Built Environment within Planetary Boundaries

Book of Abstracts

sbe 22 berlin

Universitätsverlag
der TU Berlin

sbe22 berlin - Built Environment within Planetary Boundaries

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Alexander Passer, Guillaume Habert

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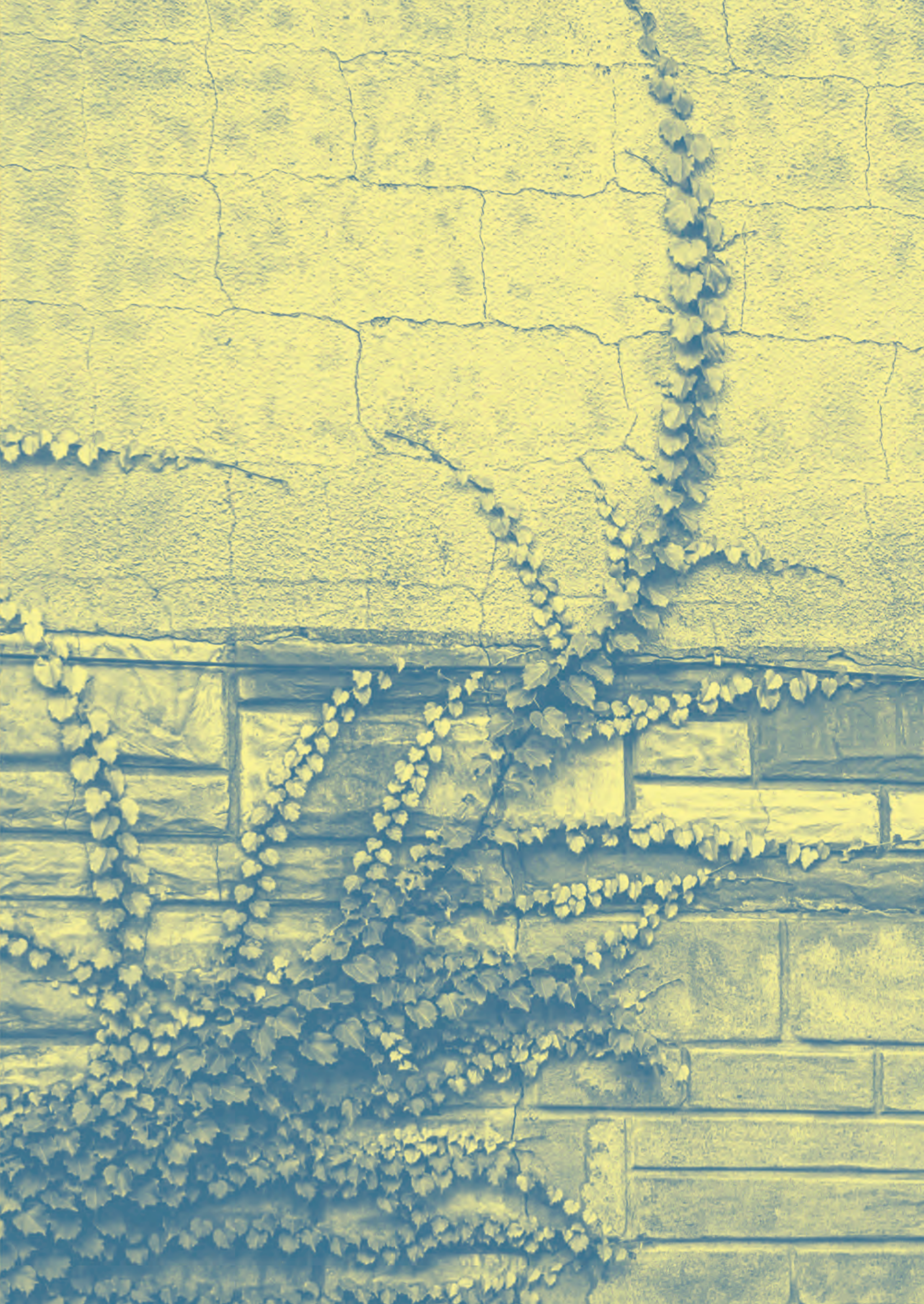


Welcoming Addresses

Dear sbe22 berlin participants,
the recently published IPCC report has again restated the need for us to radically change the way that we live, work, consume and build in the face of an acute global climate emergency. The production and maintenance of our built environment is responsible for an unacceptably large proportion of global carbon emissions, energy production and resource consumption. The need for us to exist within planetary boundaries has never been greater.

