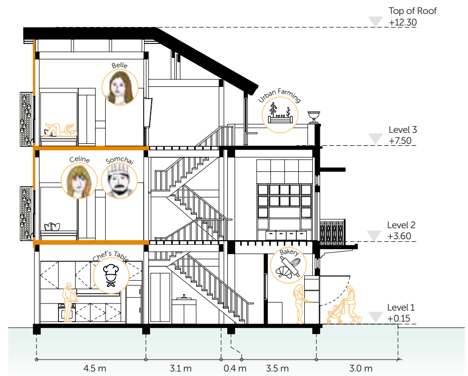
Shophouses and its ability to adapt to both commercial and residential uses throughout history has proved that they are one of the most flexible building types that remain standing until today. Therefore, the renovated building with its newly integrated parts are designed to be able to modify its floor level and space configuration as new tenants take ownership of the building in a long term. Since a typical shophouse lease in Thailand usually takes place from 10, 20 or up to 30 years, a new configuration could be applied and accommodate new users and scenarios appropriately after a certain timespan.

Therefore, our team has come up with 3 different scenarios of residents and building programs in order to prove the viability of the architectural concept to the old building stocks in Talat Noi. As we foresee the decline of the existing auto parts trading business in the existing shophouses in Talat Noi, we decided to come up with a new combination of residents that would be suitable for the building and the district.

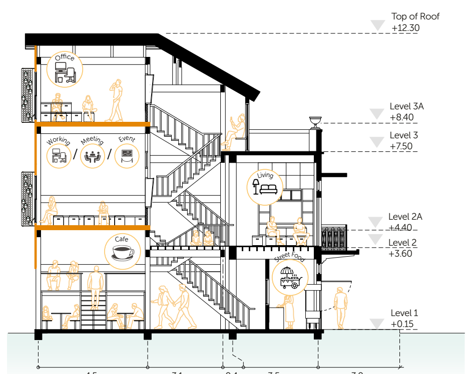
The new structure inserted into the building is designed without allowing itself to stand out from the surrounding context. The front part of the building facing the street will be kept as original to maintain the existing urban setting and impression of Talat Noi as a historic neighborhood.



Scenario 1
Co-living Program

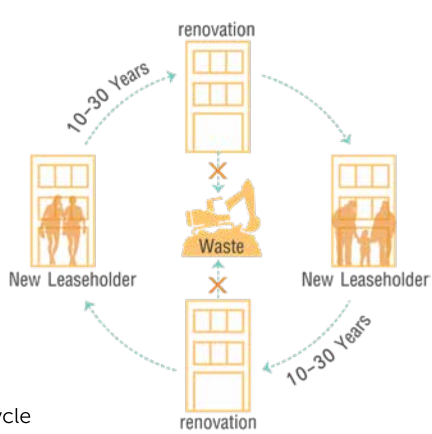


Scenario 2
Single Family with Chef's Table Business

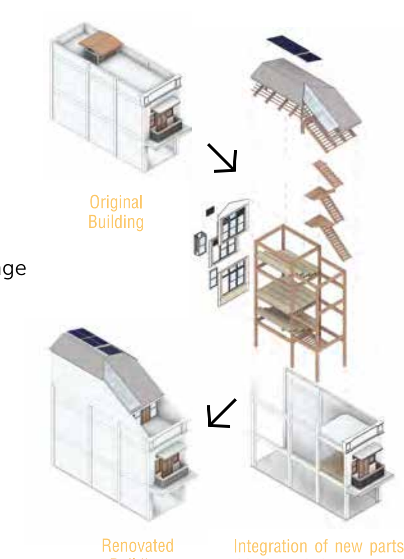


Scenario 3
Mixed-Use Commercial Building

Building section in 3 different scenarios



Building life cycle



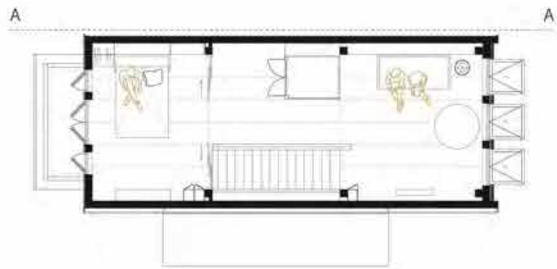
Conceptual diagram of the Design Challenge

house demonstration unit

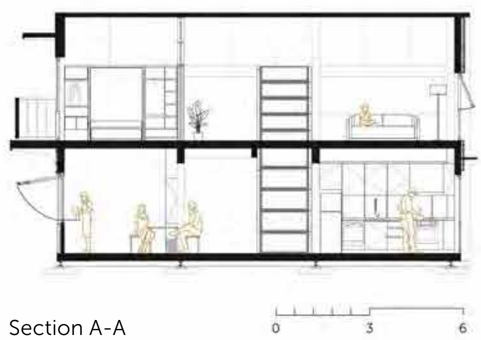
The context of a shop is demonstrated by taking the existing facade, the first two storeys and the hollow core modules to construct the building envelope representing the existing party walls and the adjustable floors from the design challenge.

The entrance function as a commercial storefront is combined with a buffer room to improve thermal control during cold months in Wuppertal. The communal space on the ground floor is shared by the residents living on the upper floors.

First floor plan

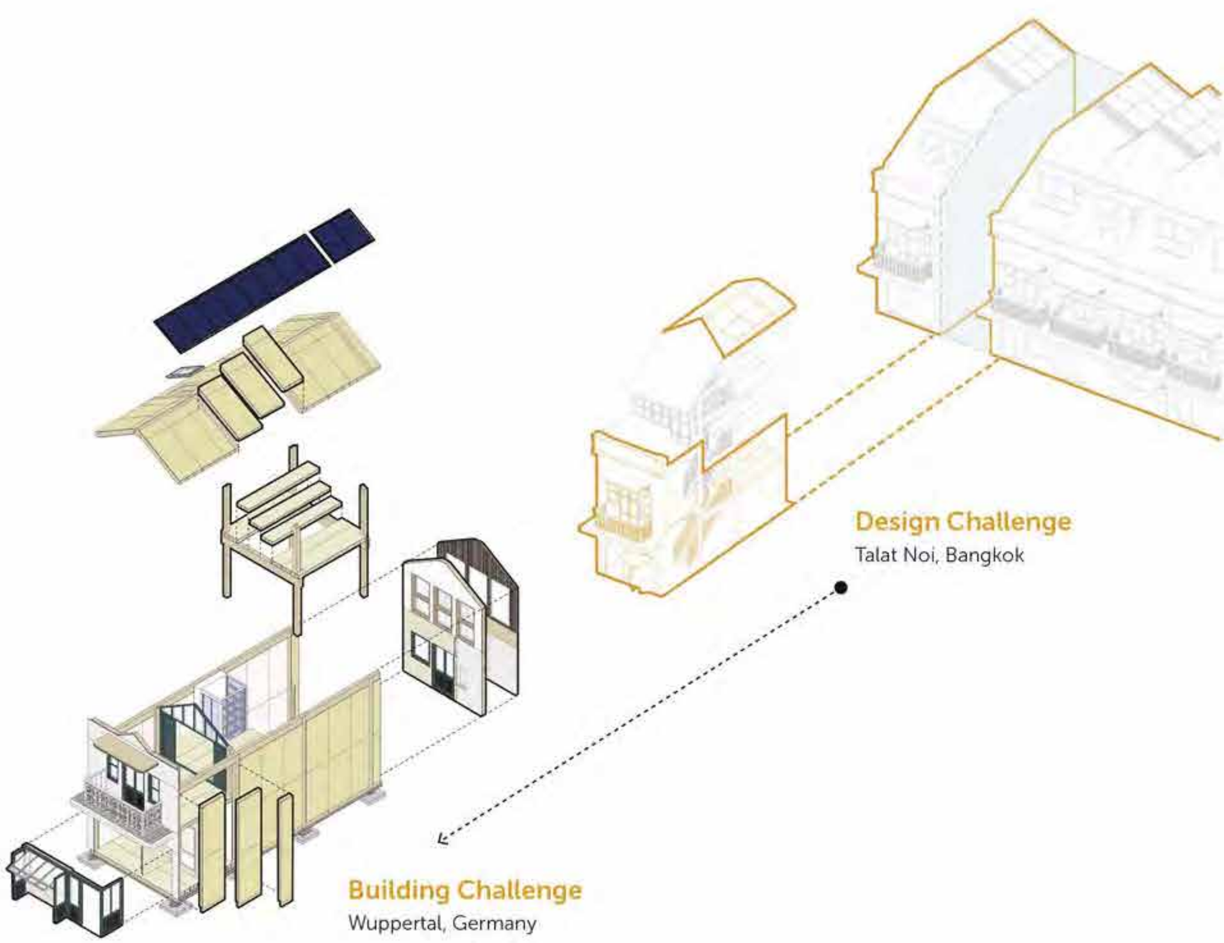


First floor plan



Section A-A

Transformation from Design Challenge to Wuppertal



key figures, team and sponsors

Further project information:
https://www.kmutt.ac.th/

Sponsorship

TMC Auto Work

SUMMA M.K. Contracting Co., Ltd.

BNS Wood Industry

Woodwork

SYS Siam Yamato Steel

T.H.A. Thai Hevea Wood Association

DECO Enterprises

CHALE'T

PANEL Plus

TGBI

CircularOEM zero waste & closed loop system

Bangkok Dec-Con Public Company Limited

Metropolitan Electricity Authority

Nippon Paint

modern AVENUE

Lannar Wood Products

ae+ allenergy+

WoodSmith

TMT

OCEAN NEW LINE

THAI PP-R

NRCT

TEKA

Saint-Gobain

ARITCO

Partnership

Kasetsart University

E@ Energy Absolute

PUNMUENG

Arsom Silp Institute of the Arts

TEAM NAME | TEAM IDENTITY

levelup | ROS

UNIVERSITY

rosenheim technical university of applied sciences rosenheim, germany

TASK

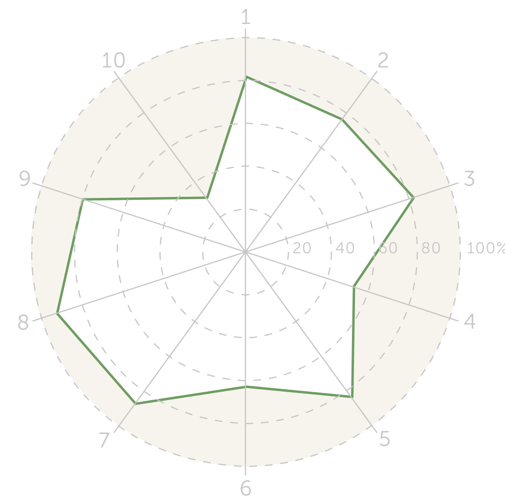
renovation and addition of storey

LOCATION OF DC

nuremberg

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



Visualisation of the Design Challenge

DC

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

Area	8610 m²	120 m²
Storeys	6	2
Persons	21 m/p	30 m²/p

levelup in a nutshell

We developed renovation measures that include adding storeys to an existing building in the Ludwigsfeld district of Nuremberg. A highly heterogeneous population characterises Ludwigsfeld, and this mixture also reflects the architecture's quality. Above all, residential development in elongated apartment buildings, predominantly unadorned social housing, is often repeated in the neighbourhood. These buildings represent typical examples of most building stock built in Germany between the 1950s-70s. Renovating these buildings is essential because their energy consumption exceeds current standards. The building sector accounts for 40% of Europe's energy demand, and three-quarters of buildings are classified as energy inefficient. The building stock from this period is at the same time statically suitable for multi-story additions due to their solid supporting structures. For this reason, we developed a parametric and adaptable addition of storeys in modular timber construction, which allows for a flexible response to different building widths and lengths. With the transferable solutions of our concept, more than 1.1 million new apartments in urban areas in Germany can be built. New flats are urgently needed, as 77% of the German population already lives in cities, and the trend is continuing. The aim is to create new living spaces and to contribute to the climate neutrality of our cities.

Our vision

We would like to create sustainable, climate-neutral, and affordable housing that adapts to different building types and sizes and the individual lifestyles and needs of different population groups through flexible use. By adding storeys to existing buildings, we avoid sealing green spaces, and through intensive greening, we instead increase biodiversity and create a healthy microclimate. By renovating the existing building and using renewable energies, we improve energy efficiency and enhance German city centres architecturally, aesthetically and socially.

urban context and mobility

Overview of Ludwigsfeld (district of Nuremberg)

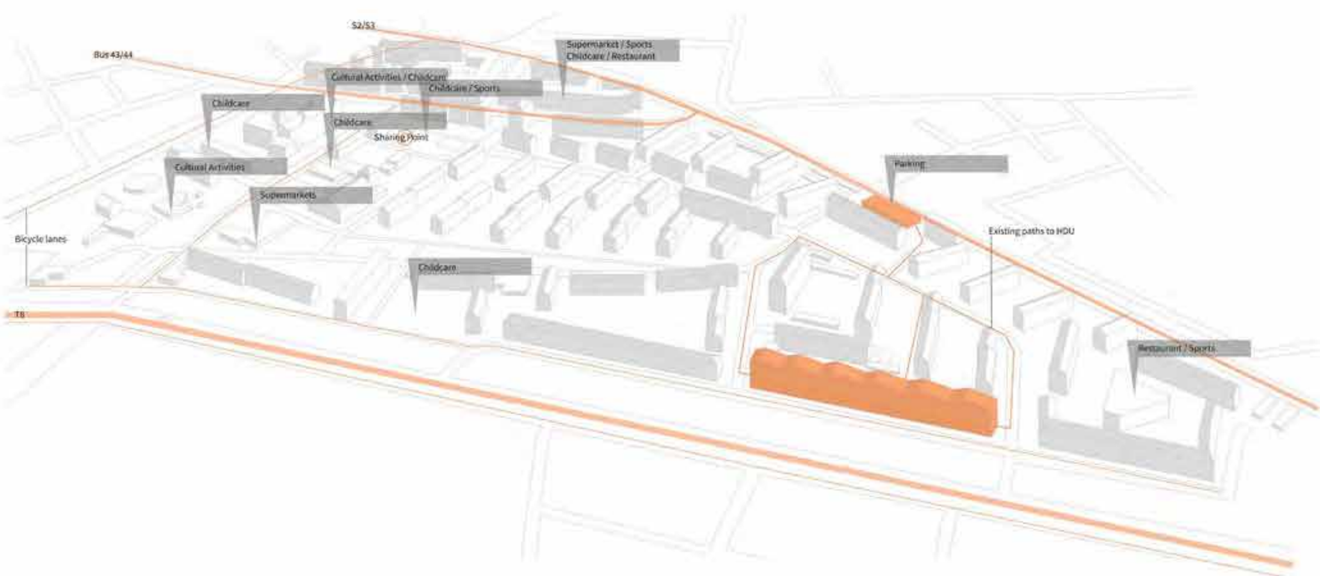
The urban situation

Ludwigsfeld is characterised by a heterogeneous population. To integrate the people into the new concept, we have developed a design that sets an expressive and visionary architecture that deliberately sets itself apart from the surrounding development. The missing perspectives create a potential for positive urban development. The design expands the living space of the existing building and its perspectives through high-quality places for leisure, culture, sports, and stay.

Mobility and community

The concept shapes the future mobility in a sustainable way and guarantees fair access. The sharing fleet, consisting of bikes, e-bikes, cargo bikes and electric cars, is designed to cover the entire private mobility needs. The vehicle fleet is located in the newly planned parking garage. The use of public transport is promoted, new bus stops are planned, enabling faster movement and access to further connections. A designed smartphone app provides access to the sharing fleet, which also allows users to offer services and borrow goods.

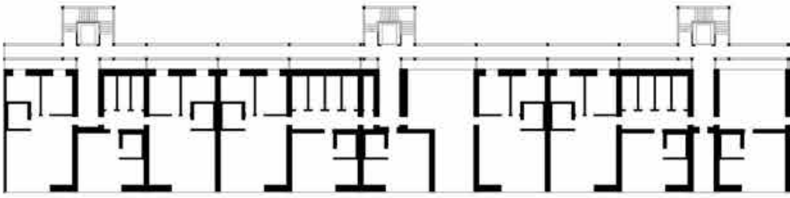
Site plan



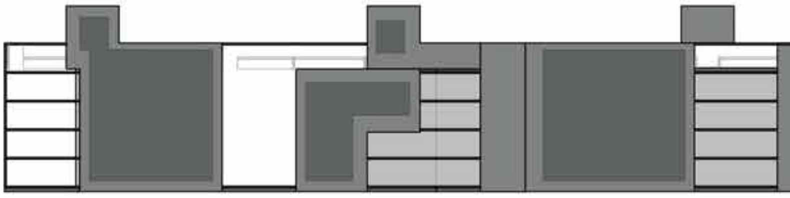
design challenge (dc) overview

Modularity and Adaptability

The extension consists of two floors with a roofscape covered with greenery and solar collectors and "crowns" the building. The long-sloping, solar-yielding surfaces are covered with photovoltaic modules, while the lower-yielding north side covers green spaces. Our building includes outdoor and communal areas as well as greenhouses. Under the roof terraces, there are two levels of prefabricated room modules in system construction. Modular construction makes affordable housing possible and also reduces construction time. The addition is accessible on the side facing away from the streets via an exoskeleton made of recycled steel. In front of this, at the level of the existing stairwells, there are new stair towers with elevators that allow barrier-free access. At the height of the extension level, an access balcony is suspended in the exoskeleton, providing horizontal access to the whole length of the building. The skeleton allows also balconies to be integrated into the steel structure.

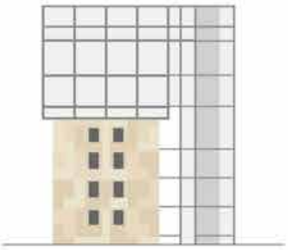


Level 1 of the addition of storeys (5th floor)



Rooftop plan

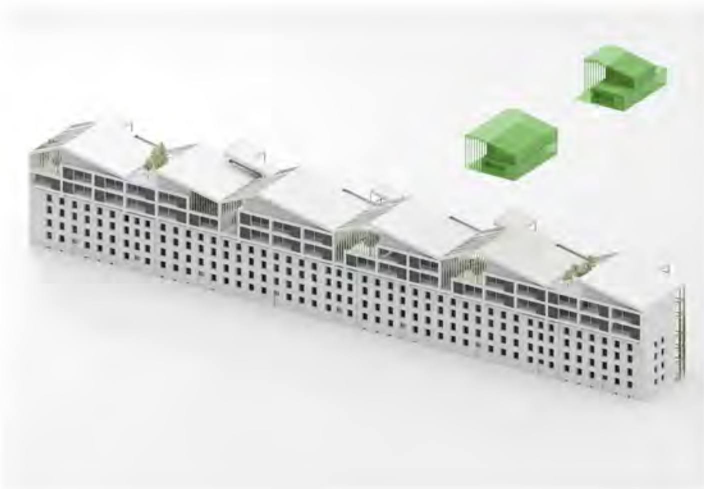
South-west elevation



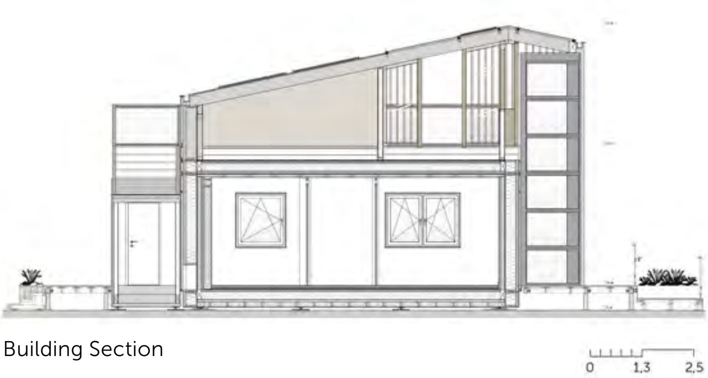
South-east elevation

North-east elevation

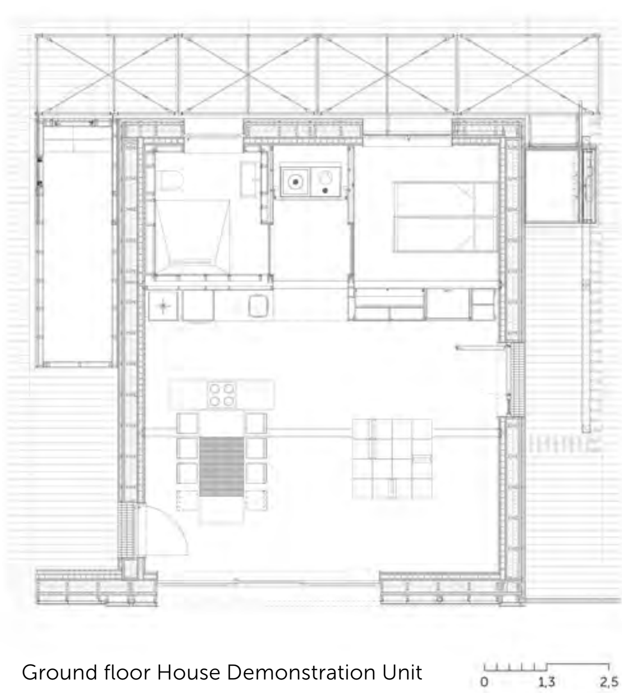
house demonstration unit (hdu) overview



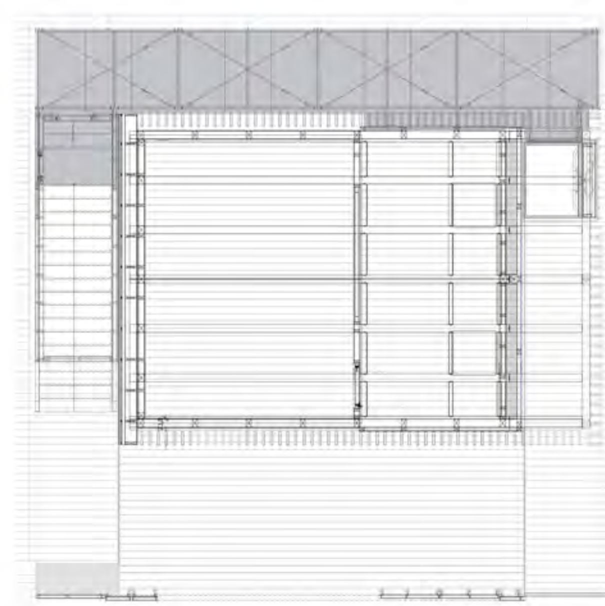
Cutout of the Design Challenge, which was built as HDU



Building Section



Ground floor House Demonstration Unit

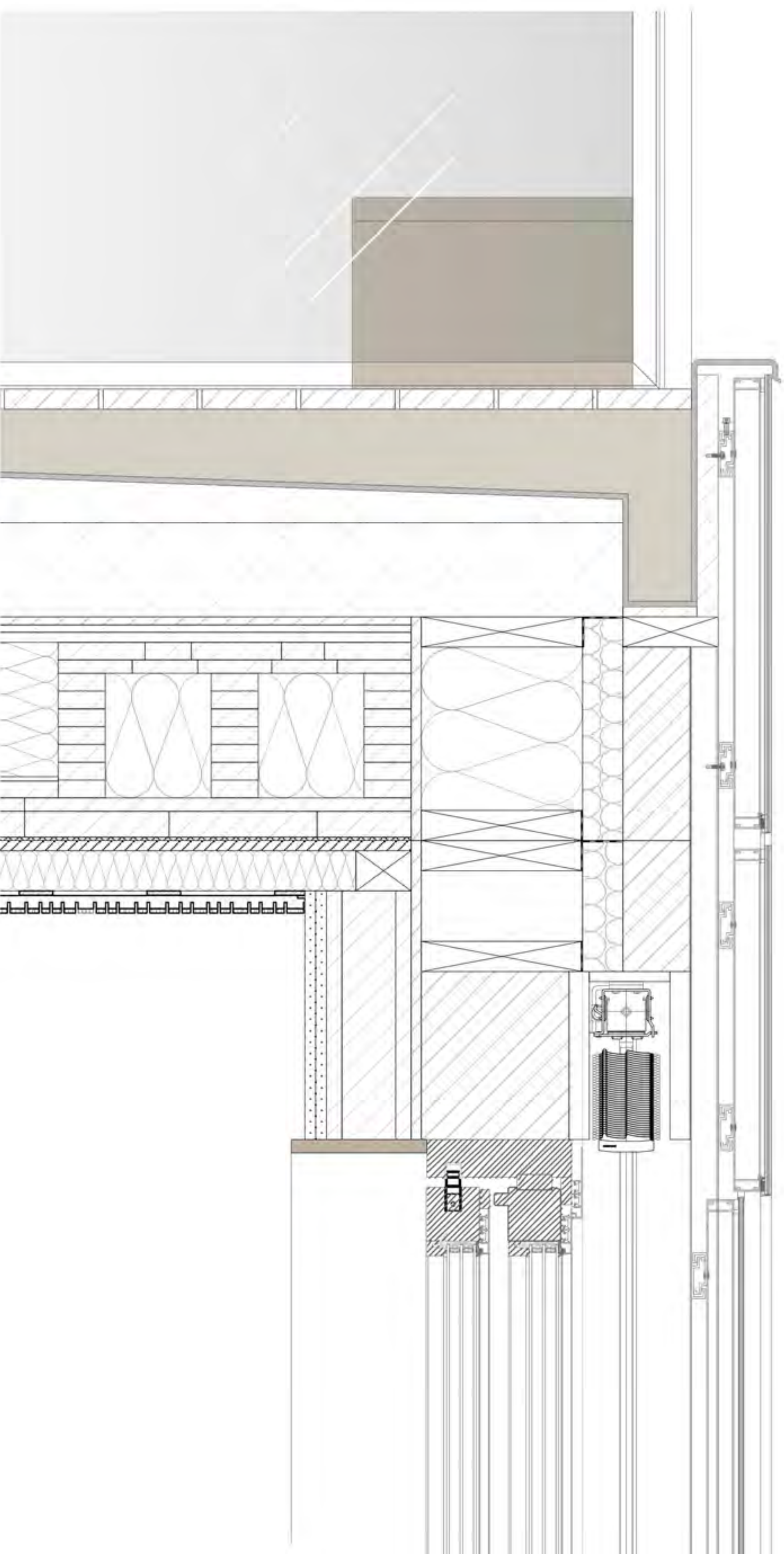


Upper floor House Demonstration Unit

Fully functional prototype

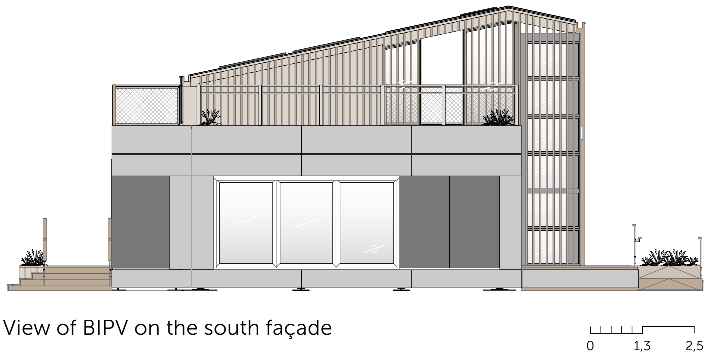
The House Demonstration Unit is a fully functional, one-story, 1:1 scale prototype consisting of three wood modules on the ground floor that exactly represents the original design of the addition. The first floor complements the living unit by a large roof terrace, a greenhouse for urban gardening, and a technical room. These upper floor elements best represent the levelup concept derived from SDE's Design Challenge, which requires common areas where social interaction can occur among all residents. The structural framework of wooden columns and beams characterizes the exterior design by wrapping itself like a unifying fibre across the southeast façade and roof of the HDU. One of the main design features is the building-integrated photovoltaic façade, which makes the module grid of the Design Challenge visible. Access to the upper floor is via an arcade on the northwest façade or an elevator. In this way, the HDU is also accessible without barriers. Our building is made of wood, a renewable material, and only recyclable or recycled materials. We have avoided glueing so that the building can be separated by material type and can also be recycled at the end of its life.

house demonstration unit (hdu) details



The House Demonstration Unit (HDU) is a modular construction. It consists of three modules, which are prefabricated in an exclusively solid timber post and beam construction with timber cladding. The interior works can also be predone in the factory. Except for the bathroom, there is no installation level in the wall of those modules. Instead, electrical cables are laid in cable ducts in the corners on the finished floor. The wall construction consists of two layers of clay building panels with clay finish. The floor is also made of clay building panels on wood-fibre insulation. This is followed by underfloor heating, a sound insulation layer and parquet flooring. The modules can thus be transported to the building site fully assembled by lorry and crane unloading and positioned there. Wood-fibre insulated, prefabricated façade elements with built-in windows and doors are attached to the modules. Insulated ceiling elements are also mounted on the modules. These consist of ribbed elements made of solid wood with wood-fibre insulation in the gaps. Inside the module joints, the installations that have already been installed are only plugged together. The upper floor consists of lattice girder walls with wood-fibre insulation and OSB planking. The roof structure is also constructed in this way and sealed against water ingress with titanium zinc panels. The flat roof on the upper floor is covered with plastic waterproofing.

solar system

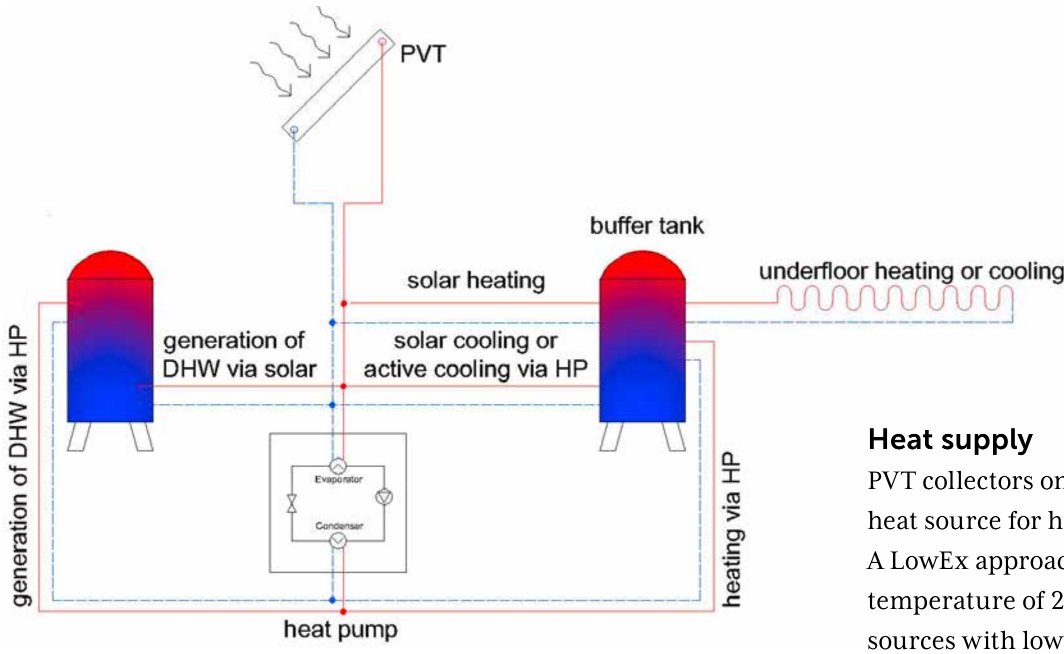


View of BIPV on the south façade

The photovoltaic system covers the electricity demand of the building. The façade is also used next to the roof to maximize the area that can be used for solar power. This makes it possible to achieve the zero-energy house standard. PVT and semi-transparent PV modules on the greenhouse are installed on the rooftop. These are a combination of PV modules for electricity generation and solar thermal collectors. This combination allows the modules to be cooled to increase efficiency. At the same time, the PVT collectors serve as a heat source for heating and domestic hot water. The PVT modules serve also as a cold source at night through radiant cooling.

Solar surfaces at the HDU consisting of semi-transparent modules, PVT and BIPV

energy supply



Heat supply

PVT collectors on the building roof are used as a heat source for heating and domestic hot water. A LowEx approach provides for a maximal flow temperature of 25°C. This concept allows heat sources with low-temperature levels and guarantees high flexibility and good transferability. An optimised building envelope via the activation of the façade by a façade heating system provides the ground conditioning of the existing building. This way, the heating demand of the existing building is reduced.

Greywater utilisation

To respond to changes in rainfall events and reduce the need for drinking water, the water that is not heavily polluted is treated by a greywater treatment plant.
The greywater is used for the operation of washing machines and toilets. This measure alone can save one-third of the water consumption.

Building automation

Automation of residential buildings serves to increase comfort, safety and energy efficiency. The technology helps the resident to support the user's behaviour. For example, automation takes away the need to turn on the washing machine when solar yields are high. But the technology also informs the resident about energy flows in the building, allowing them to adjust their behaviour. One focus of the project was the design of the interactions between the building automation system and the user.

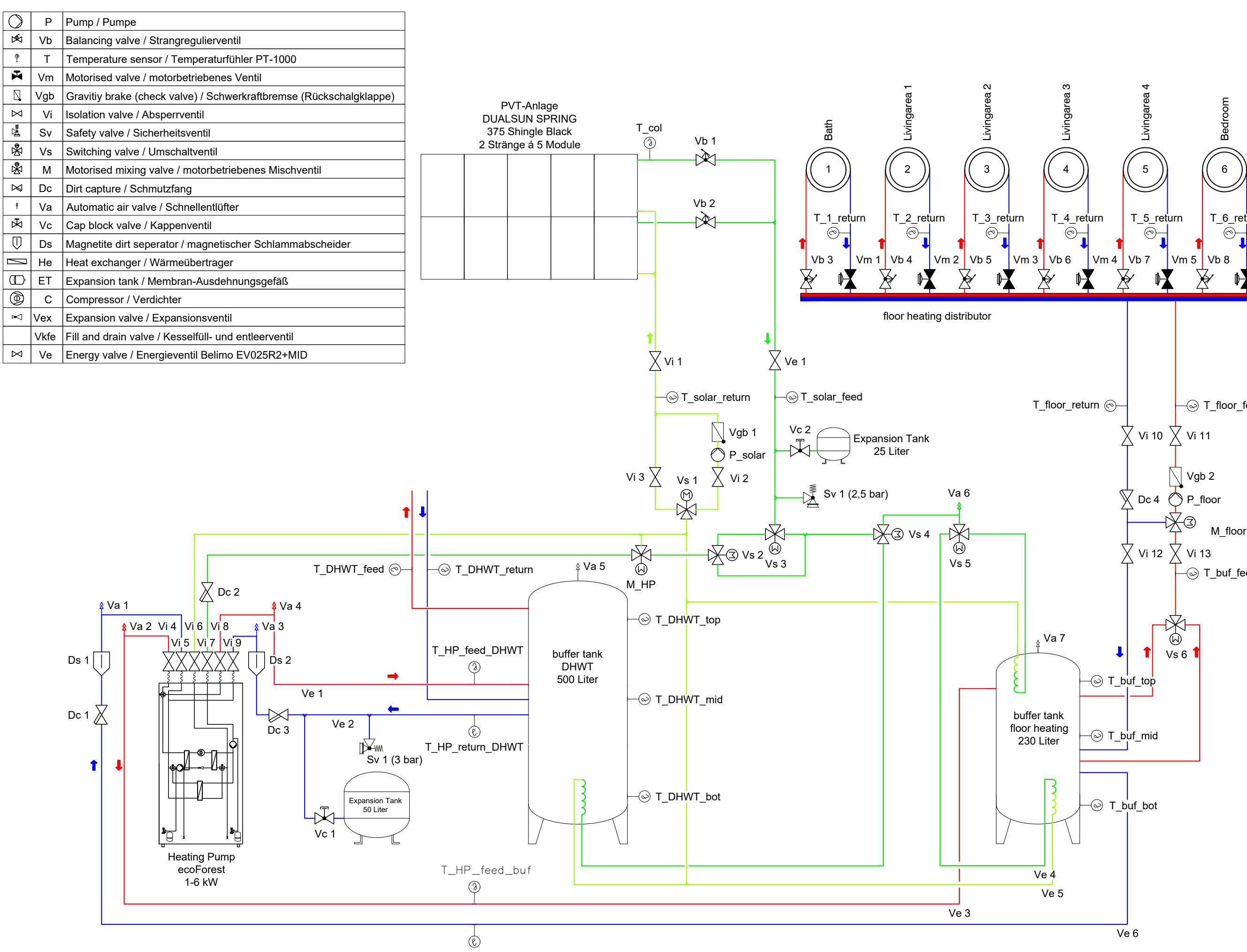
indoor climate dc and hdu

Healthy indoor climate thanks to clay plaster

The clay building boards used are thermally connected directly to the solid wood, as the HDU has no installation level. This creates a building that is comparatively inert for timber construction. In addition, clay plaster is very environmentally friendly and ensures a healthy indoor climate.

Clay plaster

HVAC schematic drawing



key figures, team and sponsors

levelup

Further project information:
https://levelup-ro.de/

Sponsors

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ALPI Deutschland GmbH
auxalia GmbH
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W. Markgraf GmbH & Co. KG
WAGO Kontakttechnik GmbH
Warema
xoio GmbH
Zimmerei Lukas Germerott GmbH

TEAM NAME | TEAM IDENTITY

SUM | TUD

UNIVERSITY

delft university of technology delft, netherlands

TASK

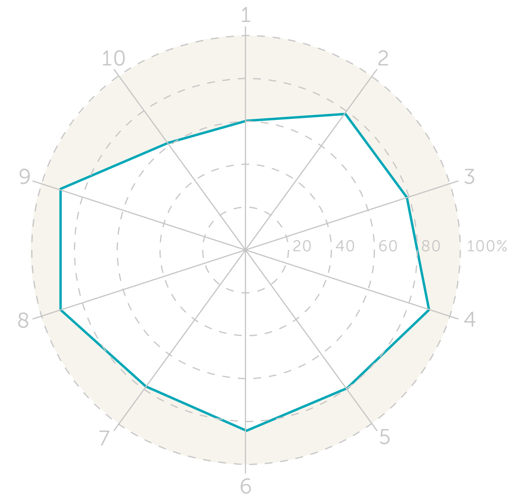
renovation and addition of storey

LOCATION OF DC

the hague

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	3695 m^2	102 m^2
	7	2
	24 m^2/p	23 m^2/p

SUM started its journey by examining large societal challenges in the team's home country, the Netherlands. Through literature and field research, SUM has identified 2 national problems that can be tackled by participating in the Solar Decathlon:

1. Housing shortage: The Netherlands has an exponentially growing housing shortage. By 2030, 1 million new homes need to be developed.
2. Energy-neutral built environment: The struggle for an energy-neutral building environment by 2050 as agreed in the Paris Agreement in 2016.

In order to select a case study site for urban and architectural intervention, SUM analysed various urban fabrics in the Netherlands. Based on its open and standardised built environment, SUM's focus narrowed down on the large Dutch post-war building stock.

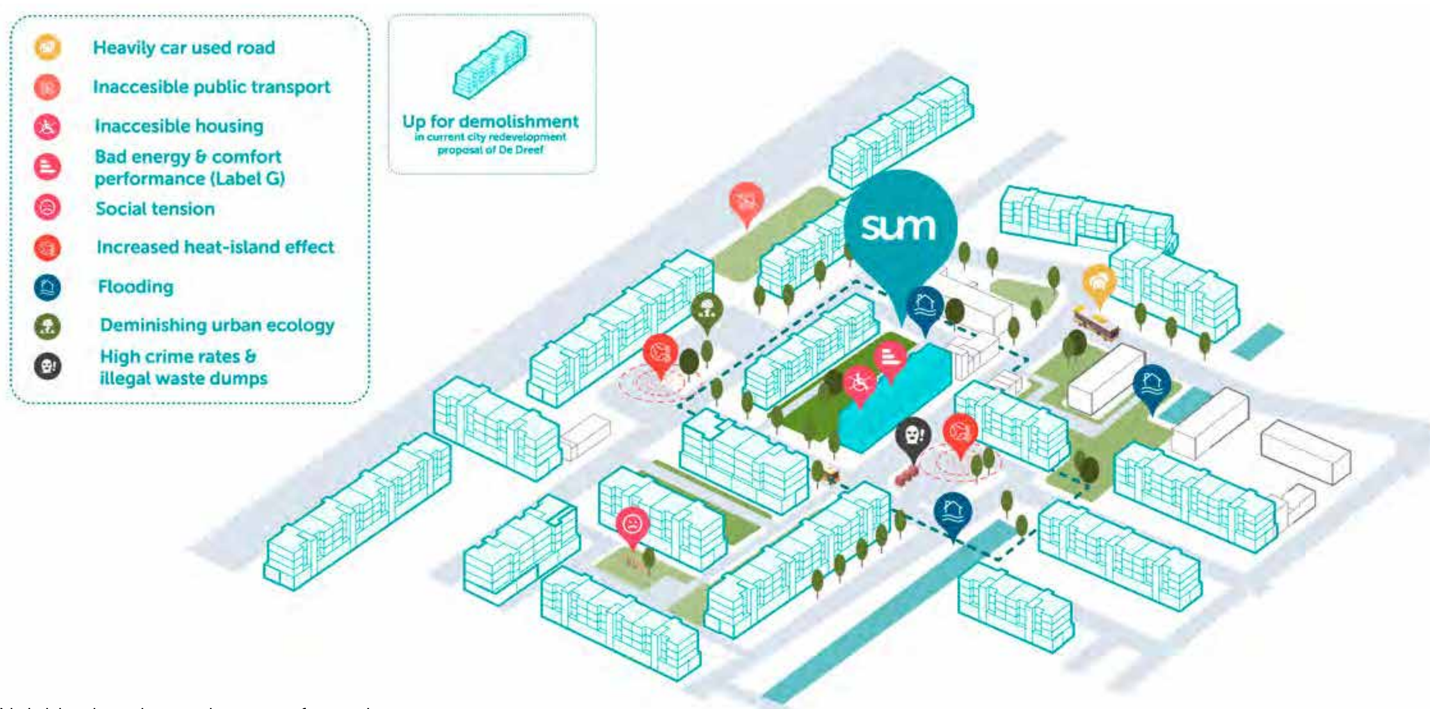
By setting clear urban and architectural goals, the SUM proposal does not only cater to the case study neighbourhood in The Hague, but it also acts as a wider redevelopment programme for post-war neighbourhoods around the Netherlands by being able to test design interventions and produce a set of recommendations to bring the post-war neighbourhoods into the 21st century.

SUM's proposal is a renovation and densification plan for the 847,000 underperforming tenement flats. With SUM's repurposing strategy for tenement flats, the proposal aims to create a world in which diversity, innovation and social interaction are stimulated; a world where social, economic, and environmental challenges across the country can be addressed with smart design solutions.

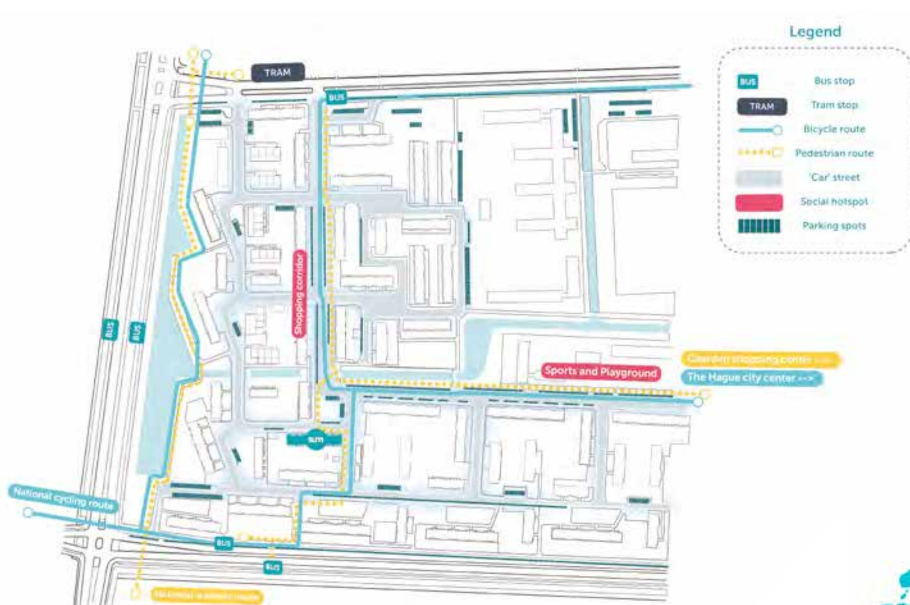
SUM aims to harness the potential of the existing neighbourhood by densifying the tenement flats with modular Top-up additions, while preserving the horizontal character of the buildings. Furthermore, SUM is proposing to create communal gathering spaces for the neighbourhood's residents, both for each building and on an urban scale

urban context and mobility

In the Hague, the case study site is situated in the Bouwlust/Vererust district, which comprises of post-WWII Dutch urban planning and architecture. The area currently lacks amenities, however it has a strong link to the city centre with great potential to integrate into the city-wide public transport system.



Neighborhood complete transformation

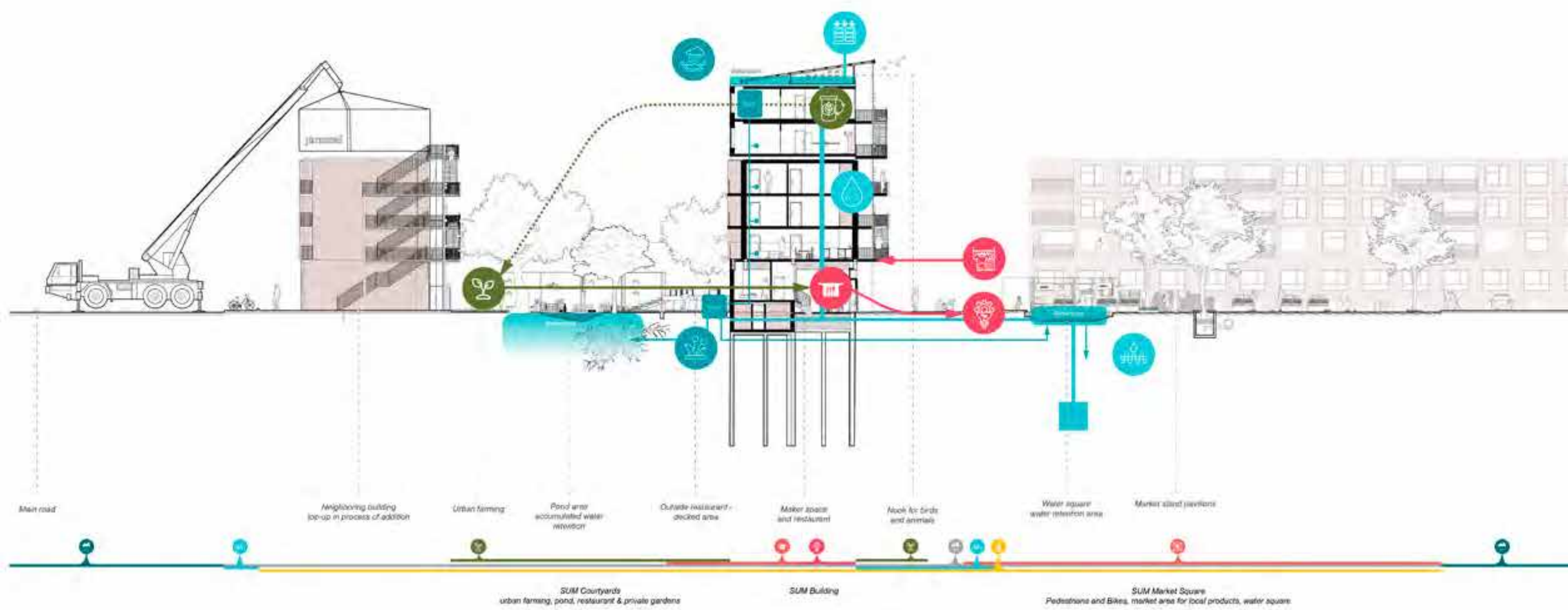


Neighborhood Mobility Analysis

Scalability of SUM

design challenge (dc) overview

SUM proposes 6 main elements for the design, which include: ground floor activation with new public functions, multi-functional circulation core, gallery, the renovation of existing units, the addition of modular Top-up units and a productive roof.