Triggering these transformation processes will require building new proactive alliances - in this sense we are thrilled to welcome you to the Sustainable Built Environment D-A-CH Conference 2022 in Berlin. The conference offers a trans- and interdisciplinary platform for international scientists, practitioners, politicians and interested guests to exchange their knowledge and experiences related to the key themes of the conference: resource management and material flows, climate neutral buildings, post-fossil infrastructures, critical digitalization and socio-political frames for transition. The aim of the sbe22 berlin conference, hosted by Natural Building Lab, TU Berlin in cooperation with KIT Karlsruhe, ETH Zürich and TU Graz, is to use shared expertise to formulate the ideas that will be presented at the World Conference in 2023 in Montréal.

The sbe22 berlin D-A-CH conference, as part of the 2021–2023 cycle of the SBE conference series, represents an important milestone for the implementation of the climate protection agreement of the City of Berlin and the sustainable development planning of the Technische Universität Berlin. Berlin's character as an international hub for research and innovation provides the opportunity for participants and their works to set new local and global impulses, strengthen communal strategies for climate action, create a cleaner construction sector and enact holistic approaches for the transformation towards a post-fossil society.

The sbe22 berlin D-A-CH chair and organizers thank all the authors and members from the Scientific Committee for their contributions and are looking forward to four inspiring, empowering and pioneering conference days.

Yours Sincerely,
Thomas Lützkendorf, Eike Roswag-Klinge, Kim Gundlach
sbe22 berlin D-A-CH organizing committee

Dear sbe22 berlin
participants

having been thoroughly effective in enforcing boundaries to address a variety of problems for quite some time, we definitely have been hesitant about limiting ourselves when it comes to the building sector. Yet, the idea of creating boundaries is essential concerning the harmful impact our unlimited human behavior has on the planetary environment.

The TU Berlin feels honored being the host of sbe22 berlin and to enable an exchange of knowledge and ideas for sustainable solutions and future-oriented innovation regarding the building sector. At this point I would like to mention the Natural Building Lab which follows the principles of a post fossil, ecological and socio-political sustainability including social responsibility, and which also hosts the sbe22 berlin in cooperation with KIT Karlsruhe, ETH Zürich and TU Graz.

We must make it compulsory to take CO_2-emissions into consideration at all stages of a building process. Greened roof areas, electrical heating and sustainable resource management are just a small part of what we must think about during the next decades. How can the challenge of bringing sustainability, climate protection and economy into accordance be met? How can we, e.g., ensure a fair and sustainable water supply regarding the operational optimization of local water infrastructure concerning demography, climate change and socioeconomics?

It needs a new understanding of how we want to live, work and consume.

Since we can´t consume and build endlessly in a finite world, we must be aware that giving a small part back of what we took from our planet is essential.

The problems we are facing today have direct consequences for tomorrow. Sustainability must not be an ad on but rather a must-have for each building project.

We will be delighted about a numerous participation in many planned events during the sbe22 berlin. Furthermore, we wish you all the best and an exciting conference.

Yours Sincerely,

Geraldine Rauch
President of Technische
Universität Berlin

Dear sbe22 berlin participants

Today, humanity is facing challenges of global dimensions – most of all, the consequences of man-made climate change, and related to this, the urgent need for an energy transition. Time is short, and already now, the world is dealing with terrible conflicts, driven by competition for resources. Indeed, the first half of the 21st century is the crucial era for finding solution to long-term societal challenges. Engineering will play an essential role here: a new role, that cannot be defined by economic interests alone.

Crises, whilst often difficult to manage, are pacemakers in the evolution of mankind. Stability has always been an illusion, wishful thinking, only possible for short periods. In particular, the expansive growth of economy over the last centuries has become a drive also for global change: today, we live in the Anthropocene, and »untouched nature« is hard to find on our planet.