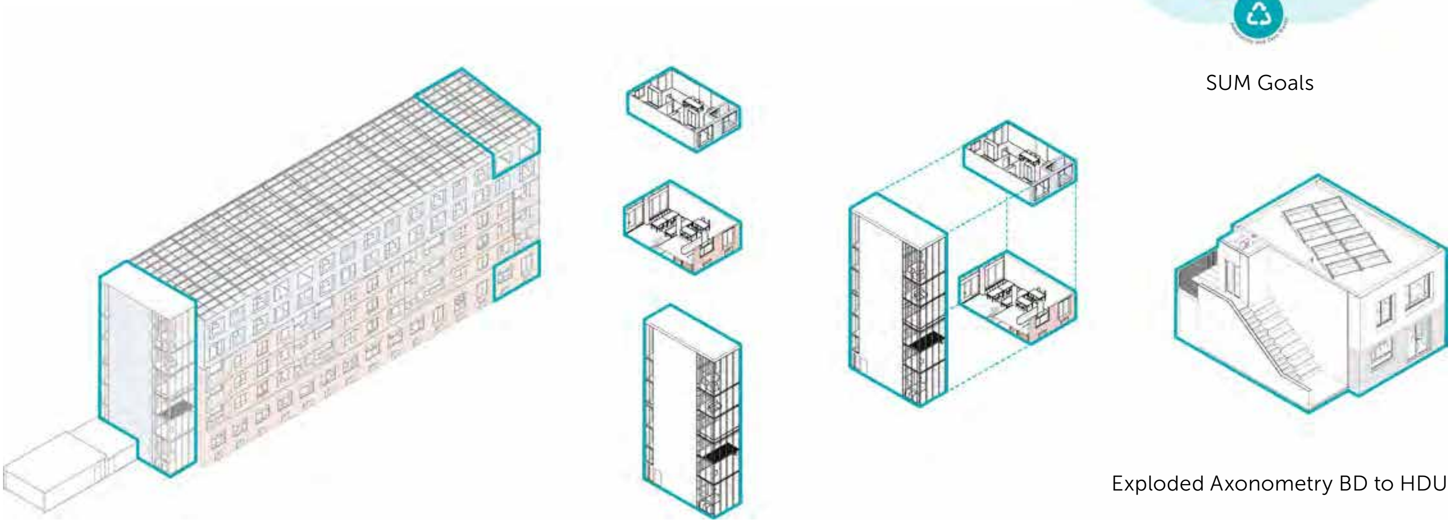
Urban Section of the Building Design

Floorplan Renovation Unit

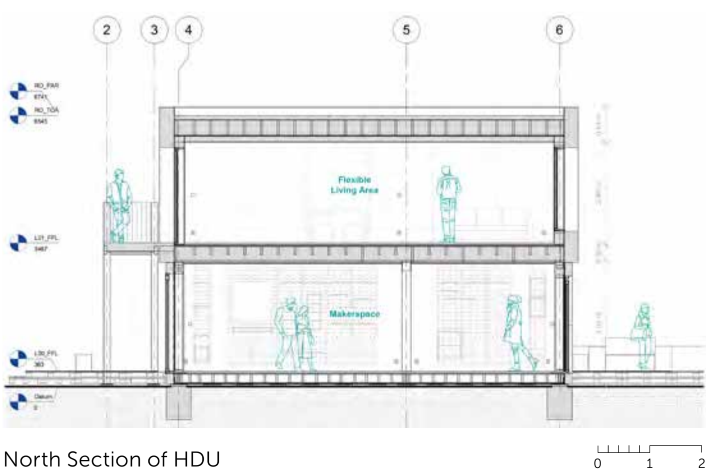
Floorplan Top-up units

house demonstration unit (hdu) overview

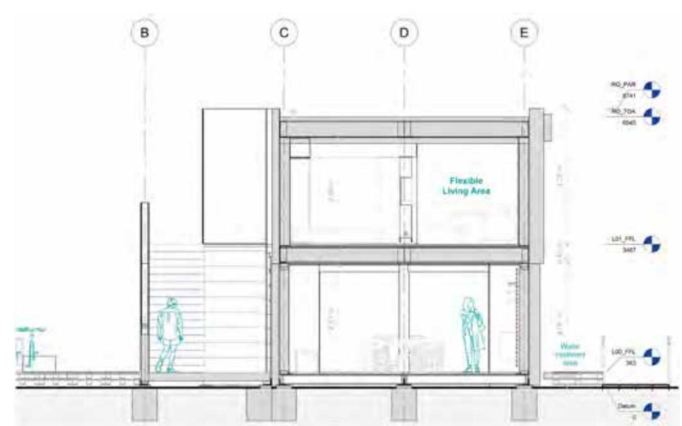
SUM Goals



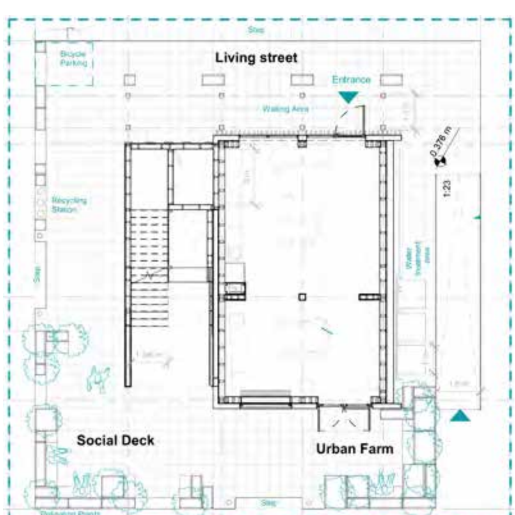
Exploded Axonometry BD to HDU



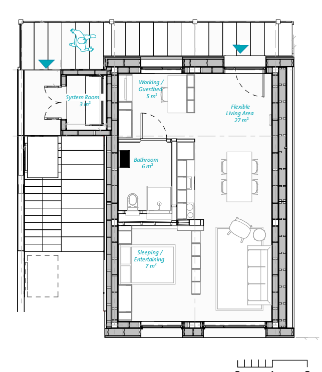
North Section of HDU



West Section of HDU

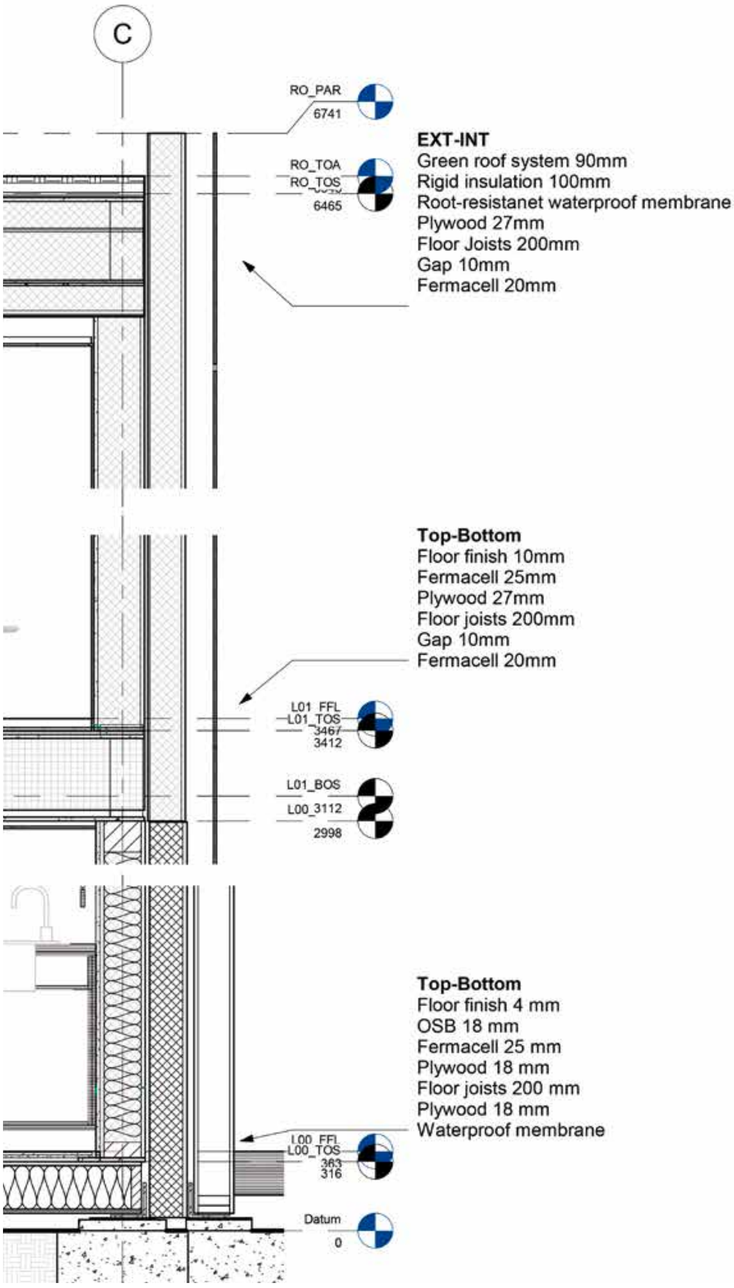


Floorplan HDU Ground Floor



Floorplan HDU Upper Floor

house demonstration unit (hdu) details



Detail Section of HDU

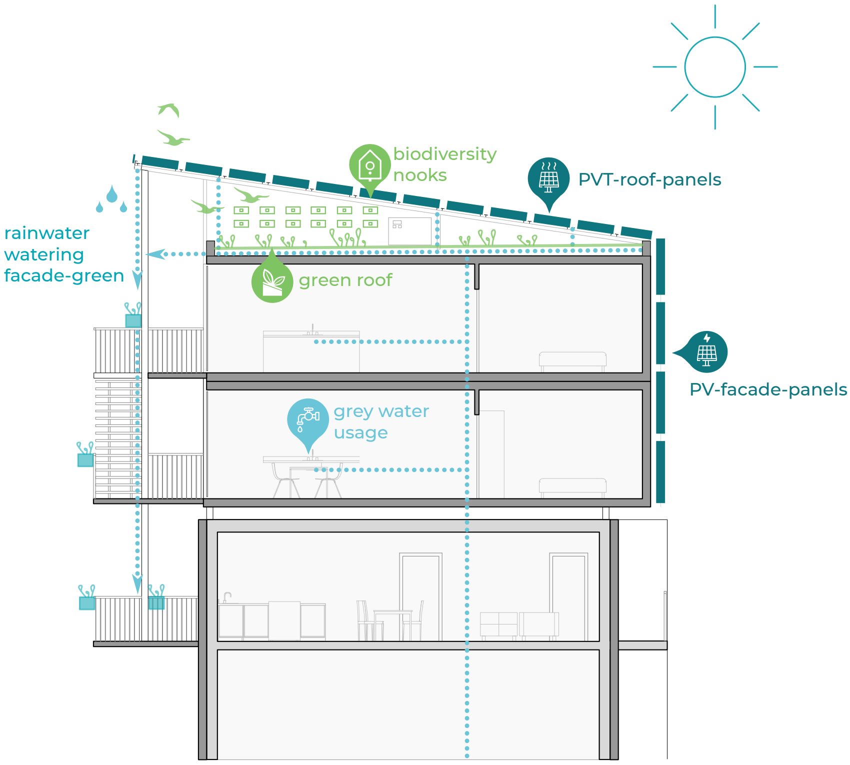
The HDU represents 3 components of building design: renovated ground floor, top-up housing unit, and circulation core.

The ground floor renovation strategy shows a multi-functional community space that enables a variety of social activities.

The top-up densification strategy is comprised of 2 pre-fabricated modules and showcases a one-bedroom unit layout for a young entrepreneur. The smart module houses the bathroom and kitchen, while the standard module is an open living space. Thanks to flexible furniture, the layout can be adapted to cater to various living scenarios.

The HDU's circulation core is a modular wooden staircase that acts as a circulation space, public forum, systems core, playground and urban vehicle storage.

solar system



Section of the installation of PV panels

The main energy production of the building is from the photovoltaic-thermal (PVT) panels on the roof. PVT panels are a combination of PV panels and heat exchangers which benefits efficiency. In addition to PVT roof panels, the south facade and the circulation core of the building are wrapped with building-integrated PV panels (BIPV) that will increase production, reduce daily peaks and create an overall stable electricity generation throughout the day.

The goal of the solar system is to optimize the available space to generate the maximum possible energy for load balancing. PVT panels are selected for the Top-up roof as it is one of the most space-efficient methods of solar panels due to the combination of heat and electricity generation.

The system selected for the facade consists of Kameleon-colored solar panels. These panels are fully customizable and will be used to give the new Top-up layers its characteristic appearance, showcasing that sustainability can be beautiful.

HDU Solar System
© Steinprinz / University of Wuppertal

PV facade in the Building Design

energy supply

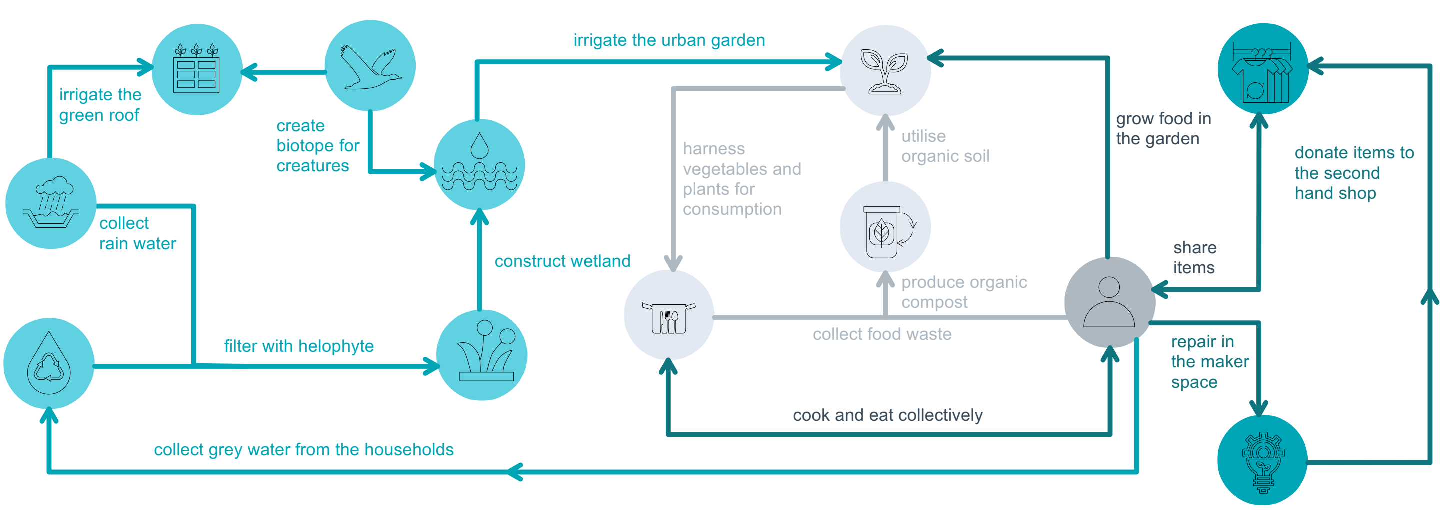
Heating:
By applying the Passive House Standard, most of the heating and cooling demands are reduced drastically. As a result, no additional heating system like radiators or floor heating is required.

Domestic Hot Water
The PV-T panels will not only produce electricity, but also heat. This heat is used by individual water-to-water heat pumps that produce water for domestic use of up to 60°C.

Controlled Ventilation:
The prefab modules of the Top-up will be equipped with semi-decentralised Mechanical Ventilation with Heat Recovery (MVHR).

Solar Energy gaining:
The energy concept follows a strategy focused on three main concepts:

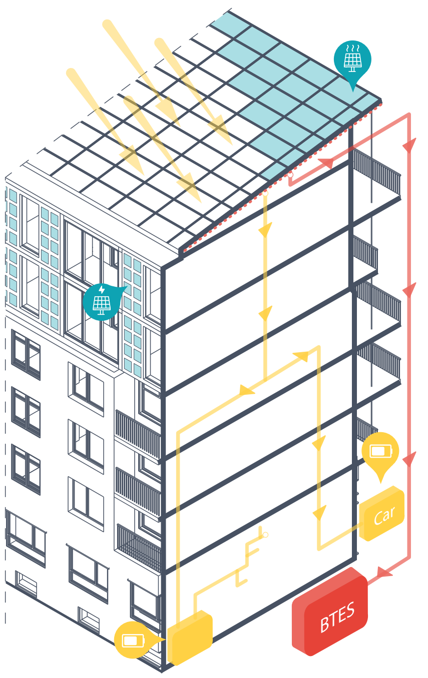
1. Reduce energy demand by creating an energy-efficient thermal envelope.
2. Reuse of energy, ventilation and plumbing systems play a key role. Heat and humidity are recovered from the outgoing ventilation air.
3. Produce the required energy in a sustainable way. The Top-up apartment functions as an energy hub that produces all the electricity for the prototype.



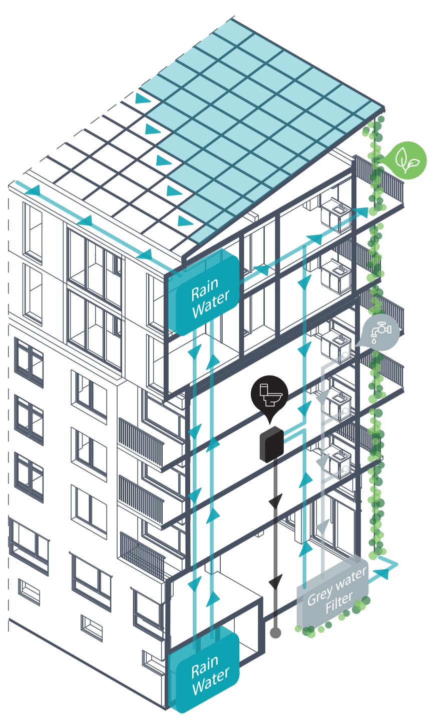
Circularity diagram

indoor climate dc and hdu

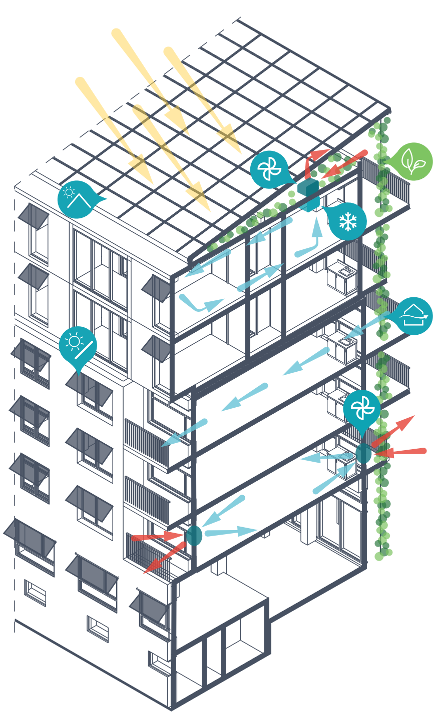
Post-war tenement flats are currently faced with major comfort issues, like drafts, molt, and overheating. To make these buildings future proof, SUM is implementing a phased strategy. Starting with reducing the energy demand by wrapping the existing building with a new layer of insulation and replacing the windows. Sunshading will be integrated in this new facade, preventing overheating in summer. Heat is reused with heat recovery showers and decentral heat recovery ventilation units integrated in the new facade panels. These ventilation units provide the houses with fresh healthy air, creating a comfortable indoor climate. The renovated apartments are heated with radiators, while the new Top-up apartments are completely climatized with the pre-heated ventilation air. Electricity and heat are produced with PVT panels and BIPV on the Top-up, working in symbiosis with the renovated building below.



Energy Management



Water Management



Summer Ventilation

Winter ventilation

key figures, team and sponsors

Further project information:
https://delftsolardecathlon.com/

James Hardy/ Fermacell
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joneneel
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sarens
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The Green Village
Unilin
velbus
victron energy

TEAM NAME | TEAM IDENTITY

SAB | BKU

UNIVERSITY

bangkok university
bangkok, thailand

TASK

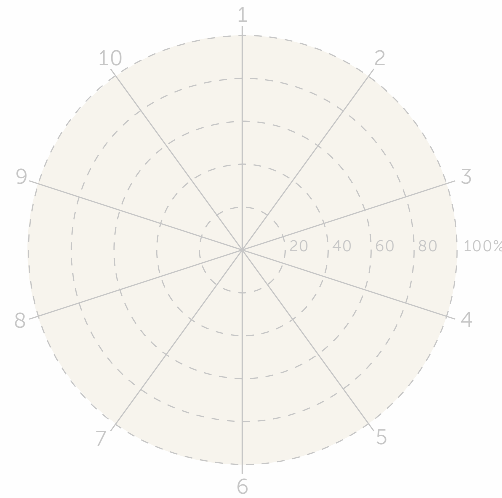
closing gaps

LOCATION OF DC

wuppertal

evaluation

1. architecture
2. engineering
& construction
3. energy performance
4. affordability
& viability
5. communication,
education &
social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

Visualisation of the House Demonstration Unit

our vision

		140 m^2
	5	2
		36 m^2/p

“SAB Adaptive living quarter” under the project objective to propose a solution for waste management issue by using recycling material for building construction. investigate two recycling materials: UHT and Beer brewer’s grain board, to analyze the best passive design solutions through building simulation and experimental design and to provide open space for urban connectivity the town vertically and horizontally of Wuppertal, Germany.

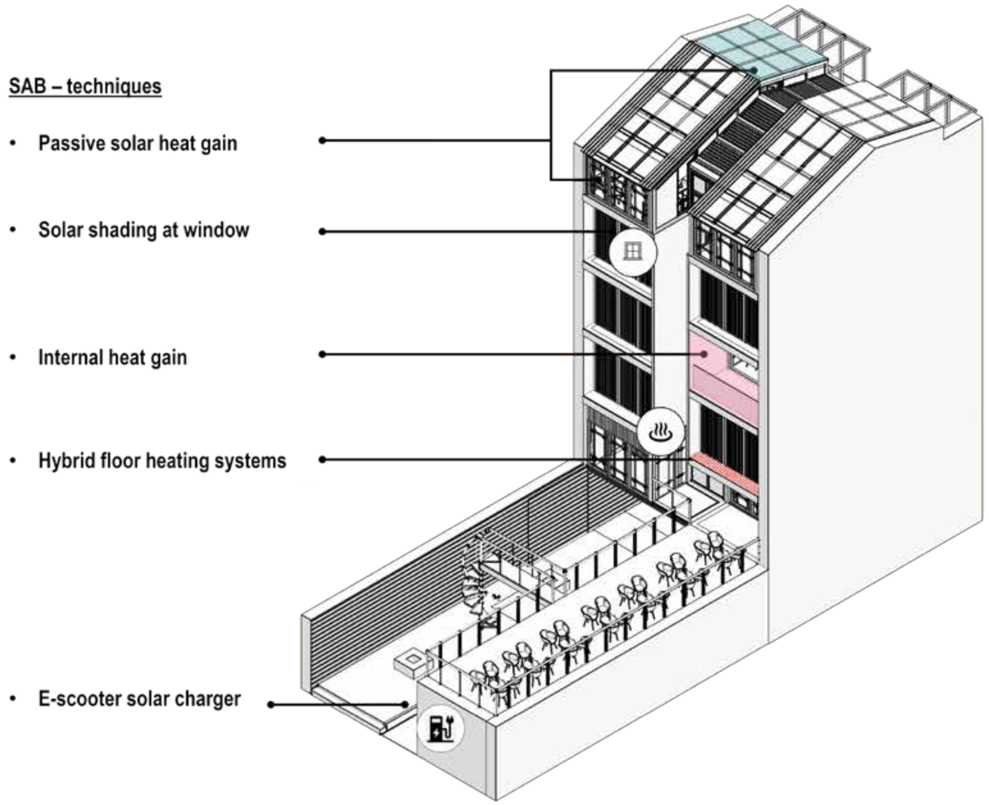
The urban mobility and connection for historical cities is chancing lifestyle for outdoor living. As per the existing dwelling for medium densifying cities and issue of in 50% of waste in Germany is mentioned and 40% of EU energy consumption are criteria for solution. The waste management is expected impact in Mirke Quarter area with over 800 building block, the current situation. The challenge No. 2 namely “closing gap” is selected for investigation in “waste reduction- and neighborhood connectivity”. The site location is rich with potential for urban mobility and activities with large garden and playground on the opposite. Thus, the concept of this proposal for using recycling material can be influence in reduction of waste in German.

urban context and mobility

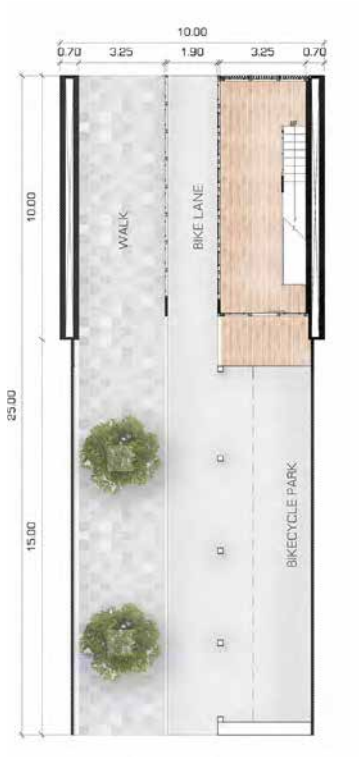
Isometry of the 3D-Model of the site concept

The lift-up space for connecting the two park of Wuppertal is main concern that how we can make people enjoy lifestyle without any borders. After we decided the connecting area, we think more on locals' activities and research that the city of Wuppertal is known for educational with the University of Wuppertal. Therefore, lacking of parking space is still issues. Thus, we design EV charging area and parking underneath the building. Also, we were considering the basement for hidden from some uncomforted climate where people could be gathering and partying with the ground temperature.

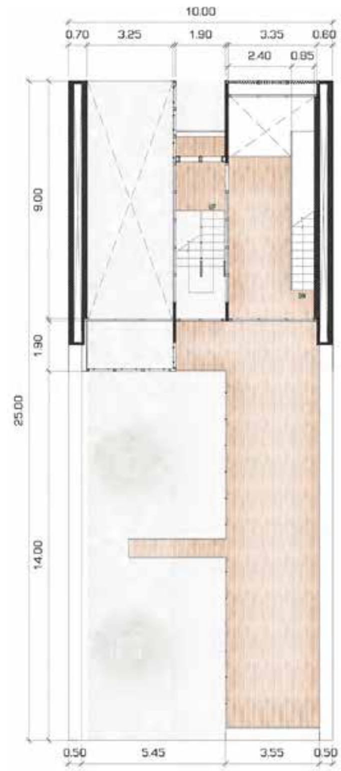
Urban Design Explanation



design challenge (dc) overview



1st Floor plan

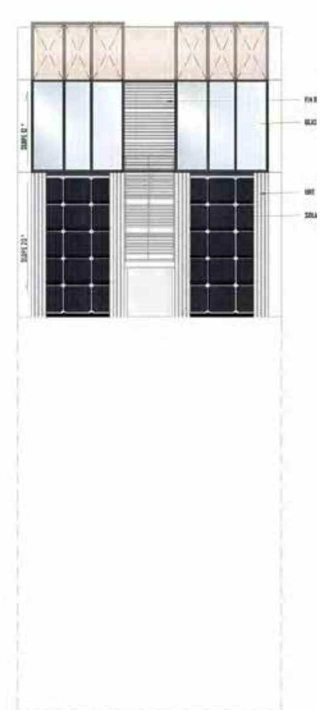


2nd Floor plan

4th Floor plan

5th Floor plan

Sun room

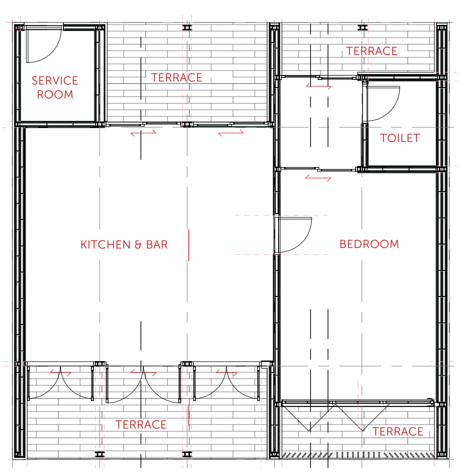


Roof plan

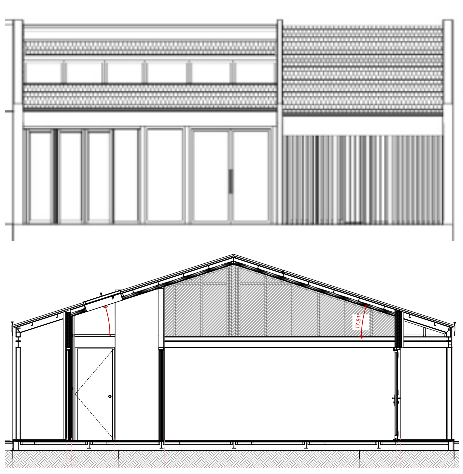
house demonstration unit

The house demonstration unit (HDU) is selected at the roof top position where sun room is located. The approach the solar heat gain from clean energy of sunlight is applied high-performance glazing. Together with recycling wall and floor material, we expected the heat is collected into the materials for releasing mean radiant temperature at night with naturally ways.

The HDU is consisted of public space for social gathering area that we design as a 'beer bar' for German concept. The space is cozy and chill with sun path comfort bubble chairs. We do not want the kitchen to be typical kitchen, it can be adaptable and moving shelves to anywhere we want. The dinning area is set at the back of the house to emphasize kitchen zone of bar. On the right hand, there is a demonstration of resting area for bedroom with the restroom and private terrace. The service is behind this house for PV systems and invertors. The selected materials are recycling of steel, teakwood vinyl, beer's brewer grain wall tiles, UHT board for floor tiles and thai traditional fabric called 'pa khao ma' that is adaptive clothing for Thai people. The cloth is commonly used in various seasonal here and also it is hand-made craft products.



Floor plan



Section

key figures, team and sponsors

Sponsors

School of Architecture Bangkok University

School of Engineering Bangkok University

Department of Alternative Energy Development and Efficiency - Ministry of Energy

The Federation of Thai Industries

SCG

MQDC For all Well-Being

AGC

SYS Siam Yamato Steel

Department of Industrial Promotion

National Geopgraphic

room life

baanlaesuan

Fiber Pattana Co., Ltd.

MinebeaMitsumi

Electrolux

MI

Bosch

Sharp

Mitsubishi Electric

Daikin

Hanergy Thin Film Power

Esara Living

Further project information:

https://solarsde21sab.wixsite.com/sabstudio

TEAM NAME | TEAM IDENTITY

LOCAL+ | FHA

UNIVERSITY

aachen university of applied sciences aachen, germany

TASK

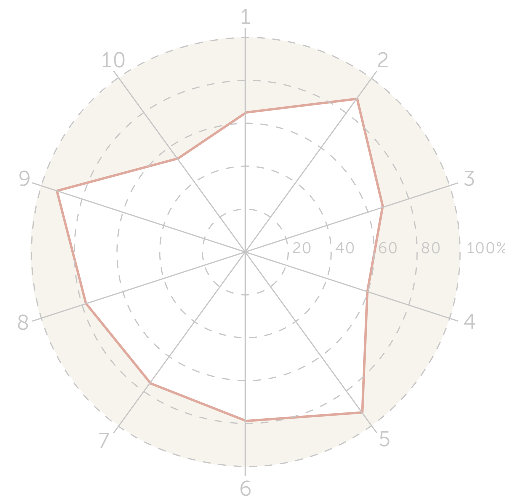
closing gaps

LOCATION OF DC

wuppertal

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	$482\ m^2$	$156\ m^2$
	6	2
	$31\ m^2/p$	$37\ m^2/p$

In response to today‘s challenges, such as climate change, scarcity of recourses, urbanisation and a growing and aging population, LOCAL+ aims to promote a flexible, sustainable and social housing solution that keeps pace with the constant changes of everyday life.

For this purpose, the team has chosen a building gap in the Mirke district as the setting. Here, in addition to social differences, age differences in particular play a decisive role. To promote social interaction, the team has developed a living concept for (temporarily) single people like newcomers, students or pensioners who want to be part of a community.

To support social exchange, the building design is based on the idea of minimising individual space to the necessary essentials and thereby offering larger communal areas.

Additionally, a high amount of flexibility allows an innovative living concept that adapts to the individual needs of the diverse group of residents.

In this context, the CUBE was invented to replace traditional rooms. The room units are a central design aspect and an architectural innovation, because they are fully movable! The CUBEs create spatial diversity by allowing adaptable zoning of rooms but mostly serve as a personal retreat and work space. Their minimised size puts interaction, communication and communal living in the spotlight and reduces the living space used per person.

In addition to social interaction, the aim of LOCAL+ is to create a building that innovatively and intelligently integrates new energy and sustainability concepts. With a clever combination of different concepts for generating, storing and using energy, two thirds of the building’s energy needs can be covered.

Furthermore, the circularity of the house is improved by an efficient and sufficient choice of materials and a detachable construction. In this way, the goal of reducing the carbon footprint, as well as planning and building in a way that conserves resources, can be achieved.

All in all, the building has been designed in such a way that the concept can be transferred to other urban situations and can thus serve as a prototype for closing gaps as well as for vacancies or new buildings.

urban context and mobility

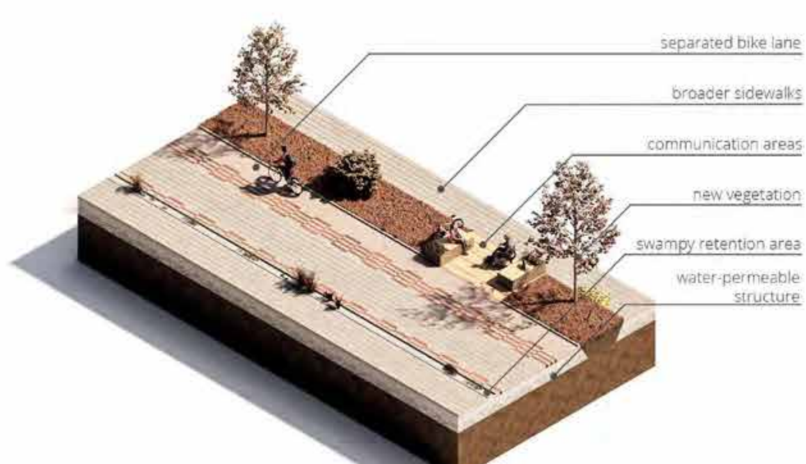
Site plan

Ground plan

In line with the gap-filling concept in the Mirke district, LOCAL+ analysed Mirke as well as the city of Wuppertal in detail. Based on that analysis, an urban mobility concept was designed that aims to target problems of the future city, such as climate change, flooding resiliency, urban biodiversity and problematic space distribution. The concept is especially suited for the district of Mirke but could be transferred to other European cities.

The basics of the concept are a strengthening of carbon-neutral mobility, such as cycling, walking and alternative and efficient motorised mobility solutions. By lowering the amount of space-inefficient motorised vehicles, room for social exchange, biotopes and other utilisations is generated.

The urban design by LOCAL+ could be a vision of future cities that is realistic and futuristic at the same time. Thus, it could be the linkage between climate theory and climate action. It could play a part towards a safe and socially fair future.

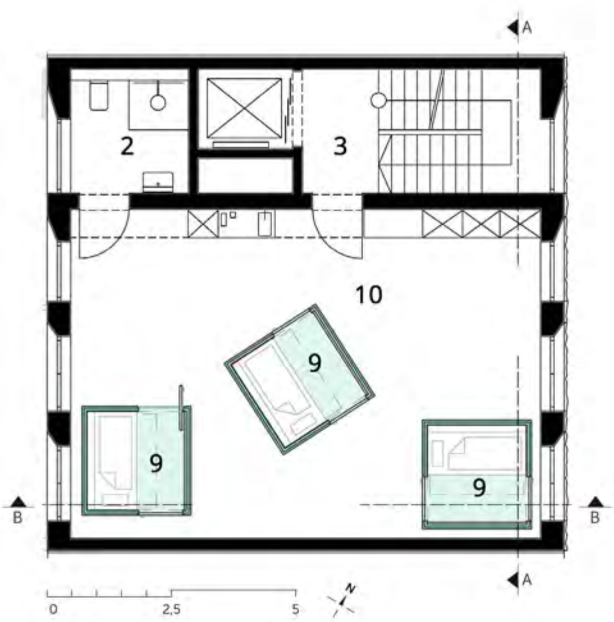


Axonometric-view-of-street

design challenge (dc) overview

While the basement, the ground floor and the attached garden offer communal areas for the entire building, the four upper floors each form a shared apartment for three flatmates. Each one measures about 60m² and the flatmates share a bathroom, a pantry-kitchen and a flexible communal area that is constantly being changed by the CUBEs.

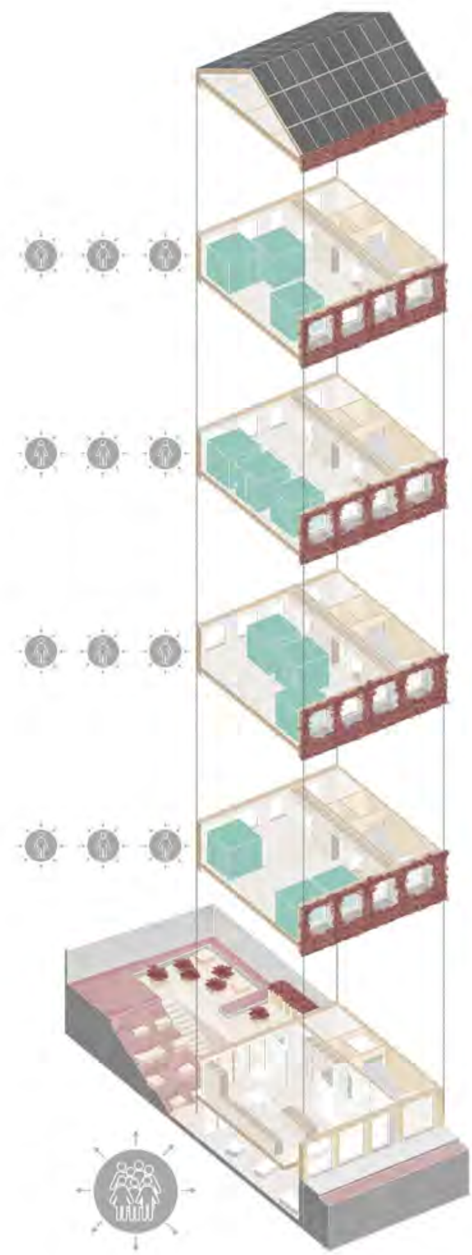
Section AA - DC



Floor plan - regular floor - DC

Legend numbers for DC and HDU:

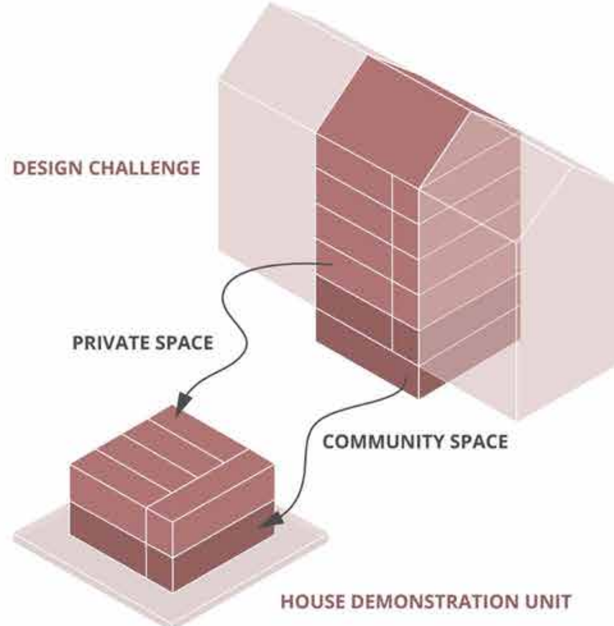
1. community space
2. bathroom
3. corridor
4. technical
5. community kitchen
6. terrace
7. garden
8. recycling area
9. CUBE
10. apartment
11. storage

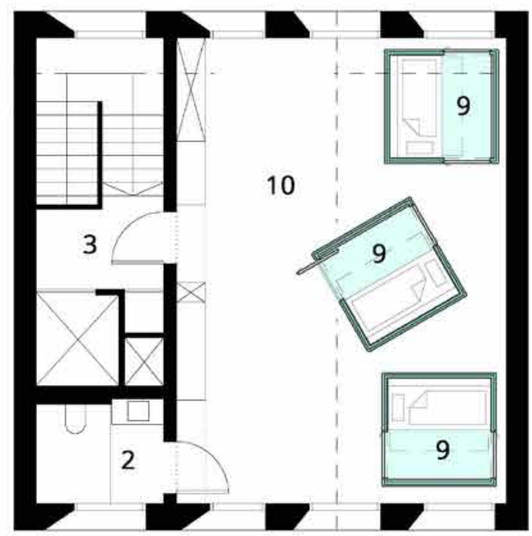


Exploded Isometry - DC

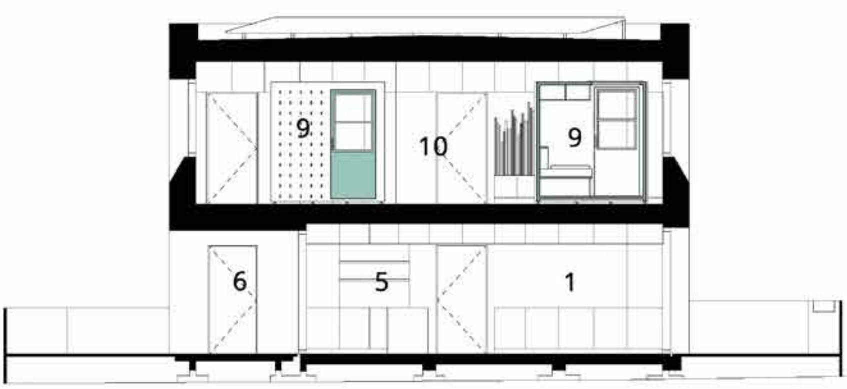
house demonstration unit (hdu) overview

The HDU is the translation of the DC into an exhibition architecture. While the lower floor combines the communal living room and the kitchen, the upper floor represents one of the four living floors of the DC. The demonstrator, which consists of 10 solid wood modules, was built using mostly detachable, reusable and eco-friendly materials and construction methods. The facade picks up on the photovoltaic panels, the wood cladding and the plant elements of the DC. In addition, the two outer walls with an air-cleaning textile reflect the neighbouring walls of the building gap. Finally, the energy concept with the PVT panels, the heat pump, the ice storage and the heating/cooling ceiling were also adapted.

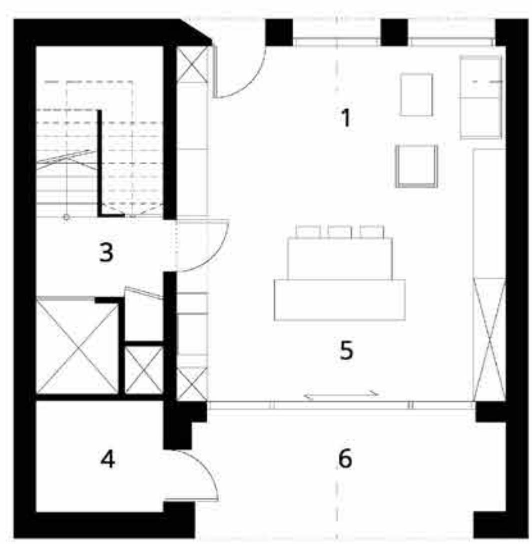




Floor plan - first floor - HDU



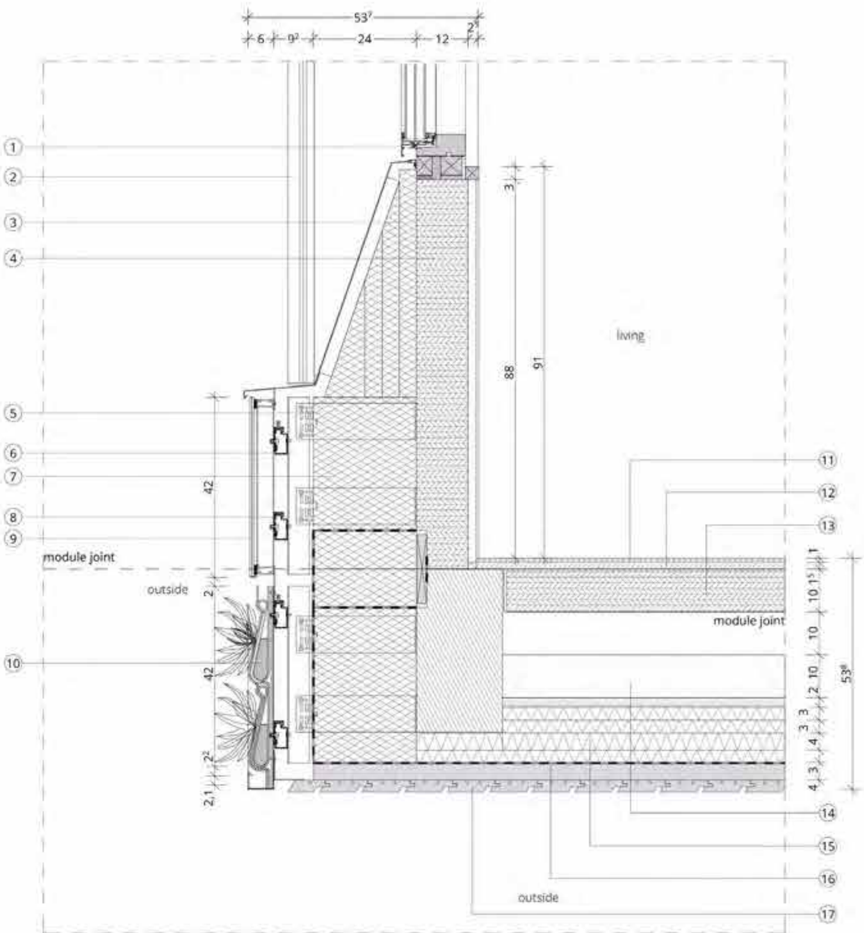
Section AA - HDU



Section BB - HDU

Floor plan - ground floor - HDU

house demonstration unit (hdu) details



Construction detail south facade

Circularity

A consequent closing of material cycles and the consideration of waste as a resource is the basis for the responsible use of (limited) resources and to reduce the dependency on global and unstable resource markets. The HDU will be used as a future material store that can be made available again for upcoming constructions at the end of the exhibition.

Construction

In the planning, the focus is on finding alternatives to the composite constructions that are usually difficult to remove. Most joining techniques focus on pressing on and pressing in (e.g. screws, nails, clamps) and cavity filling. The disassembly of the connection systems is made in reverse order to the assembly, a separation by type can therefore be guaranteed.

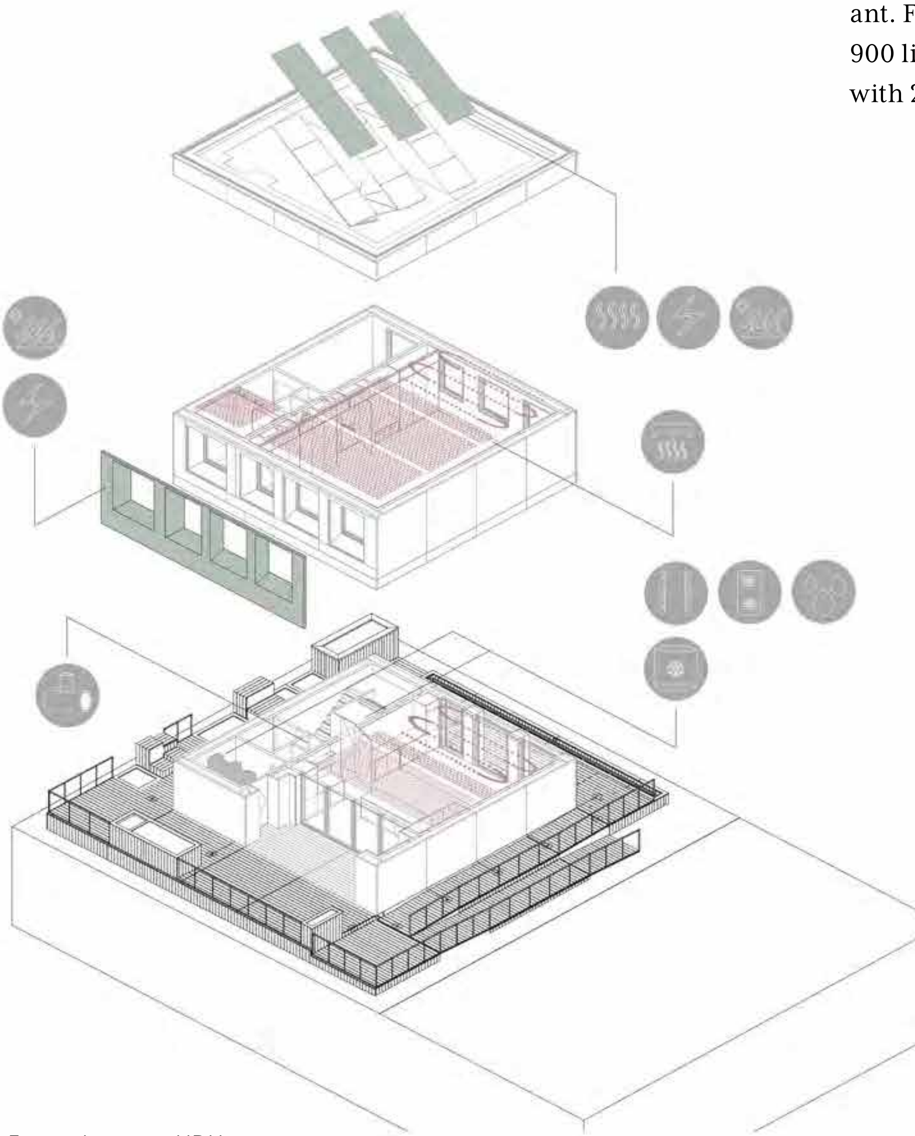
1. Outward-tilting window Velfac Energy 200
2. Roma ZIP Screen
3. Calostat insulation 120mm
4. Derix X-Lam 120/3S
5. L-Console Systea UBE
6. T-Profile Systea UBE
7. Wood fibre insulation 240mm
8. Agraffe Systea UBE
9. PV module Sunovation
10. Vertiko LWO Panel 60mm
11. Flooring 10mm
12. Dry screed system (Unifloor Jumpax Nature) 15mm
13. Derix X-Lam 120/3S
14. Filling (Unifloor Ecopearls) 100mm
15. Calostat insulation 130mm
16. Vapor barrier
17. Wood cladding 27mm

Facade north © Steinprinz / University of Wuppertal

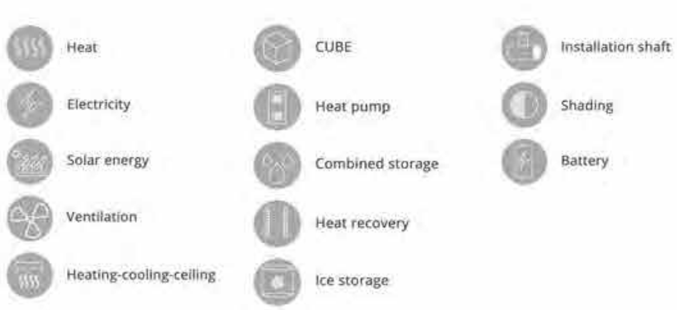
Urban Mining Index - HDU

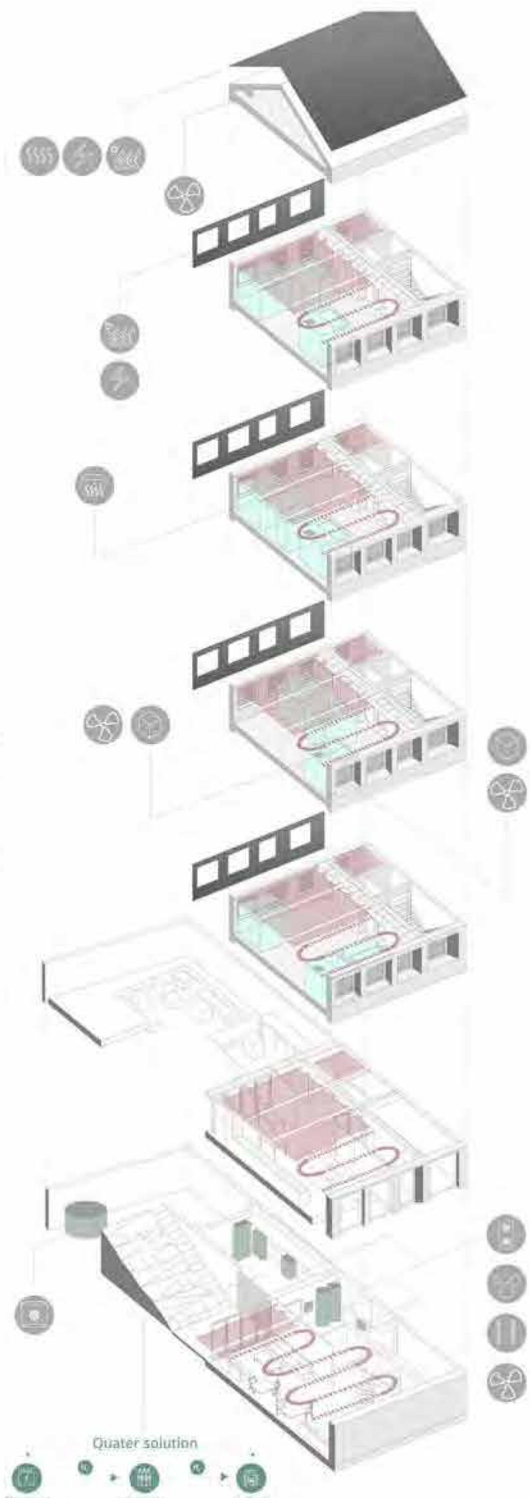
solar system

The core of the energy concept is a photovoltaic system with nearly 3 kW_p, which is connected to a 2.4 kWh battery storage system. In order to significantly reduce the carbon footprint of the technical components, special attention was paid to the selection of the heat pump with a natural refrigerant. For the HDU, an insulated ice storage with 900 litre capacity is provided, which is equipped with 2150 PCM elements.



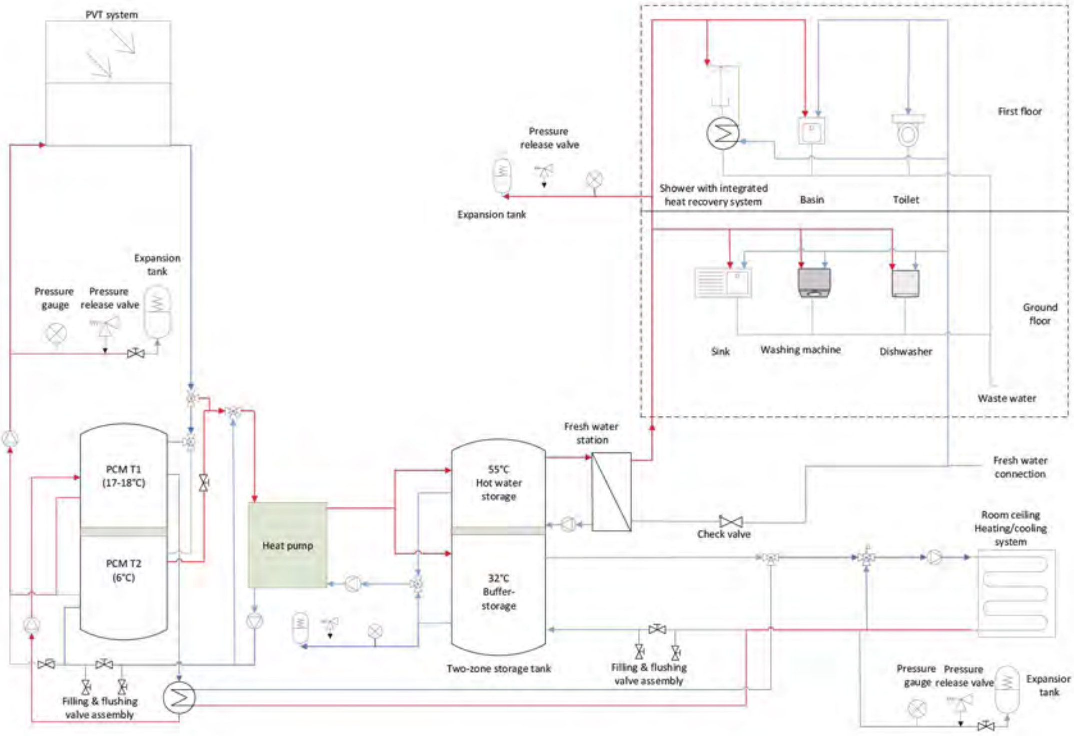
Energy Isometry HDU





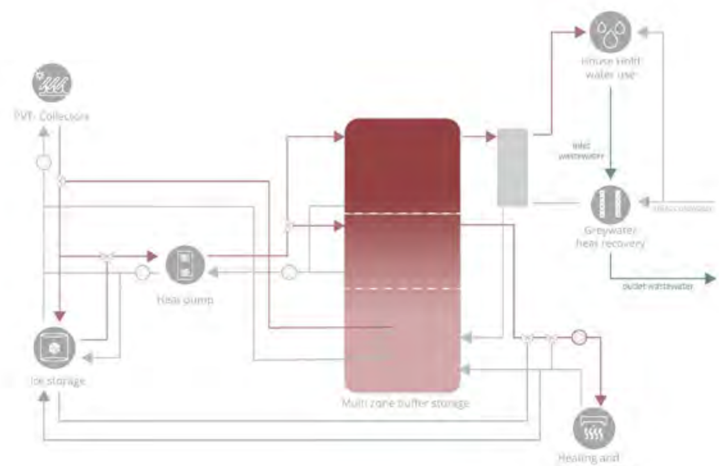
Energy Isometriy DC

energy supply

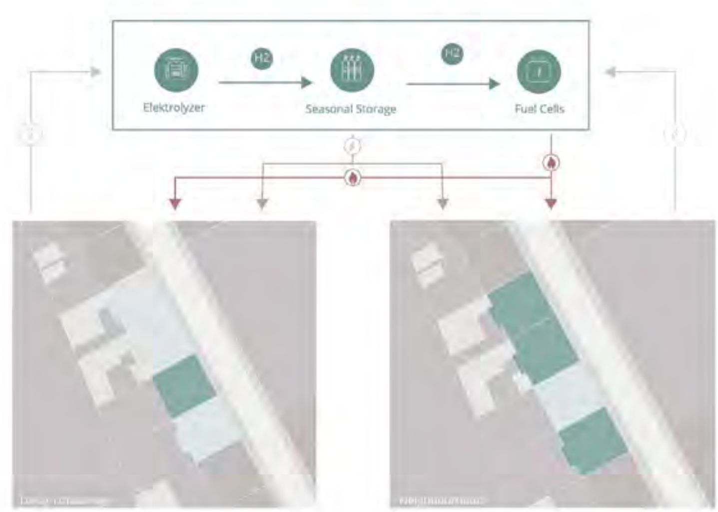


HVAC schema

PVT modules are planned on the roof of the DC building. Additionally, PV panels are integrated at the south-west facade of the building. The electricity produced is supplied directly to the apartments as needed during the day. Excess electricity from the PV system can be stored in a battery and it can be used later in covering the energy demand during the night. As a district concept, PVT and PV modules are connected with a central hydrogen system to use excess electricity for hydrogen generation. The complete energy concept was transferred to the HDU apart from the hydrogen concept. To ensure the highest level of comfort, energy efficiency and security, a central building management system (BMS) is planned. As well as the personalised visualisation, intelligent control strategies can be implemented by customised programming. Additionally, it can communicate with wide range of protocols. The planned HVAC system will be connected to KNX via gateway for central control and monitoring purposes, which includes heat pumps and all other pumps, valves, sensors, thermoelectric actuators and ventilation devices. The required weather data forecast for energy demand forecasting will also be integrated by calling API from the weather portal. Additionally, a PV energy forecast is integrated in the BMS.

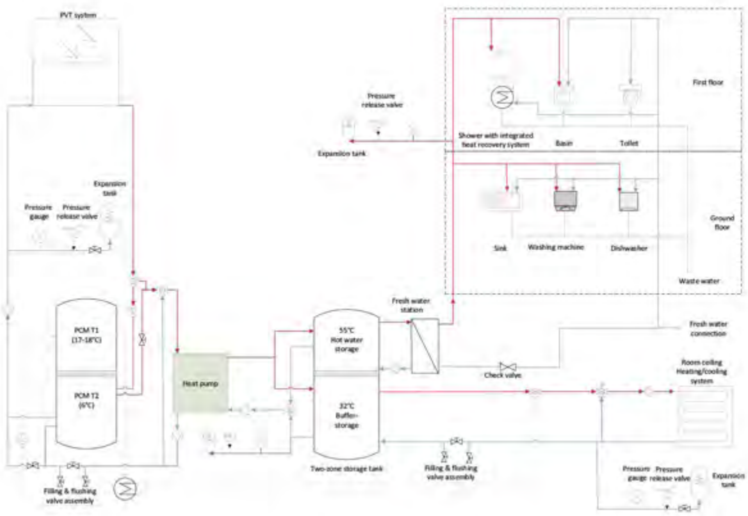


DC energy concept

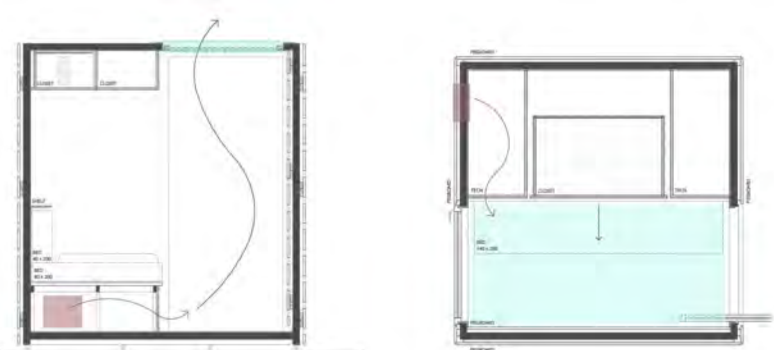


Enery concept neighbourhood

indoor climate dc and hdu



Cooling summer



Ventilation CUBE

Indoor climate

Heating/cooling system

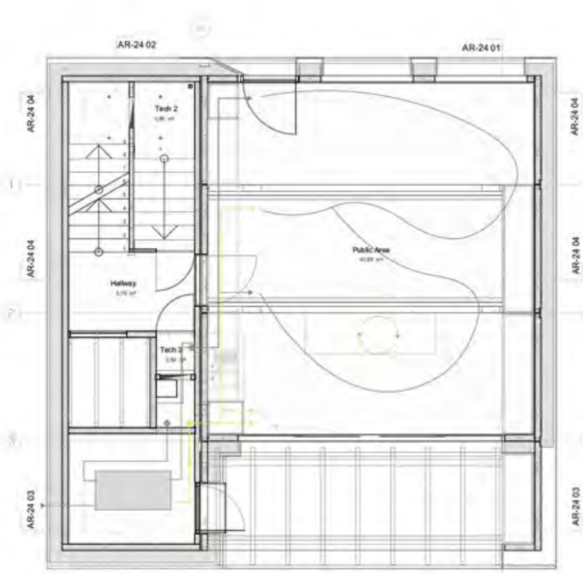
To regulate the temperature in the HDU, a water-fed heating/cooling system is provided in the ceiling, which is mainly made of clay. Since straw is used as a binder, the greenhouse gas potential is negative and the system can be fully recycled. Due to an inherent property of clay, it also helps to control humidity in the room and provides evaporative cooling to some extent.

Hot/cold water preparation system (HDU)

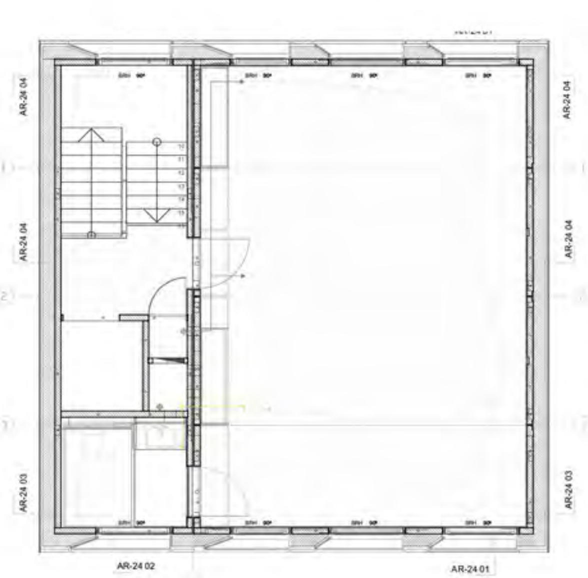
For the hot water preparation in the HDU, a PVT system and a heat pump are planned along with a multi zone buffer storage tank and an insulated ice storage tank. For the cold-water preparation, water from the cold-water storage tank is pumped to the PVT collectors at night to dissipate the heat environment.

Ventilation

To ensure the appropriate air quality, a central ventilation system is provided in the HDU. As the building is well insulated, a ventilation unit with heat recovery cannot be avoided. Therefore, the ventilation unit is placed under the ceiling of the technical room.
In the CUBEs, a sound-proofed ventilator is planned, which creates the lower pressure by blowing air into the big room. The control of the ventilation devices will be done mainly based on the carbon concentration in the CUBE.



Ventilation Groundfloor



Ventilation Firstfloor

key figures, team and sponsors

LOCAL+

Further project information:
https://www.team-localplus.com/

We would like to thank our sponsors for their support and cooperation!

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pro KÜHLSOLE GmbH
SPAX International GmbH & Co. KG

TEAM NAME | TEAM IDENTITY

TDIS | NCT

UNIVERSITY

national yang ming chiao tung university taipei, taiwan

TASK

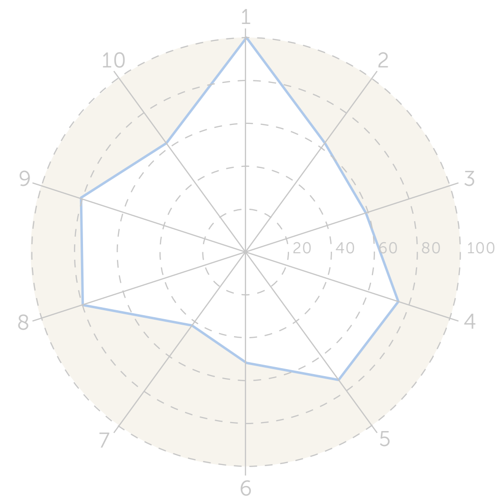
closing gaps

LOCATION OF DC

taipei, taiwan

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	445m²	123m²
	6	2
	301m²/p	58m²/p

The average building life in Taiwan is about 35-40 years. In Taipei, many old and structurally unsafe buildings built in the 1970s waiting for renewal. However, the process usually lasts more than 10 years. Many gaps have been created in our city. Instead of waiting a long time for urban renewal, team TDIS propose a new concept, which is to build mid-way housing.
"1 House for All" is an efficient way to refurbish residential buildings.
The goal is to close the gaps of time and space created by the complicated urban renewal process.
"How could we make a change for all?"
"What if...we have a house for all growing all over the city gaps that optimize the existing space and energy?"

Team TDIS believes that good designs are a sincere response to people's true needs, and are best done by trans-disciplinary teamwork. Team TDIS (Transdisciplinary Design Innovation Shop) is named from the pronunciation of "This", focusing on contemporary (This Moment), local (This Place), and immediate (This Time).

Our students are from different major fields; the professional backgrounds of our faculty are also highly diverse. With trans-disciplinary members, we aim to solve Taiwan's increasingly crowded and deteriorating living conditions.

We propose an integrated solution that could be replicated in diffe rent site conditions: "1 House for All".

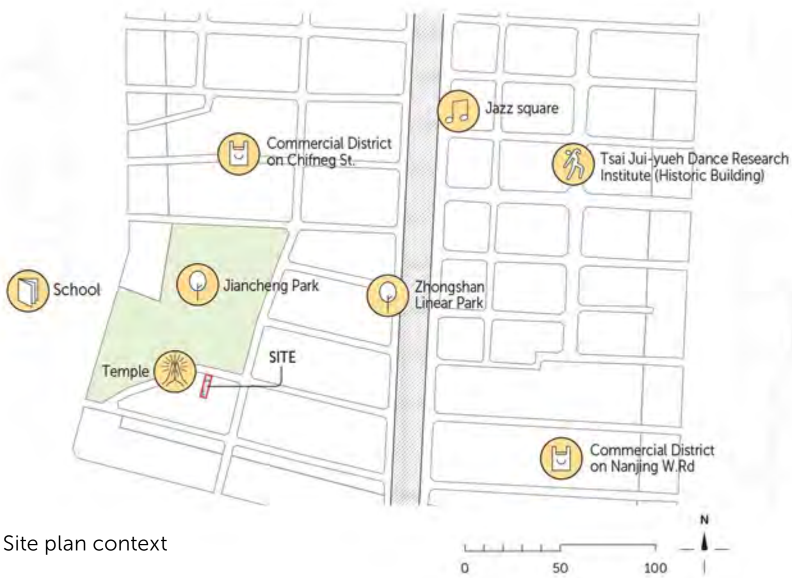
This is how we imagine housing for the future and the innovative measures we want to take. To combat "Energy Over-consumption", "Inefficient Urban Renewal" and "Housing Injustice", we propose an integrated sustainable solution that could be replicated everywhere– "1 House for All." It is not only a net zero mid-way house, but also a social enterprise-housing, and an energy-efficient sharing station of the city.

urban context and mobility

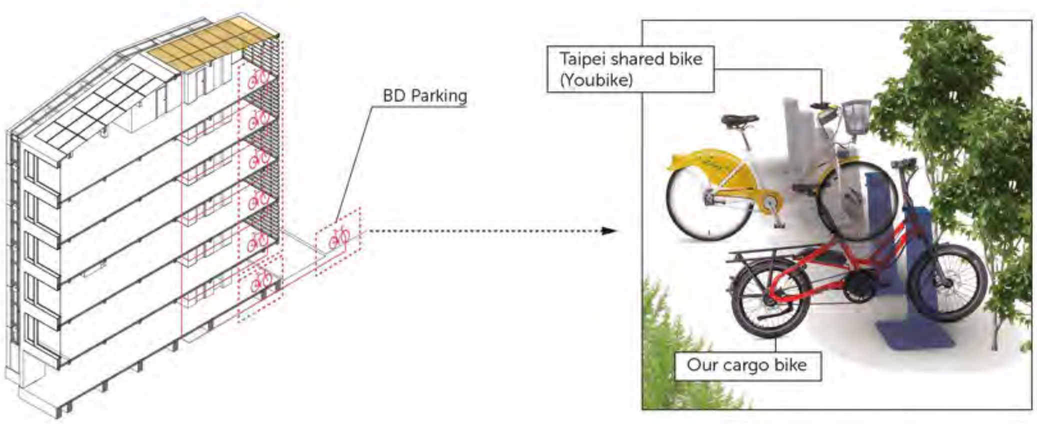
In Taipei, Taiwan, most of the houings were row houses or apartments built in the 1970s, made of reinforced concrete, which is not safe or sustainable nowadays.

Although the government has been encouraging citizens to rebuild their houses through land integration, it is difficult to implement urban renewal. The average time of processing the renewal is 10 years. Especially in the Datong district, the ownership structure is diverse and complex. Still, many landholders had torn down their buildings waiting. That created many gaps in the neighborhood.

By closing the gaps with the mid-way buildings, it could not only bring affordable housing but also provide more e-bike charging stations to the neighborhood. Some of them will be e-cargo bikes for goods unloading.

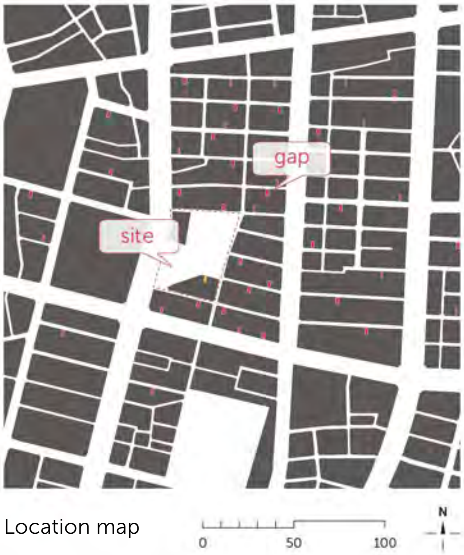


Site plan context

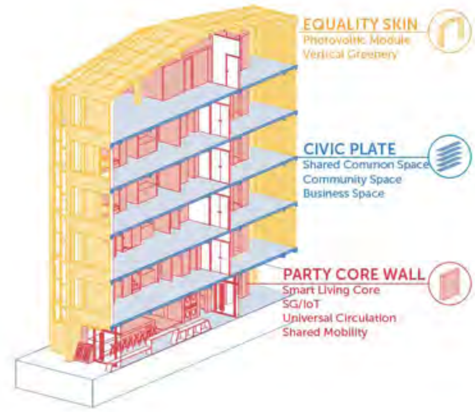


Building design parking

Site image

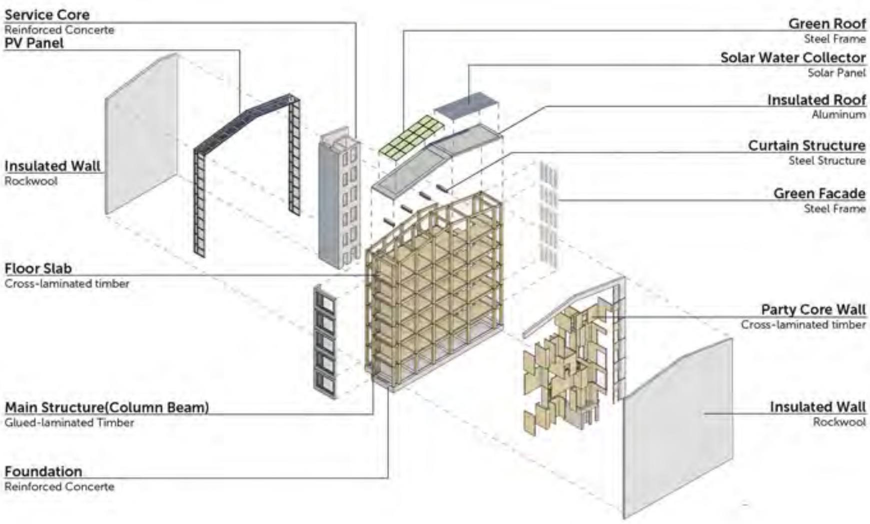


Location map

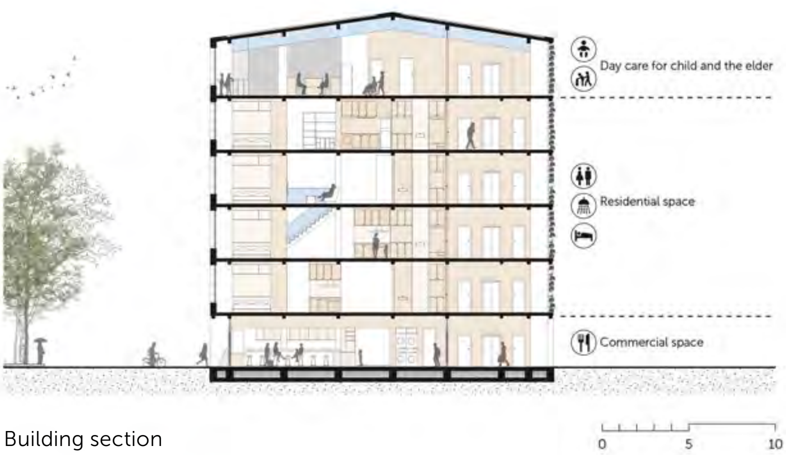


Design concept

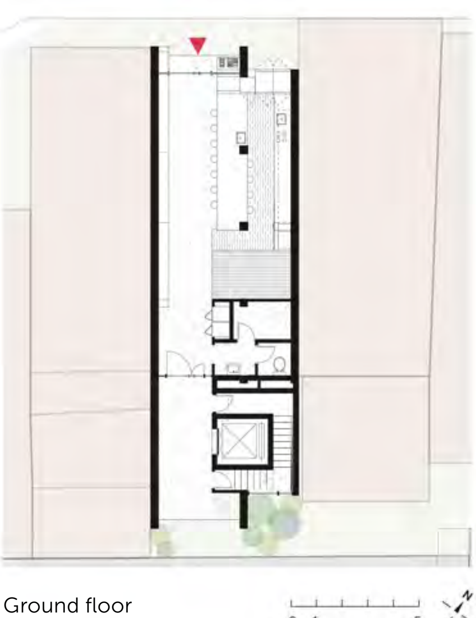
design challenge (dc) overview



Building design explode



Building section



Ground floor

Additional floor

Party Core Wall

A shared structure integrates all kinds of utilities. All the service spaces are embedded, including piping, electricity, air conditioners, vertical circulations, 5G Wi-Fi, IOT systems, shared vehicles, etc.

Civic Plates

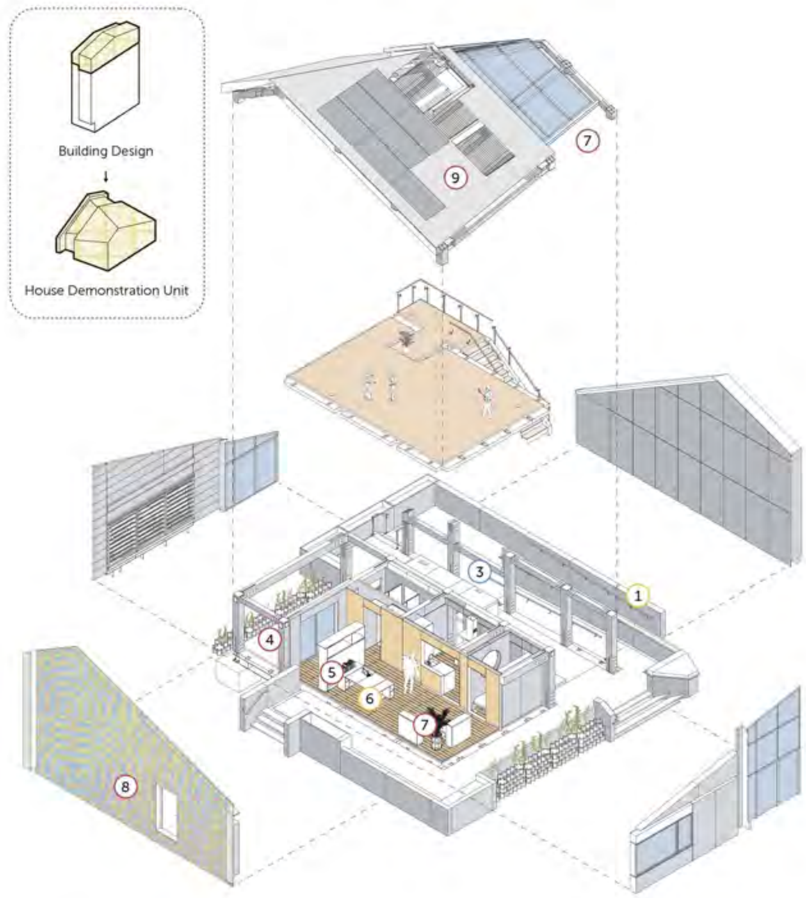
On the ground floor, social activities take place in the common room, both for residents and neighbours. People could meet, cook, eat together, etc. The roof floor, on the other hand, is an activity center for the elders in the neighborhood.

Equality Skin

A shared thermal control layer, which is also a container where energy is generated by solar panels on the rooftop, collecting raindrops to reuse, planting vegetation, cleansing the polluted air, and balancing the tempter from outside to inside.

house demonstration unit (hdu) overview

From building design to HDU, we reorganize the place of different programs but keep the sequence from outdoor to indoor, including a community space, a healthy entrance, a living space, a bedroom, and the rooftop. Above all, we keep the party core wall concept in the middle of HDU. Every program thrives next to the party core wall. We also integrate the service core and transformable furniture into it.



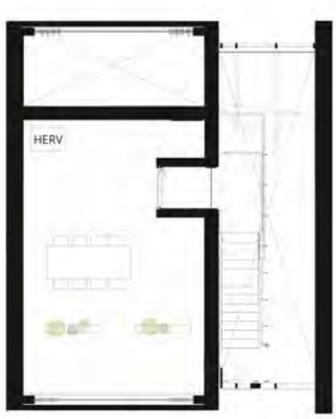
Solution: Social Enterprise-Housing
1 Waiting Line
6 Transformable Furnitures
Solution: Net Zero Mid-way House
3 CLT Staircase to Second Floor
10 Bike Park

Solution: Energy-Efficient Sharing Station
2 Intelligence Thermal Resistance Curtain
4 Breathing Balcony
5 Party Core Wall
7 IOT Home Automation System
8 Interactive Thermochromic Insulation Tiles
9 Solar Roof

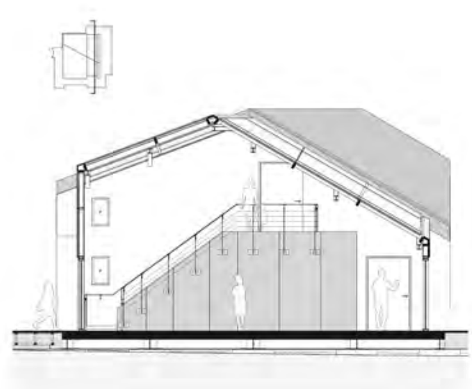
HDU explode image

Ground floor

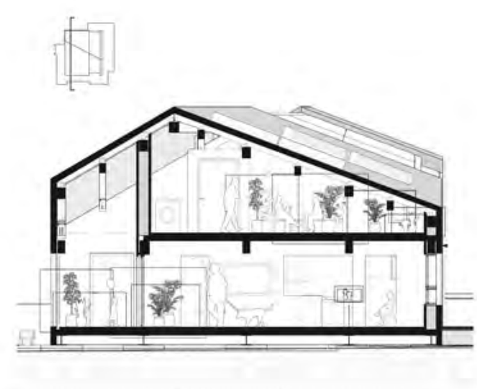
0 1.25 2.5



Second floor



Section A

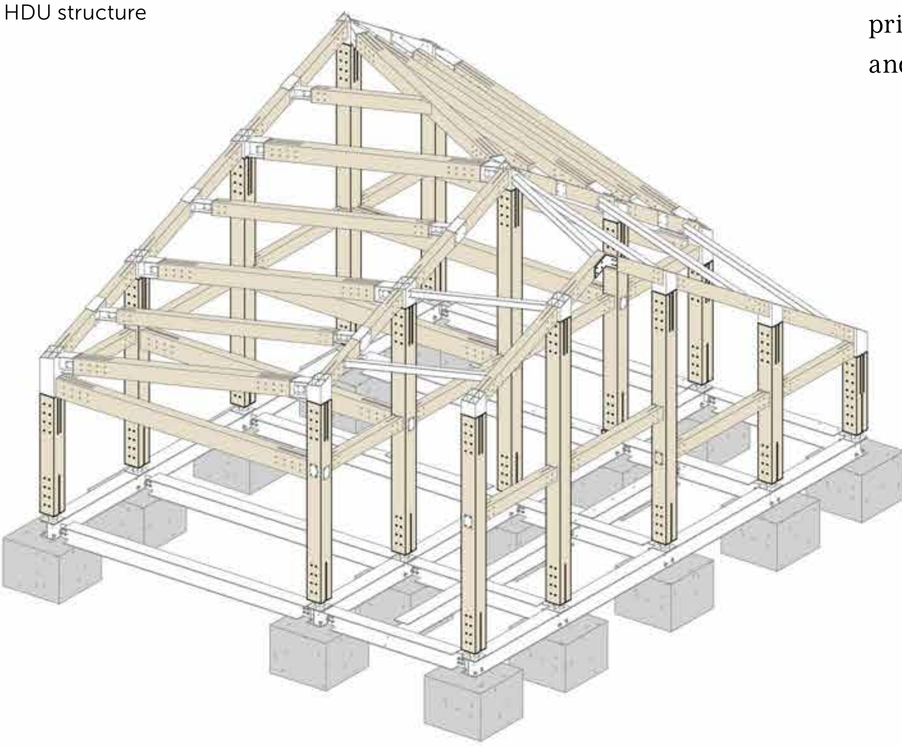


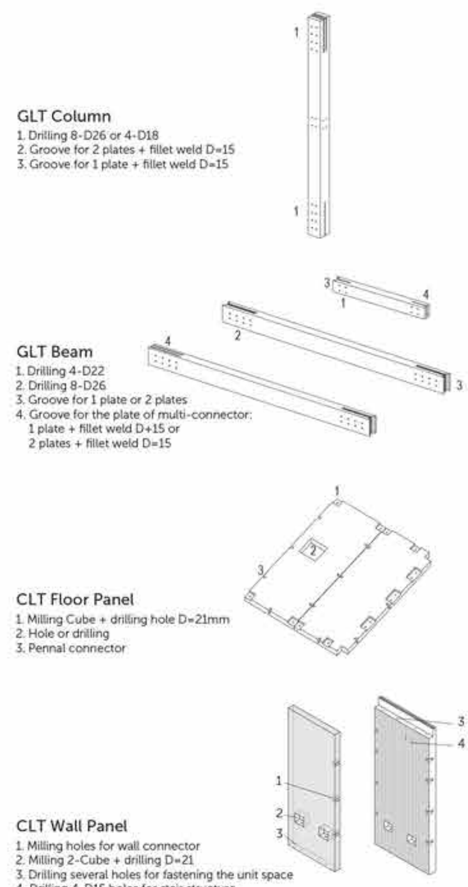
Section B

house demonstration unit (hdu) details

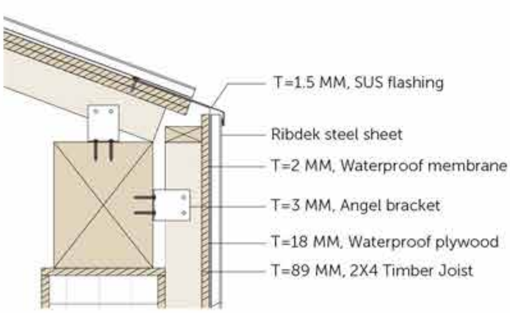
Steel is used in the joints of the house foundations and column beam systems for better weather resistance and stability. Through accurate lofting and casting methods, the joints and foundations are tightly fastened to the timber structure. The GLT and CLT plates are assembled with bolts and iron components, which make the house can be fully disassembled, recycled, and reused. This design minimizes the carbon footprint in the building life cycle with this modular and reversible design method.

HDU structure



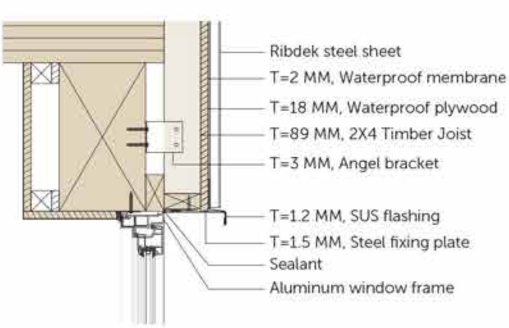


Processing type of structures

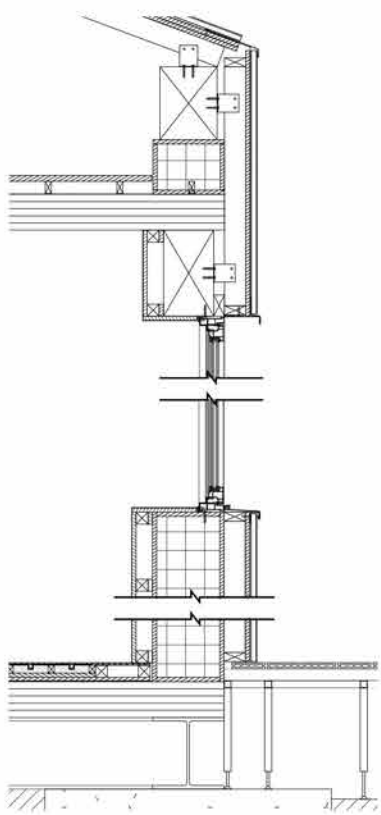


External wall system detail

0 50



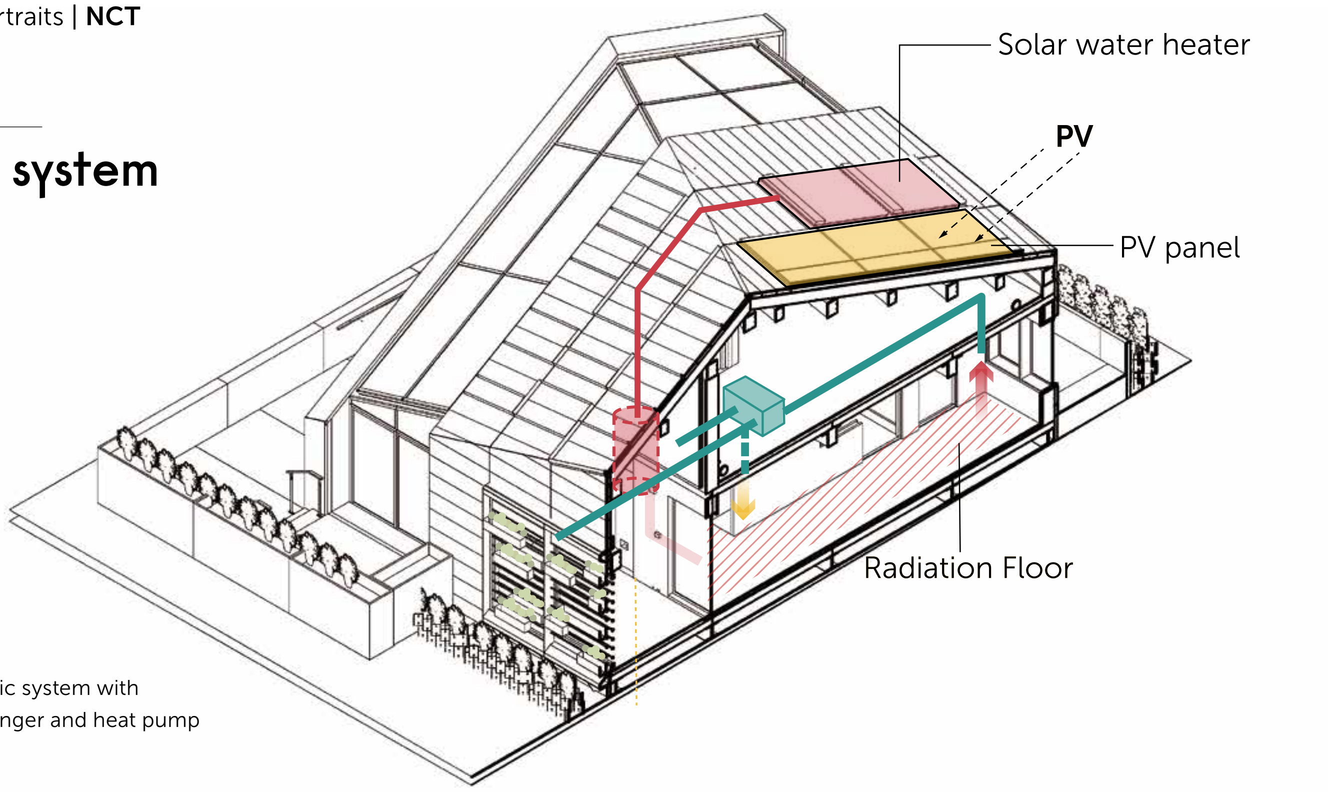
Window detail



Constructive facaded

0 5

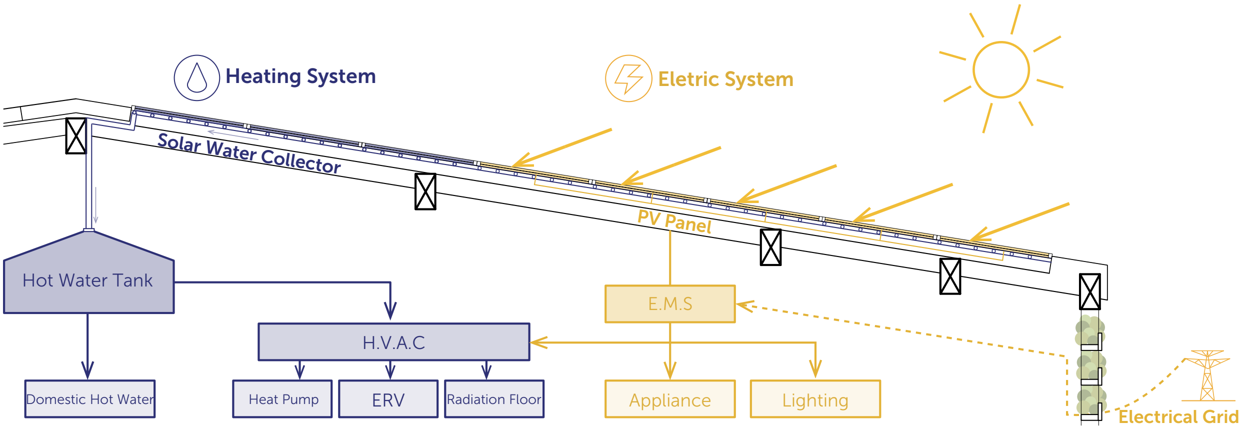
solar system



Photovoltaic system with
heat exchanger and heat pump

Photovoltaic system

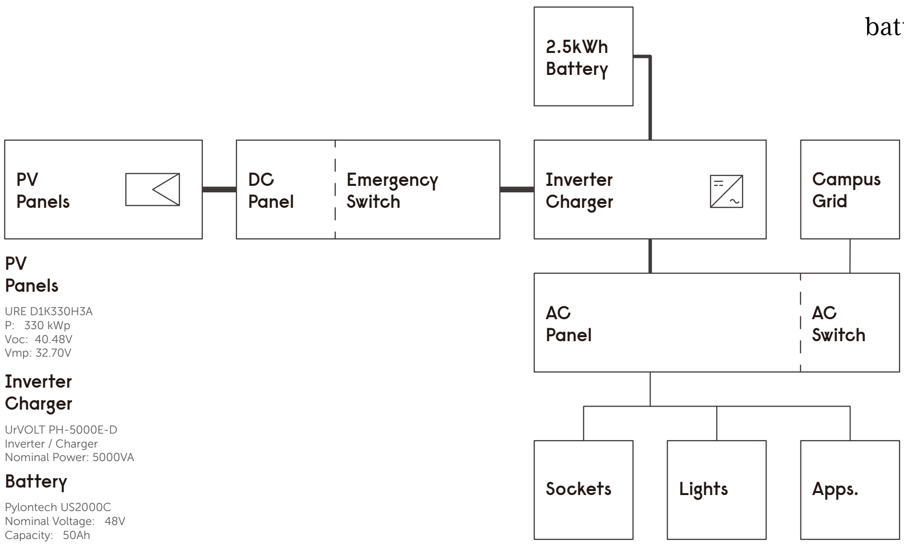
In order to use the solar energy in the most efficient way, we adjusted the roof slope and direction to optimize the efficiency of energy generation. The glass on the curtain wall system has the potential to be replaced with Solar Glass, a translucent glass sealed PV system, in order to provide more power.



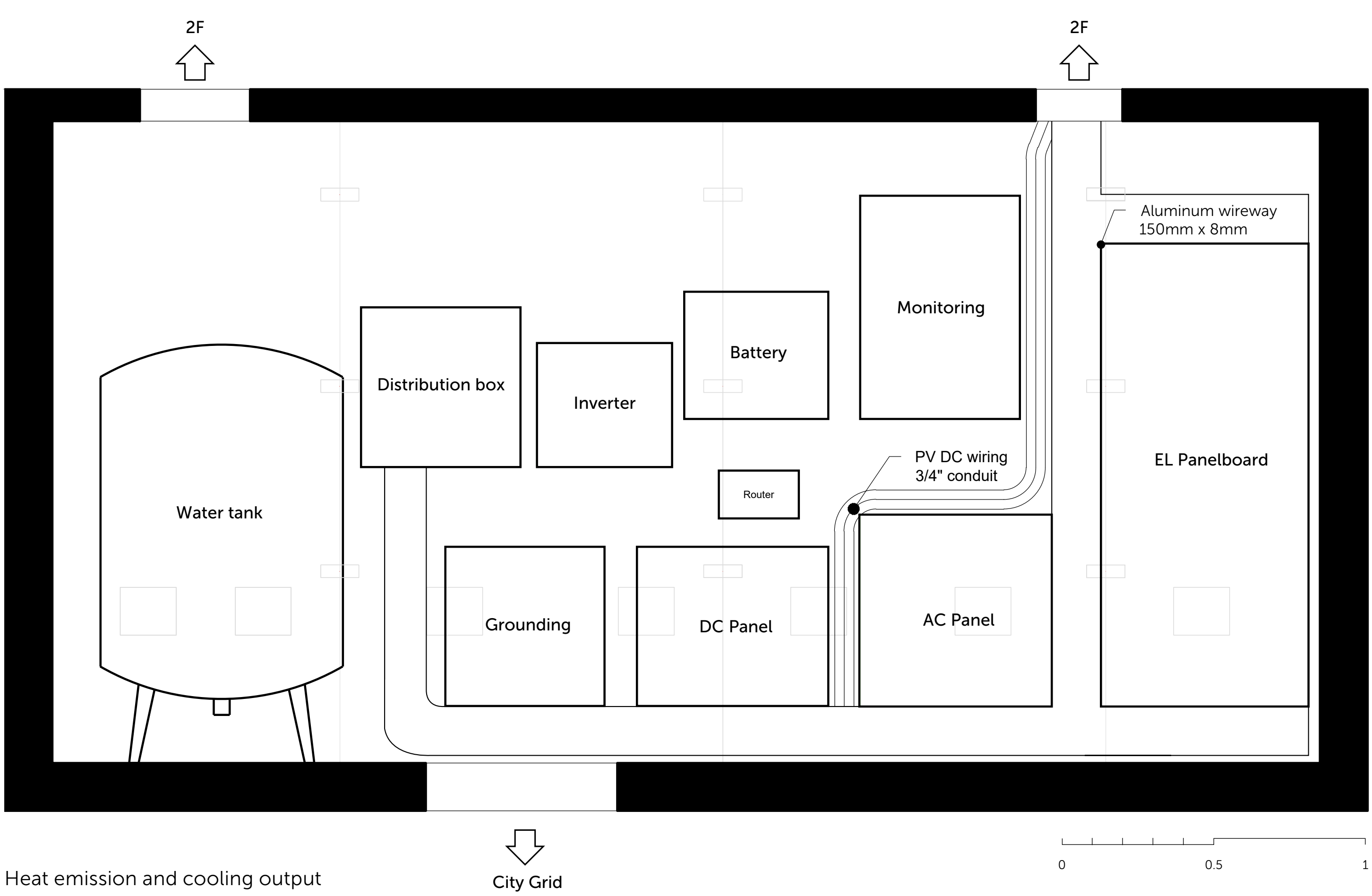
PV Panel Detail

energy supply

We are creating an electricity generating system specialized for a neighborhood. Local infrastructures can be powered, and the locals can benefit by acquiring electricity at lower costs. The operation mode is similar to an “OFF GRID” mode, the AC grid acts as a backup power source, and loads will be switched to AC input automatically while needed. We will use an Energy Management System (EMS) to control the charging period of our battery to lower the consumption peak.



Energy supply connection

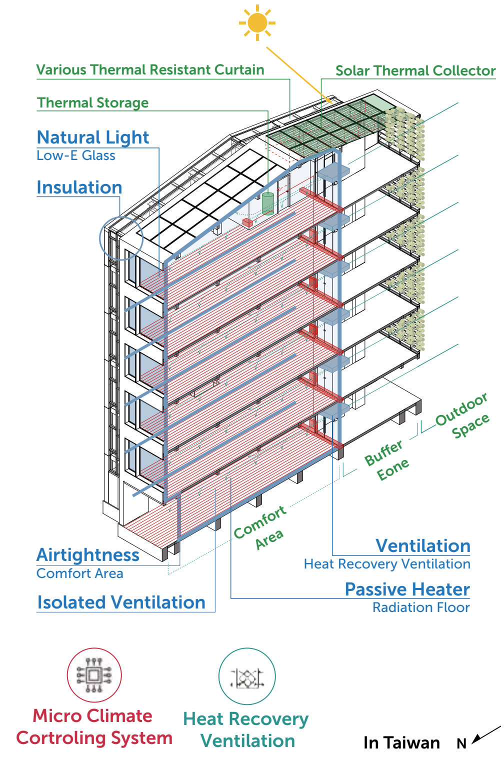


Heat emission and cooling output

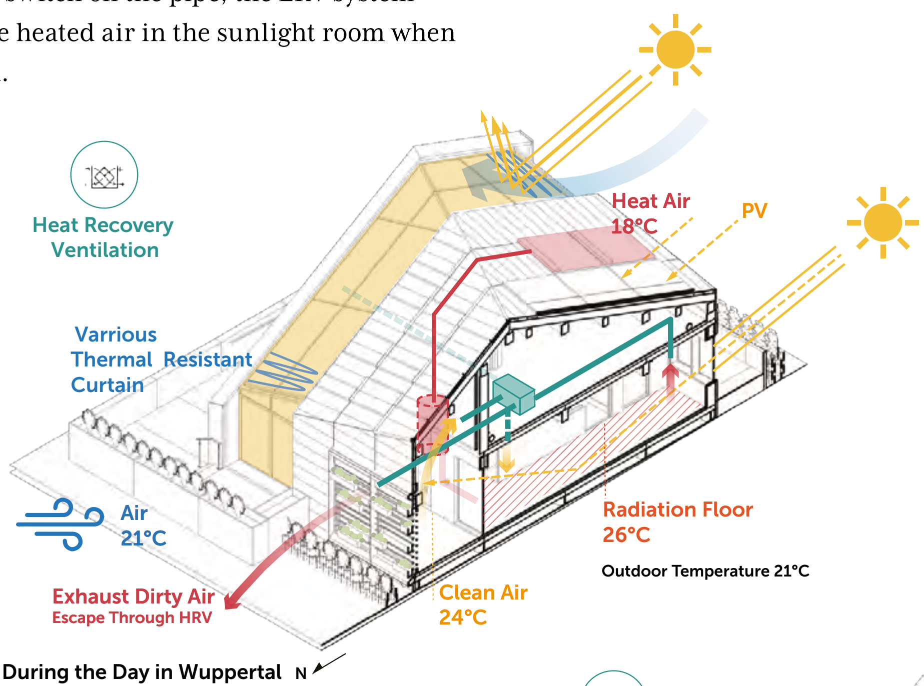
indoor climate dc and hdu

This building can save lots of energy compared to the traditional air conditioners, which consume most of the electrical energy in daily life. This building achieved high electric efficiency by integrating the PV panel system and other electrical equipment.

For radiation flooring, the solar water system can heat up the water in advance during the day and save them in the tank. After sunset, the indoor temperature can still be adjusted by the system. Through a switch on the pipe, the ERV system can use the heated air in the sunlight room when it's needed.

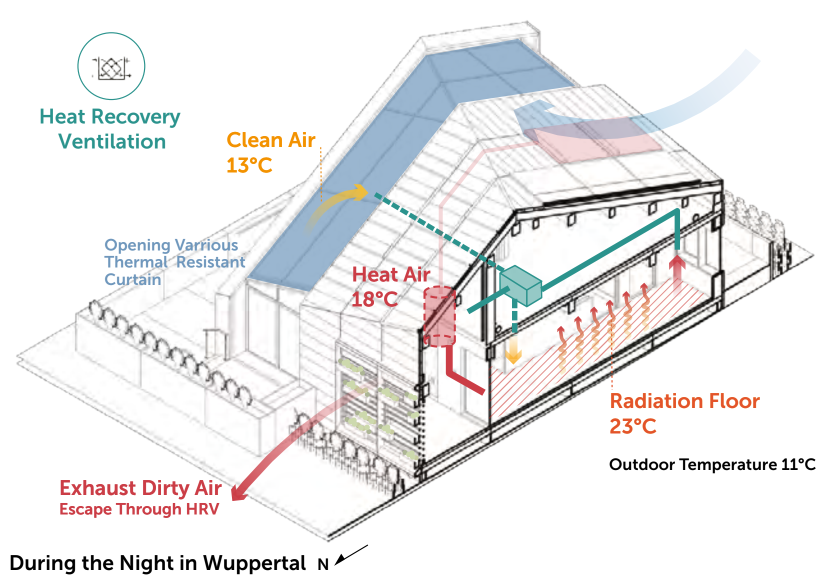


Energy active control strategy and passive control system DC



Controlled ventilation system summer daytime HDU

Controlled ventilation system summer nighttime HDU



key figures, team and sponsors

Further project information:
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TEAM NAME | TEAM IDENTITY

Lungs of the City | UPH

UNIVERSITY

university of pécs, pécs, hungary

TASK

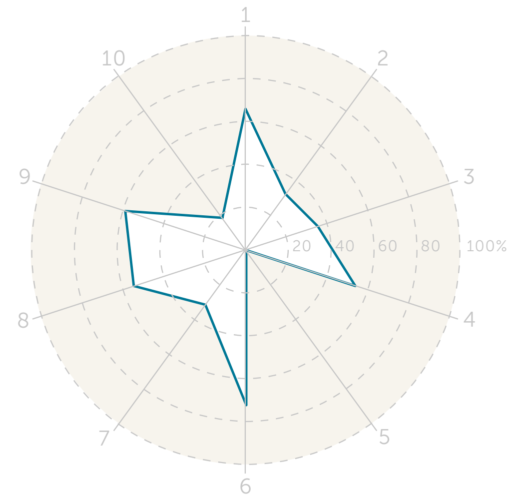
closing gaps

LOCATION OF DC

pécs

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	481 m^2	139 m^2
	5	2
		12 m^2/p

The goal of the Lungs of the City team is to cement Pécs' reputation as a liveable, healthy and developing city, and to maintain the role of the university in the economic, social and environmental life of the town.

At the heart of our design objectives is a simple equation:
minus emission, plus green energy times community interactions.

The solution to this equation is the re-greened blocks project. Its long-term impact is a breathable, green city, a built environment with negative emissions, and an aware society.

Our architectural concept focuses on a sample building named the RGB Gatehouse. Our green strategy has four main thrusts.

1. Green energy surplus:
Our modular design is open to free rearrangement as residents age. In addition, we have a sunspace on the south side of our building, which contributes to harnessing passive energy through a unique feature of our building – the Trombe wall. Our green facade also serves numerous purposes.

2. Reduced emissions:
We are changing to renewable energy sources. There is a strong focus on recycling and the RE8 principles (rethink, reduce, reuse, replace, recover, recycle, reunite, regenerate). The building is 95% recyclable. The structure is 85% wood, locally sourced; it does not pollute the atmosphere during its formation but binds CO_2. Our steel and aluminium come from recycled metal, our panels are made of recycled timber, and we use partially recycled concrete for the foundations. Gardens also compensate for harmful emissions.

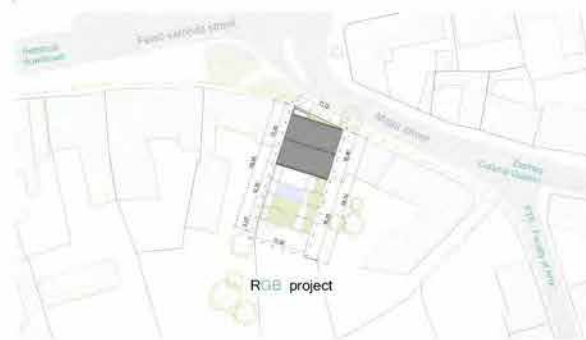
3. A healthy and affordable living environment:
Our overall design reduces energy costs, travel costs, construction and maintenance costs, and in the future will also cut alteration costs, making the building more affordable.

4. Creating a cooperative residential community:
We realise this in the building by means of a wide range of initiatives from a communal kitchen and activity space, a club room, laundry room, co-working facilities, educational offerings and workshop, to communal gardening.

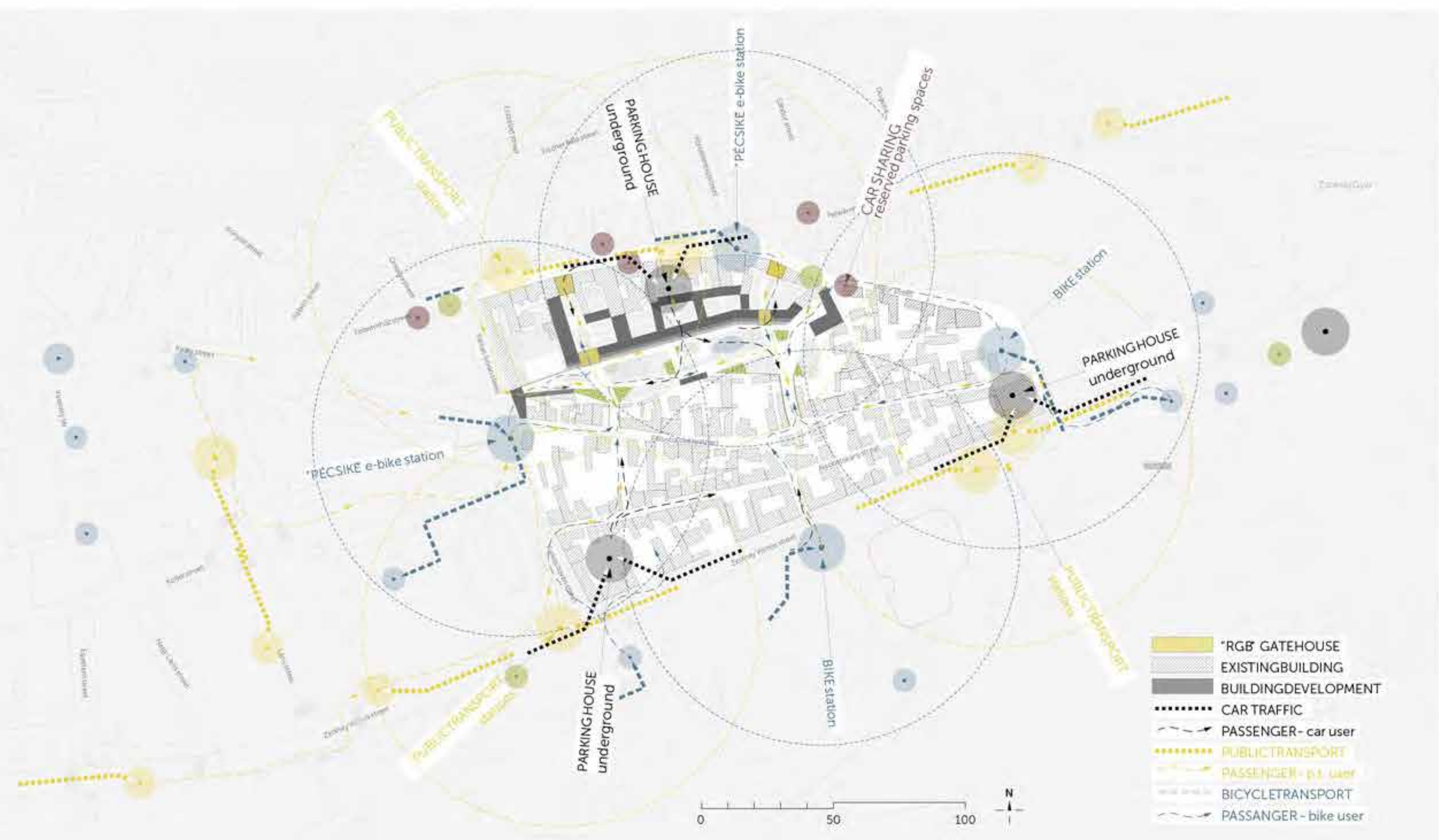
urban context and mobility

The chosen district for our design challenge is central Pécs. The urban structure of our neighbourhood is a crowded, historic city centre comprising row type or city block public and residential areas. This is the main source and destination of peak traffic.

Project city and district connection



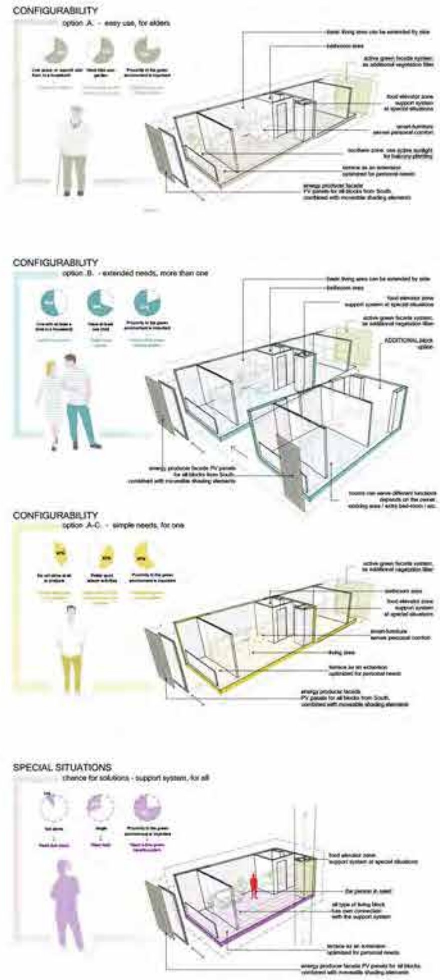
Site plan



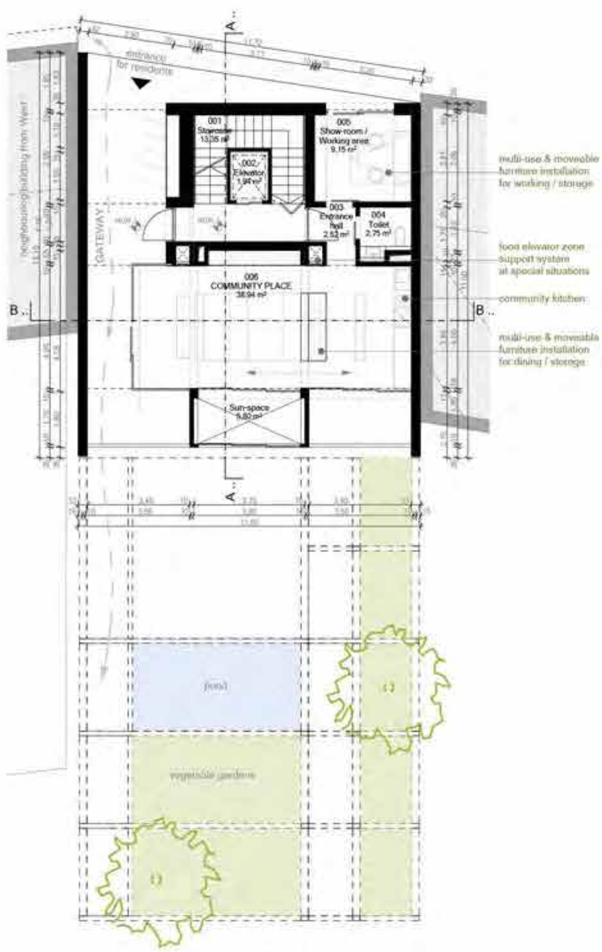
District exploration

design challenge (dc) overview

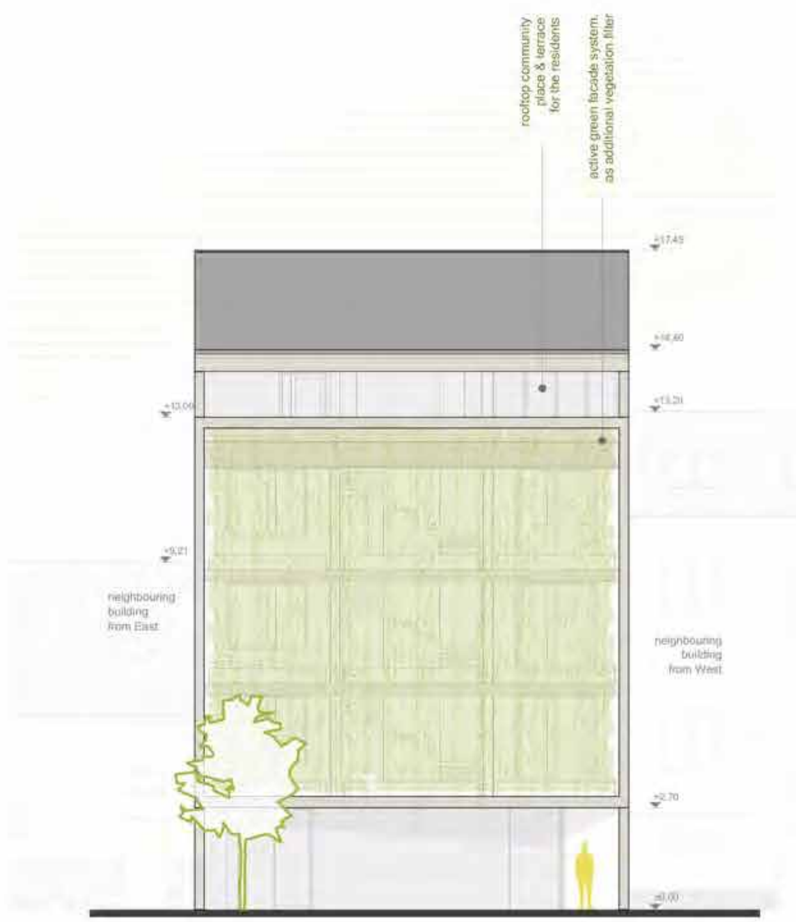
We aim to create breathable cities with healthy housing by closing the gaps with green buildings, and by adopting healthy urban design strategies. We wish to forge cooperative communities by designing functionally diverse neighbourhoods, promoting community activities and embracing green mobility principles.



Group of residents



Ground floor plan

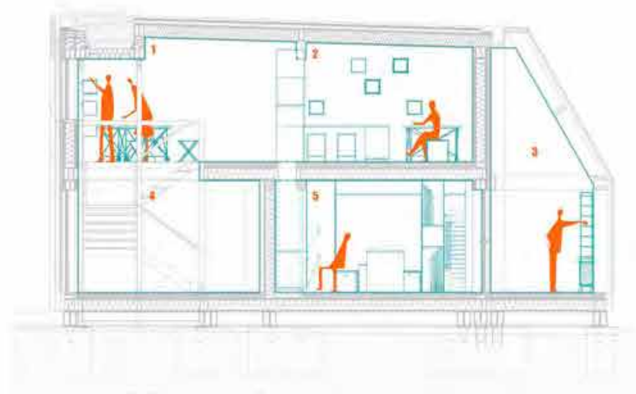


Northern elevation

house demonstration unit

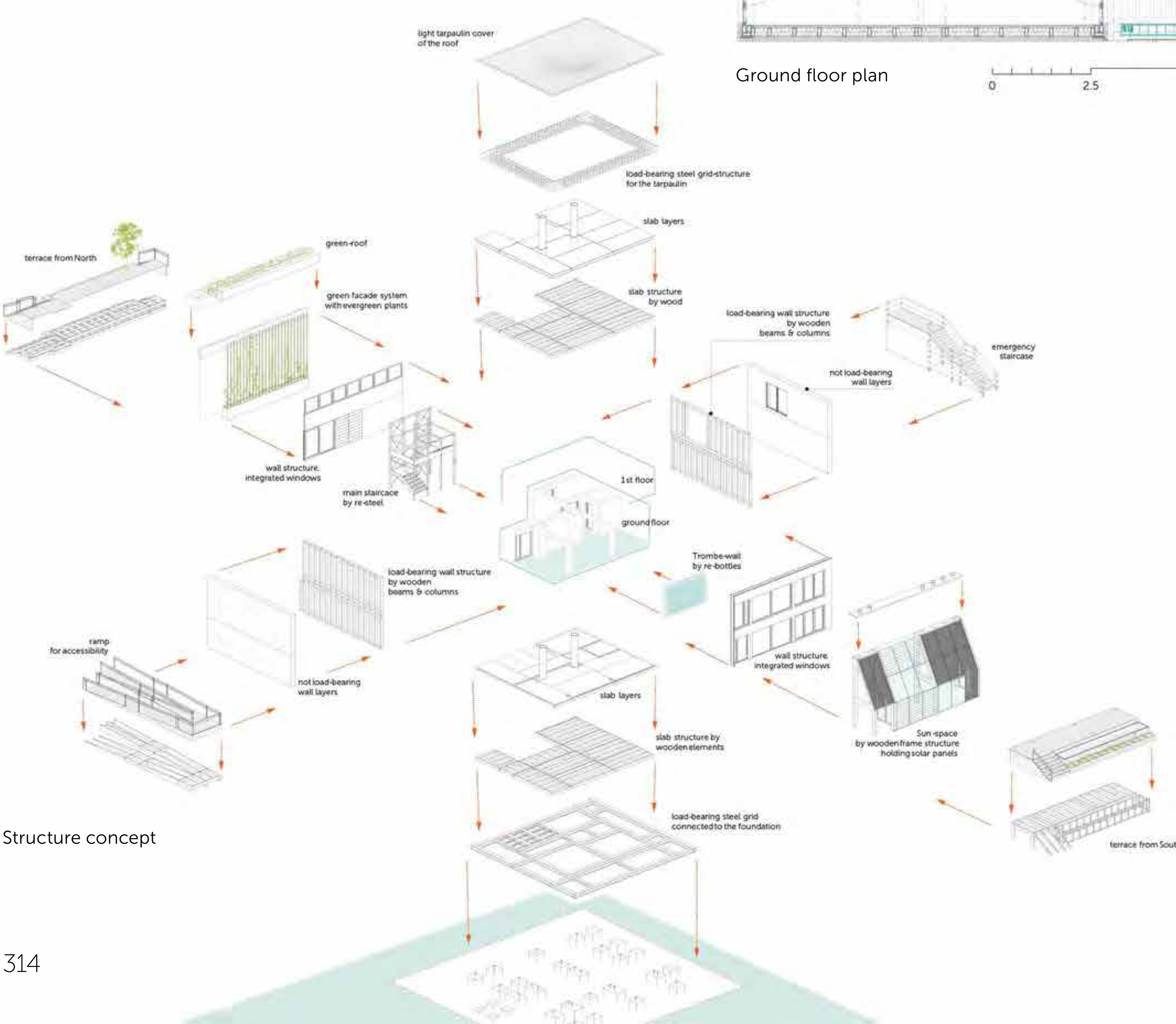
The HDU is designed as a combination of the keynotes of our overall concept and ideas. The ground floor of the building serves as a scaled-down sample apartment that will simulate living conditions similar to those of the design challenge building. Meanwhile, the upper floor highlights a vital part of our concept – the communal area.

Exciting features include the green façade system and Sunspace – an energy zone with moveable deciduous vegetation and a Trombe wall made from recycled bottles filled with water, as well as a pond, a weather-resistant spice garden, and a nesting wall.



Section

Ground floor plan



Structure concept

key figures, team and sponsors

Lungs of the City

Further project information:
https://lungsofthecities.comg/

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Baranya Megyei Mérnök Kamara

TEAM NAME | TEAM IDENTITY
Azalea | UPV

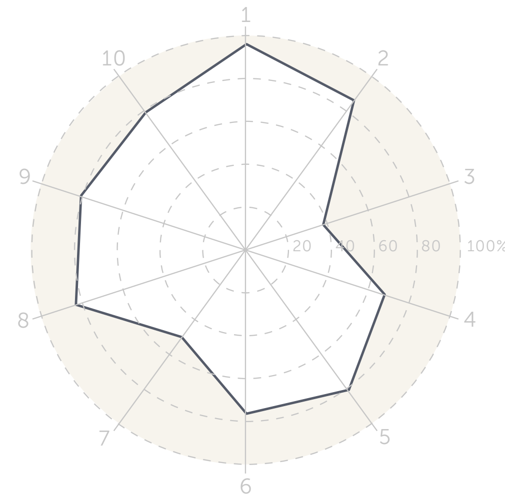
UNIVERSITY
polytechnic university of valència valència, spain

TASK
closing gaps

LOCATION OF DC
el cabanyal, valència

evaluation

1. architecture
2. engineering & construction
3. energy performance
4. affordability & viability
5. communication, education & social awareness
6. sustainability
7. comfort
8. house functioning
9. urban mobility
10. innovation



DC

Visualisation of the Design Challenge

HDU

House Demonstration Unit
© Steinprinz / University of Wuppertal

our vision

	273 m²	71 m²
	3	1
	28 m²/p	38 m²/p

Azalea UPV has had very clear objectives from the very beginning: developing an adaptable housing solution that unites tradition and innovation; this is how the Escalà project was born.

The team decided to work in El Cabanyal neighbourhood, one of the most historic neighbourhoods in Valencia, whose history has always been linked to the sea. Its way of life, its traditions, and its picturesque architecture make El Cabanyal a unique place in the city. Unfortunately, the recent history of this neighbourhood has been strongly influenced by urban planning that involved the expropriation and demolition of many houses. This left a desolate scenario with a great number of urban voids and a situation of social instability.

For this reason, the team decided to develop a standardised sustainable housing proposal that give a global solution to the overall situation of the district, while always respecting the identity and tradition of El Cabanyal.

With these clear principles, Azalea UPV focuses on the traditional escalà as the main character of the project. The escalà was once used for the maintenance of the rooftops and, at the same time, allowed natural ventilation across the streets. With this concept in mind, the escalà is now reinvented to improve the climatic conditions of the building and favours the passage of the sea breeze between the streets of the neighbourhood.

This way, both the architectural and the energy performance concepts arise from the tradition of the neighbourhood. But the proposal goes much further. Fostering social relationships has been a major priority, since El Cabanyal has always had a great sense of community, and this should not be dismissed. For this reason, Azalea UPV creates social networks on a neighbourhood scale, sewing the existing urban landscape through a housing model based on a cooperative and environmentally responsible lifestyle.

Thus, Escalà relies on local tradition and local resources linked to innovative solutions to shape a sustainable future for El Cabanyal.

urban context and mobility

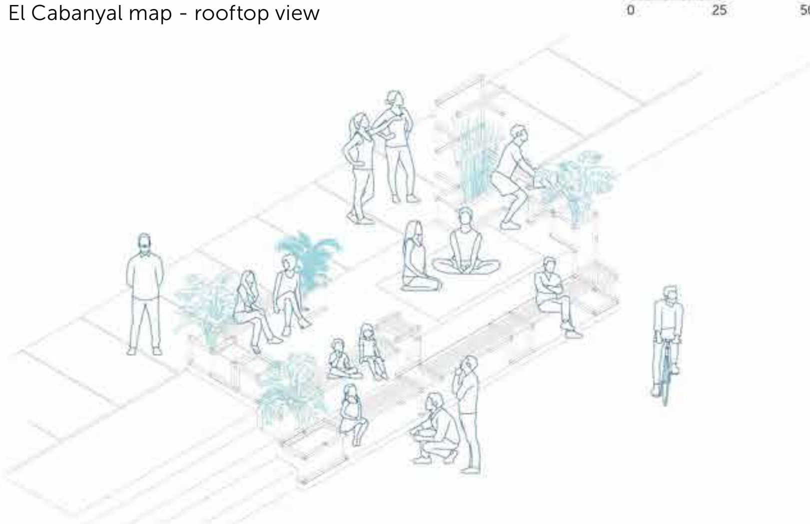
Escalà urban strategy
in El Cabanyal

In recent years, the streets of El Cabanyal have changed from being spaces for socialising to being invaded by cars. From the mobility analysis of common social profiles and the classification of the main architectural barriers present on the streets, the concept of mobility is born with the aim of reducing the number of cars in public spaces, returning the streets to pedestrians and cyclists and recovering public spaces as an extension of housing.

The main action at urban level takes place in Dr. Lluch Park and Marítim Serrería Street, both of them considered barriers between the neighbourhood and its surroundings. The proposal is to turn them into accessible green axes of life, related to clean ways of transport, that extend towards the residential area through green corridors and are connected to the seafront and the rest of the city.

The modular street furniture is also an important element in the proposal, since it provides a solution to the neighbourhood's mobility problems, such as the lack of spaces for bicycles or the lack of resting places on the road that facilitate the mobility of any social profile.

El Cabanyal map - rooftop view

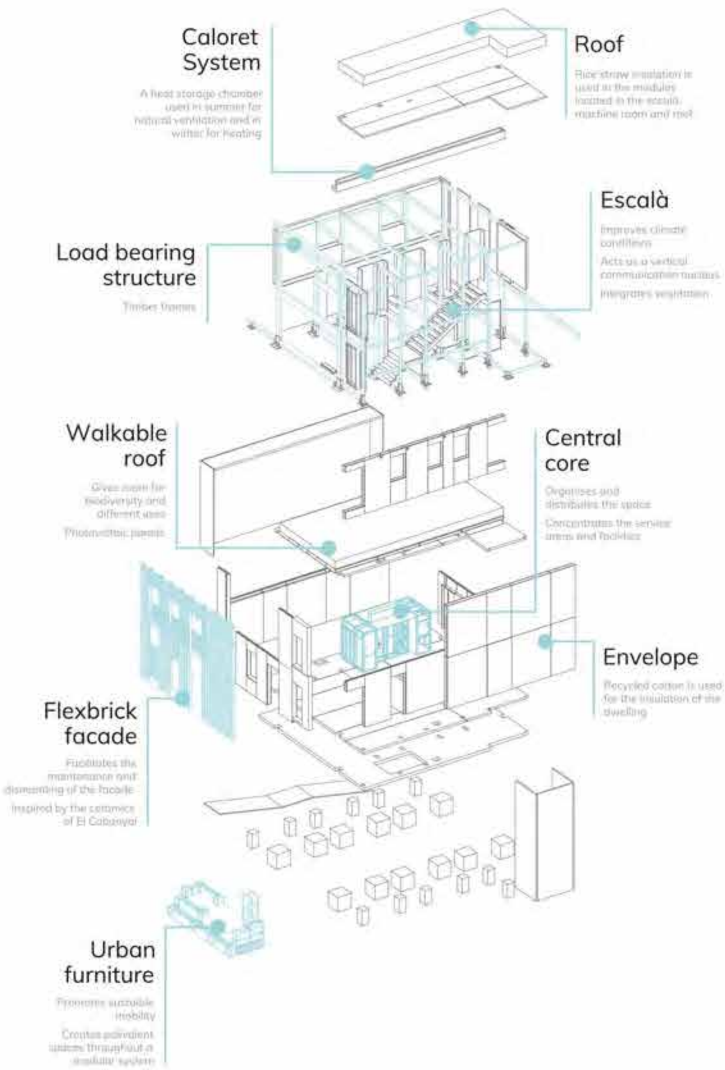


Mobility hub

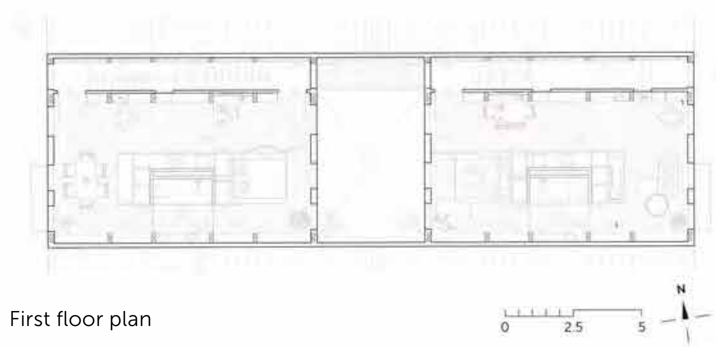
design challenge (dc) overview

The project is conceived as a co-living complex that fits in a great number of vacant lots, sewing the existing urban landscape through a housing model based on a cooperative and environmentally responsible lifestyle. Being in such a unique urban landscape, Azalea UPV decided to develop a group of buildings between two and three storeys with a facade that follows the compositional criteria and materiality of the traditional typology.

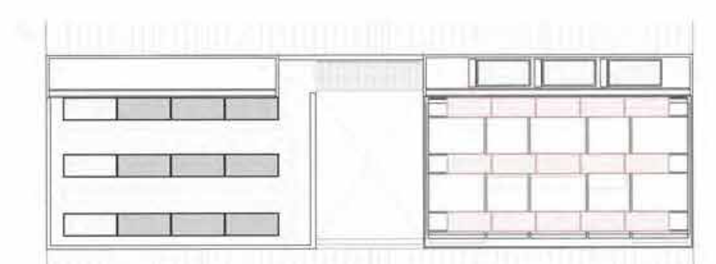
Concerning the programme, the project seeks to foster social relationships and offer different options of dwelling typologies that respond to the needs of a variety of social profiles. For this reason, the building presents one duplex typology and two simplex typologies departing from the same fundamental unit. Also, every building incorporates small commerce premises on the ground floor.



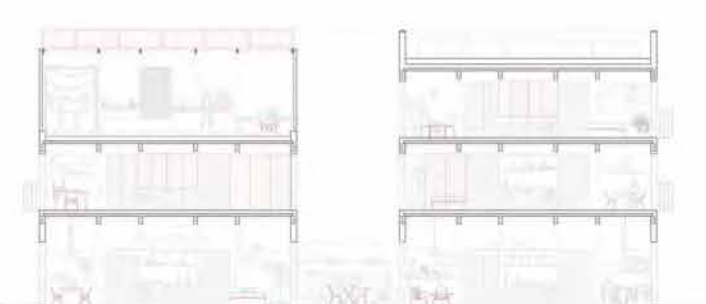
Exploded isometry



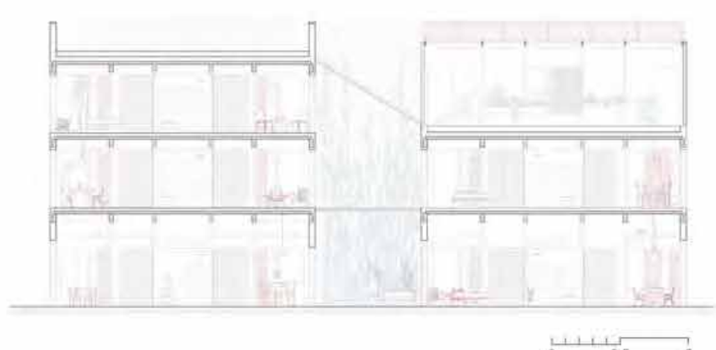
First floor plan



Roof floor plan

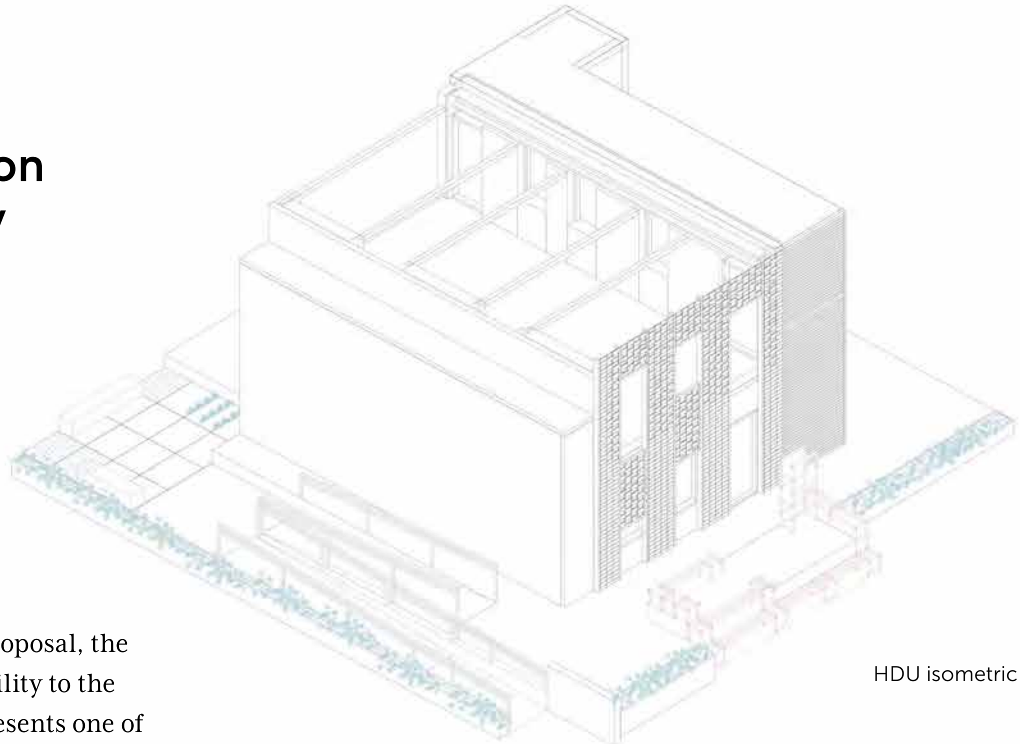


Section A



Section B

house demonstration unit (hdu) overview



HDU isometric

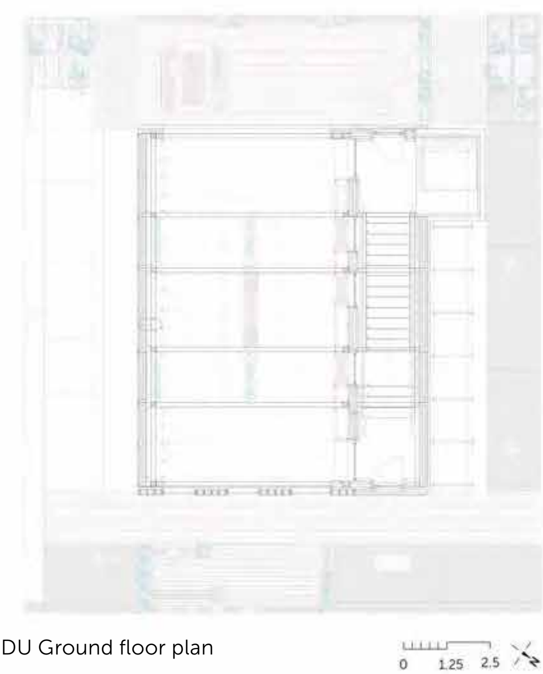
Escalà shows the versatility of the proposal, the combination of uses and its adaptability to the needs of each family. The HDU represents one of the dwellings, and pays special attention to the common spaces. Thus, the HDU is composed of the following elements:

Dwelling: Open-plan flexible space developed around a fixed central core. The exposed structure allows visitors to perceive the modulation, which sets the rhythm of the interior space.

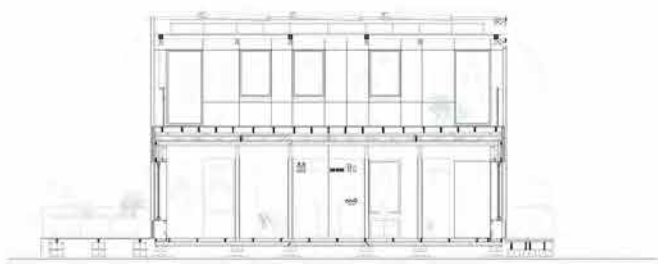
Courtyard: Traditional space where Azalea UPV incorporates a draining pavement made out of ceramic tiles in stock, to collect rainwater as well and to respond to occasional flooding.

Walkable roof: It is one of the main meeting points of co-living. The photovoltaic panels are integrated onto the pergola, offering shade and cover.

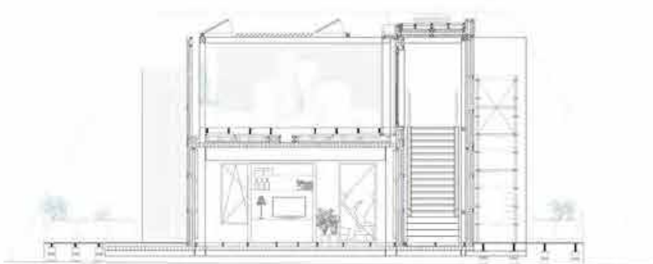
Escalà: It incorporates the stairs and acts as a thermal comfort cushion of the overall building, favoured by the cross ventilation. It also encourages natural lighting and contains a passive heat recovery system and hydroponics.



HDU Ground floor plan



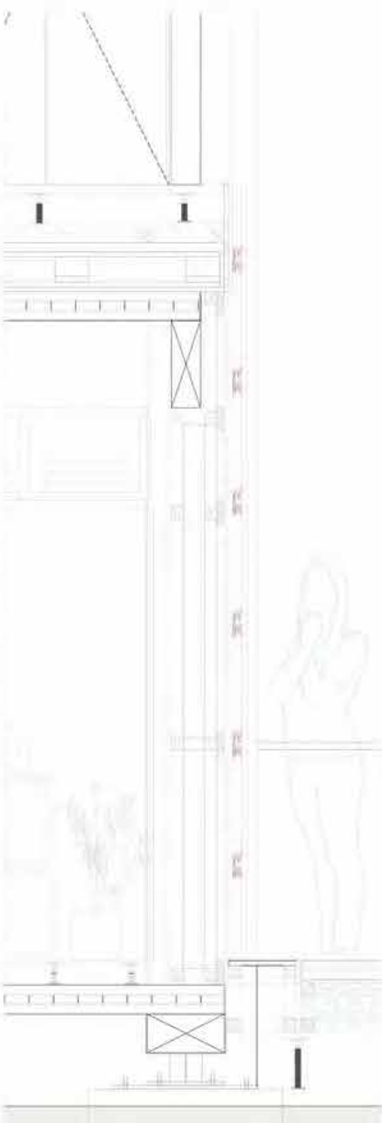
Section AA



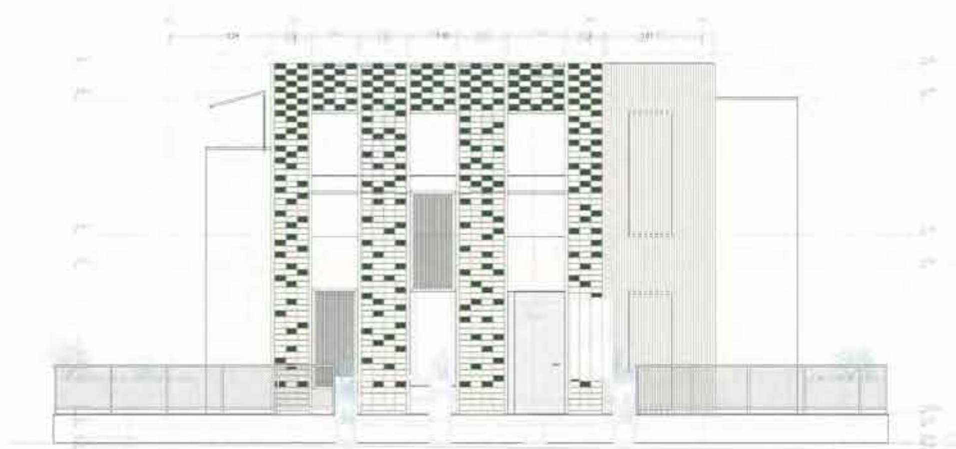
Section BB

house demonstration unit (hdu) details

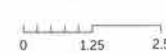
The proposal looks for optimised construction techniques (industrialised and dry construction) without ignoring the traditional and proximate resources present in Valencia. Thanks to this, construction times are minimised and maintenance is facilitated. Most components are assembled or screwed together using metal anchors, permitting disassembly. Also, the innovative façade system used in the East façade must be highlighted: Flexbrick System. In addition, exterior claddings and pavements and interior flooring are made of ceramic pieces, a local product which has very little long-term maintenance. Thus, circularity is enhanced, which can be also seen through the up-cycling of local waste materials such as ceramic tiles in stock for the draining pavement, recycled cellulose panels for the interior claddings, rice straw as an insulation material or reused wooden pallets as substructure for the insulation modules. Thanks to this, the Urban Mining Indicator obtained for the HDU is 74.3%.

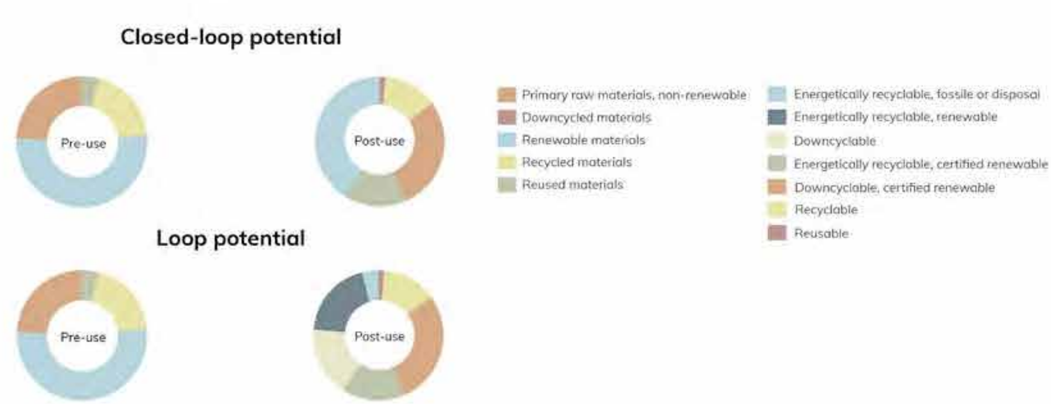


East facade detail



Elevation East





Urban mining index

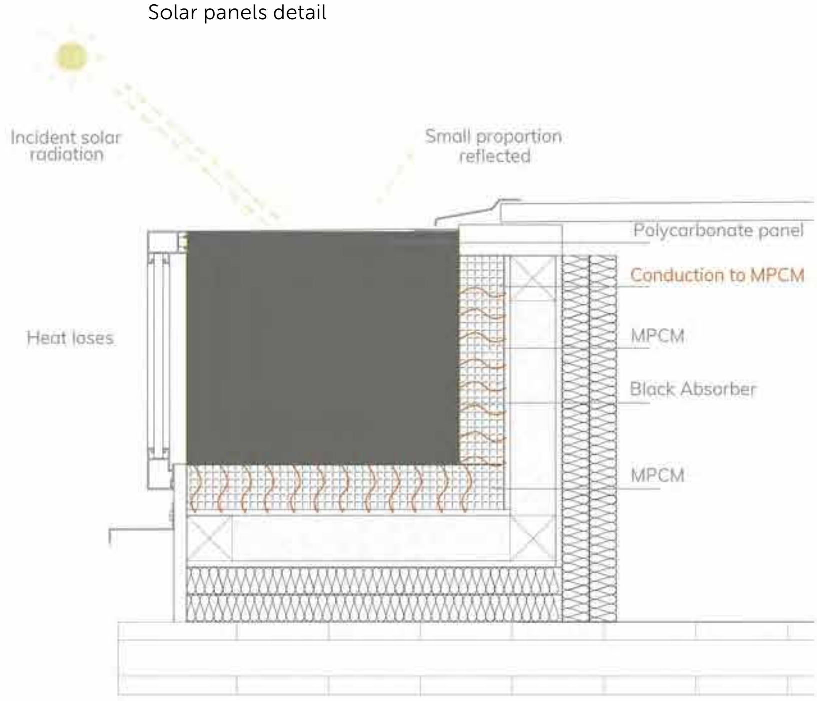
solar system

The design challenge will be powered mainly by photovoltaic solar energy and will be supported by the existing electricity network. A local energy community is proposed in which energy is shared between buildings. The installation combines conventional PV panels on the technical roof and PV Glass panels on the pergola without an electricity storage system.

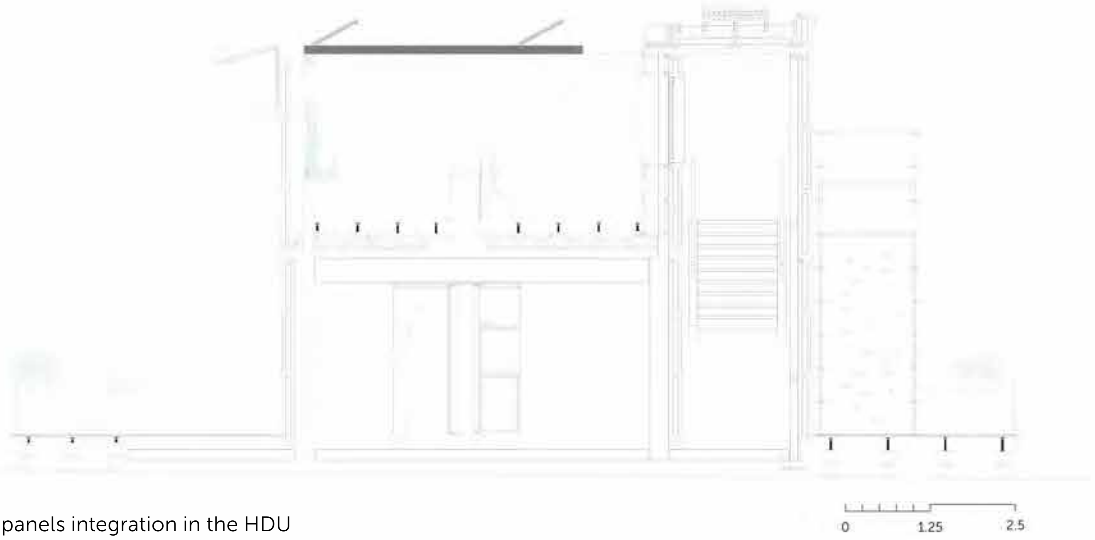
For the HDU, fewer PV glasses and conventional panels will be installed. In addition, batteries are considered for the HDU. The majority of the DHW is generated by solar thermal vacuum tubes. In the HDU, the vacuum tubes are installed in the upper part of the escalà and the tilt is adapted to the optimal conditions in Wuppertal. The air-to-water pump supports the DHW production.

A solar tube increases the quality and quantity of natural light inside the house . And the Caloret System is a glazed space that captures and stores heat through phase change materials to precondition the air in winter and as a solar chimney in summer.

Solar panels detail

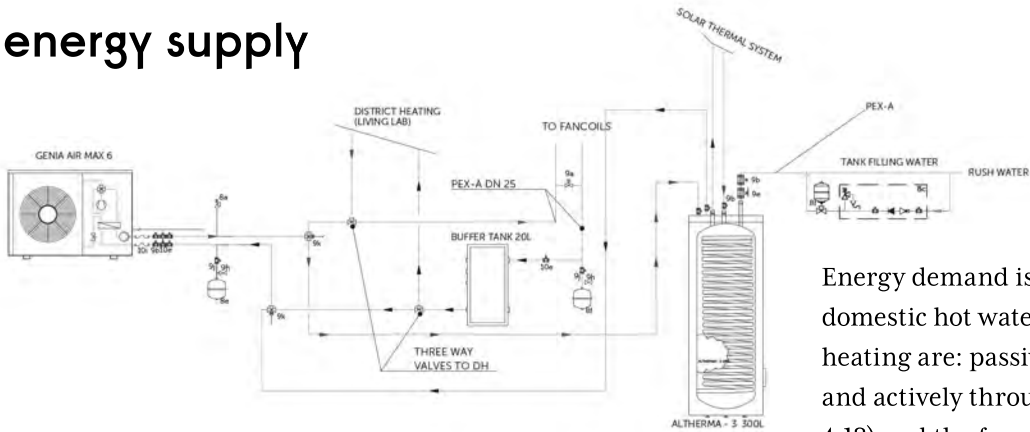


Calores System



Solar panels integration in the HDU

energy supply

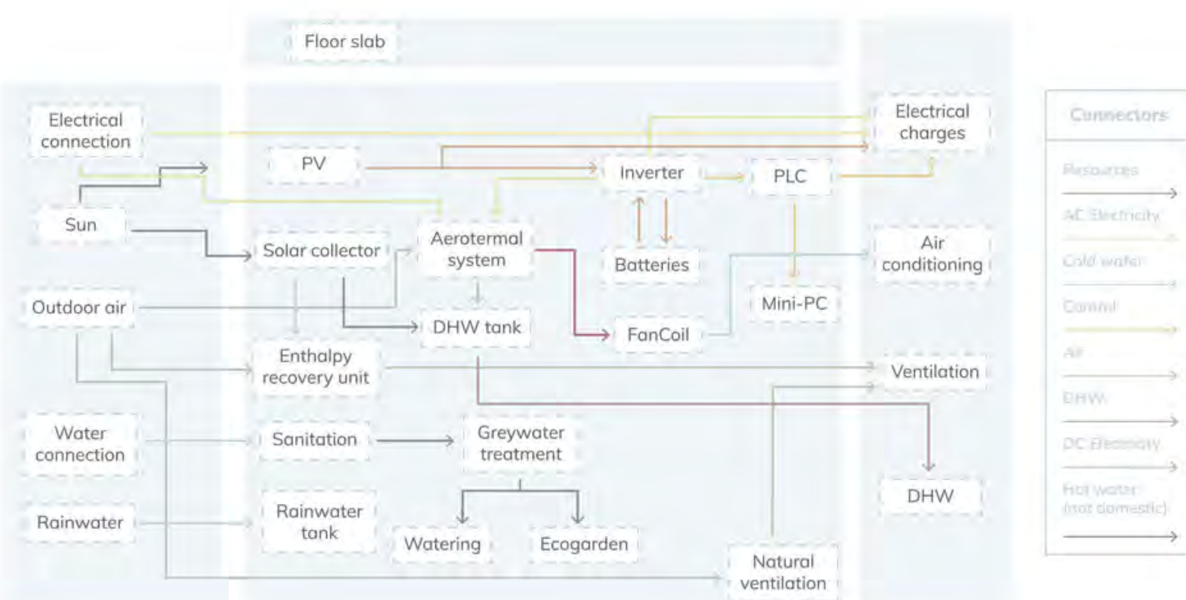


DHW and air conditioning systems

COMPONENTS

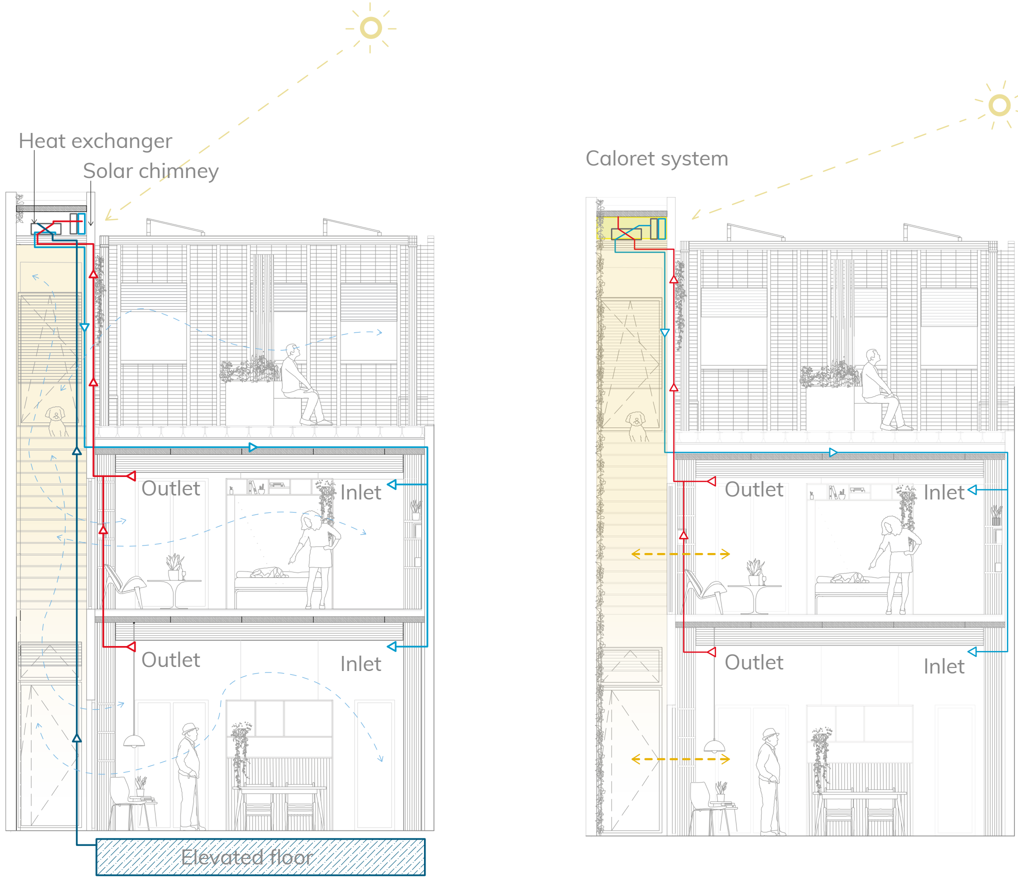
3 Heat generator circulation pump
7f Inertia tank 20l
8a Security valve
8e Expansion vessel 24L
8f Expansion vessel 12L
9a Thermostatic regulation valve
9b & 9j Regulation valve
9e Retention valve
9h Fill and drain valve
9k Three way valve
10e Dirt collector (Y-filter)
10i Flexible connections
12 System regulator
12b Heat pump expansion module (Mipro)
12k Maximum temperature regulator
12n Maximum temperature thermostat

Energy demand is about heating, cooling, domestic hot water and electricity. Two ways of heating are: passively using the Caloret System and actively through the aerothermal unit (SCOP 4,13) and the fancoils. Two ways of cooling are: through natural crossed-ventilation eventually helped by the Caloret System function as a solar chimney and actively through the same aerothermal unit that can be used in a reversed cycle. The active heating and cooling is reduced using a recovery unit. 80% of the DHW is produced by the solar vacuum tubes and the rest of it is produced by the aerothermal unit. It is stored in a 3-coil deposit, which maximises the heat inertia. The domestic hot water demand is reduced using a heat recovery system embedded in the shower plate. The electricity consumed is mainly generated by PV glasses and conventional panels having a yearly production of 600 kWh more than what is consumed. Batteries use the inestable renewable generation by the time it is consumed. A BMS is used to optimise its use and to predict the upcoming PV generation.



Energy supply

indoor climate dc and hdu



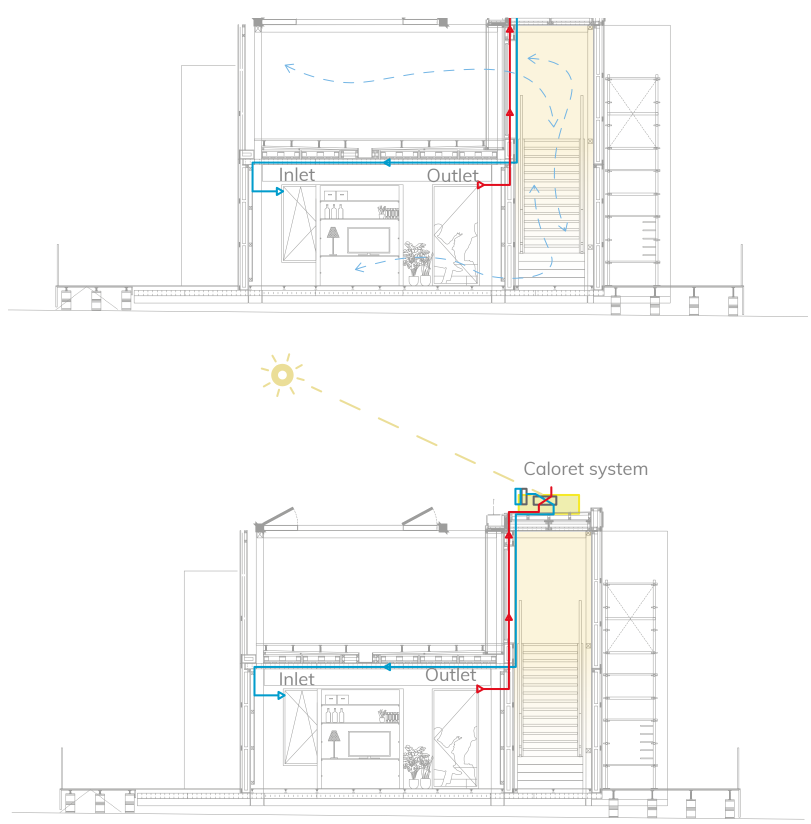
DC summer and winter strategies

DC Strategy

In winter, the objective is to enhance the passive pre-conditioned ventilation with the Caloret System and the solar radiation pass-through, removing the shadings.
In summer, the objective is to reduce the cooling load by improving both the ventilation of the neighbourhood and the natural ventilation of the building through the escalà and the solar chimney of the Caloret.

HDU Strategy

The HDU respects the Design Challenge strategy; in winter the efficiency changes are related to: reducing the thermal transmittance of the envelope and increasing the solar radiation to adapt to the Wuppertal climate. In summer, the same measures are maintained but the proportion of their application is adapted to the climate.
The active system for every strategy, both heating and cooling, is with the aerothermal unit and the fancoils as a distribution system.



HDU summer and winter strategies

key figures, team and sponsors

AZALEA

Further project information:
https://azaleaupv.com/

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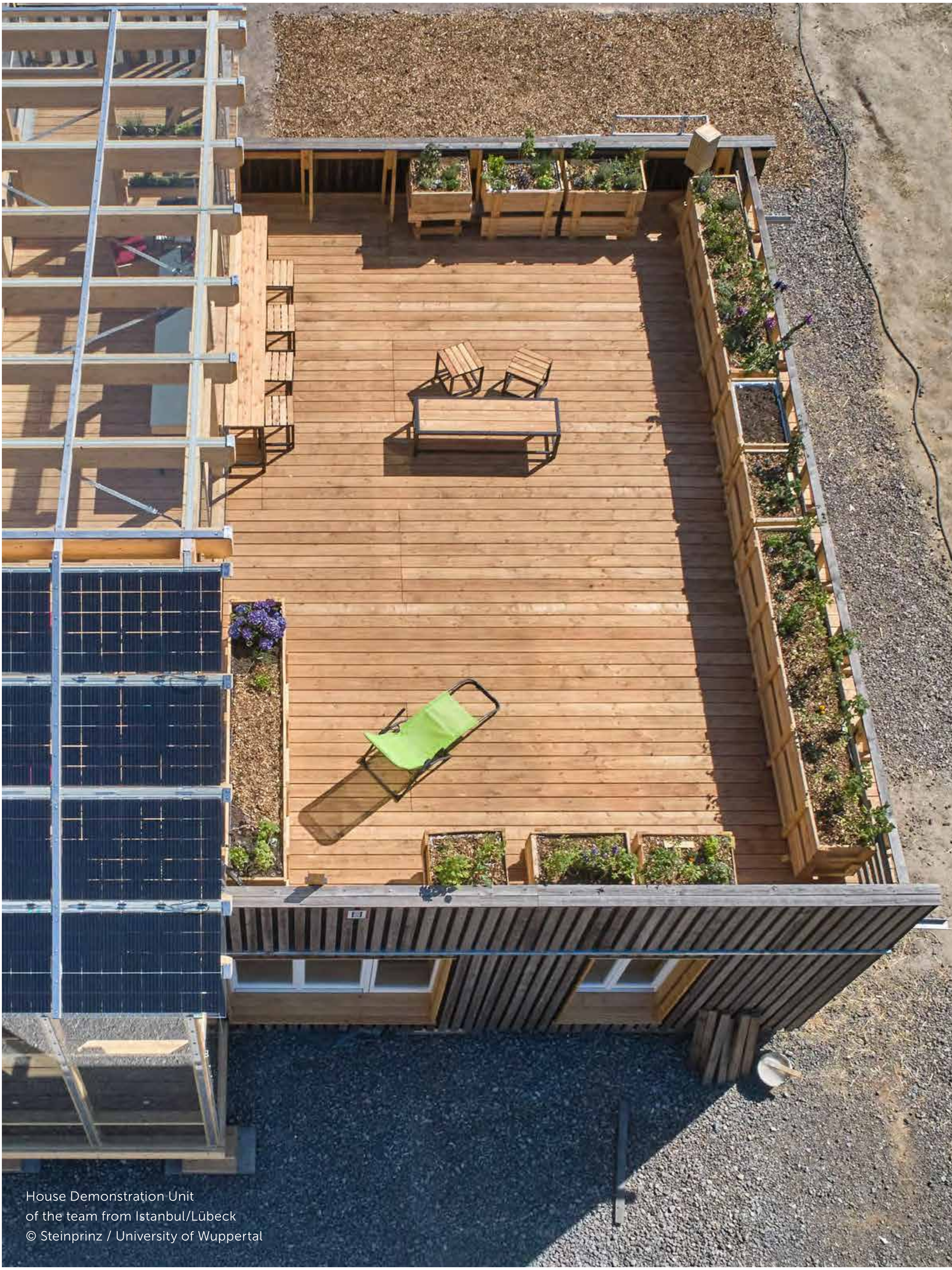

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of the team from Istanbul/Lübeck
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House Demonstration Unit
of the team from Rosenheim
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list of abbreviations

DC	Design Challenge
HDU	House Demonstration Unit
m	Meter
m^2	Square Meter
NRW	North Rhine-Westphalia (Federal State)
EU	European Union
Solar Campus	Event Venue
SDE 21/22	Solar Decathlon Europe 21/22
CO_2	Carbon Dioxide
PV	Photovoltaic
PVT	Photovoltaic Thermal Collectors
OPV	Organic Photovoltaics
BUS	Binary Unit System / Data Transfer
CLT	Cross Laminated Timber
UHT	Ultra High Temperature
LCA	Life Cycle Assessment
LED	Light-Emitting Diode
BIM	Building Information Modeling
CAD	Computer-Aided Design
2D	Two-dimensional
3D	Three-dimensional
AI	Artificial Intelligence
VR	Virtual Reality
IoT	Internet of Things
MRT	Metropolitan Rapid Transit
BTS	Bangkok Skytrain
PC	here: Private Car
PT	Public Transport
EV	Electric Vehicle
Post-WWII	Aftermath of 2nd World War
RGB	here: Re Greened Block

House Demonstration Unit
of the team from Taipei
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House Demonstration Unit
of the team from Grenoble
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solar decathlon europe

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Von den Deutschen Teilnehmer des Solar Decathlon Europe 21/22 erscheint in 2023 ein Buch in deutscher Sprache mit einer vertieften Darstellung ihrer Projekte.

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The Solar Decathlon is a major worldwide university-level building competition. Students are challenged to design, build, and operate high-performance, low-carbon buildings that mitigate climate change and improve our quality of life through greater affordability, resilience and energy efficiency.

The event came to Germany for the first time in its 20 years history. The Solar Decathlon Europe 21/22 in Wuppertal gathered architects, engineers, and multidisciplinary sustainability experts to communicate and showcase cutting-edge research and technologies in architecture, resource efficiency and renewable energy systems. The SDE 21/22 became an external event of the New European Bauhaus Festival and was awarded with the German Solar Prize.

Sixteen university teams from ten countries demonstrated on the common solar campus how to close gaps between existing urban buildings, add storeys to buildings or renovate ageing urban buildings in a climate-friendly and cost-effective way. After thrilling assembly and competition periods of hard work, heat, fun, and new friendships, the teams and their prototypes achieved remarkable outcomes. More than 115,000 visitors experienced the SDE in June 2022. They were inspired by the ideas and positive energy of 500 young international students. Although the circumstances of competition, cooperation and teamwork became the perceptible spirit of this SDE edition. This spirit underlines the power of international cooperation to overcome the ecological and economic challenges of the future.

This competition sourcebook summarizes the results, the teams' contributions and a first cross analysis of key topics.

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