KIT, the Research University in the Helmholtz Association, has defined its mission: to create and impart knowledge for the society and for the environment. With over 10000 staff and more than 25000 students, KIT envisions to enable and live the change towards a sustainable future. For this, many new technologies are being developed at KIT, including research on renewable energies and energy storage, biofuels and sustainable bioeconomy, new materials, post-fossile infrastructure, big data, machine learning and artificial intelligence, shared mobility, sustainable resource management, as well as in civil engineering, architecture and construction.

KIT, official Partner of »sbe22 berlin – the Sustainable Built Environment D-A-CH Conference 2022«, sends all participants the very best wishes for a successful conference.

Yours Sincerely,

Prof. Dr.-Ing. Holger Hanselka
President of Karlsruhe Institute of Technology (KIT)

Dear sbe22 berlin participants

Sustainable development is one of the most important challenges of our time. We are facing a major global task and with it a common duty, which requires a comprehensive approach that involves resilient solutions not just in each (scientific) sector but also a transdisciplinary foundation. Therefore, we at Technische Universität Graz (TU Graz) are aware of our role as an educational and research institution and have committed ourselves to find viable solutions for sustainable development with all our expertise. This especially involves the construction and operation of buildings, as with an amount of 37 % of global CO_2 emissions, it is one of the largest single emitters of greenhouse gases and holds therefore enormous potential in the fight against climate change.

In its Field of Expertise »Sustainable Systems«, one out of five internationally outstanding research areas of TU Graz, researchers from all seven faculties work together to form a basis in the sense of an extensive, transdisciplinary research, which also is implemented in teaching. Together with establishing the Sustainability Advisory Board, as a central body for a sustainability strategy, TU Graz filled the endowed professorship for sustainable construction. Furthermore, in June 2022 the Center of Sustainable Construction, that combines the activities of several groups on sustainability in the construction sector at our university, opened. Additionally, the TU Graz wants to operate in a climate-neutral manner from 2030 and has therefore developed a roadmap with numerous individual measures.

Knowing that international cooperation is a huge part of the transformation process, we are glad that the sbe22 berlin is held as a D-A-CH initiative, which involves academic institutions in Germany, Switzerland and Austria. Moreover, we are particularly pleased that an additional student conference is offered this year, giving students the opportunity to present their research, as in the context of sustainable development the involvement of all generations is essential.

We gladly look back to successful collaborations in the past years and wish you a fruitful and inspiring conference 2022!

Yours Sincerely,

Harald Kainz
President of TU Graz

Dear sbe22 berlin
participants

The construction industry accounts for over 40 % of all material extracted as well as 40 % of total energy and 16 % of annual water consumption. During the last century, consumption of construction minerals multiplied by a factor of 42. As all these processes entail a heavy carbon footprint, it becomes clear that business-as-usual practices are not sustainable and new approaches need to be implemented. But one can also turn these challenges into opportunities.

Future construction can be a way to reduce or even store carbon emissions when built with selected building technologies. They can also be used as depositories of materials to be later mined. Building renovation can be a catalyst to re-activate social and economic networks in a neighborhood.

To harness these opportunities, ETH Zürich is strongly engaged in research and innovation towards a post carbon environment.

Apart form research and tech transfer the education of a new generation of scientists, engineers and architects is vital for a successful transition to net zero. We want our students to acquire the fundamental knowledge and methods to tackle these challenges. But also, and most importantly to have a critical thinking so that they can engage with society by developing and designing the appropriate solutions to the needs of future generations.

The conference on the Sustainable Built Environment, sbe22 in Berlin, is part of a major international series of conferences that are supported by several important initiatives and alliances in the realm of sustainable construction. The series, now on a three-year cycle, is recognized as the world's preeminent conference series in this important field.

I am delighted to see the joint initiative from German, Austrian and Swiss universities to co-organize this conference. It is hosted by the TU Berlin in collaboration with Karlsruher Institut für Technologie , TU Graz and ETH Zürich.

I wish you all the success for the conference and hope that under this shared roof you, as researchers or industry partners, will have fruitful discussions on how to progress towards a net zero emission-built environment.

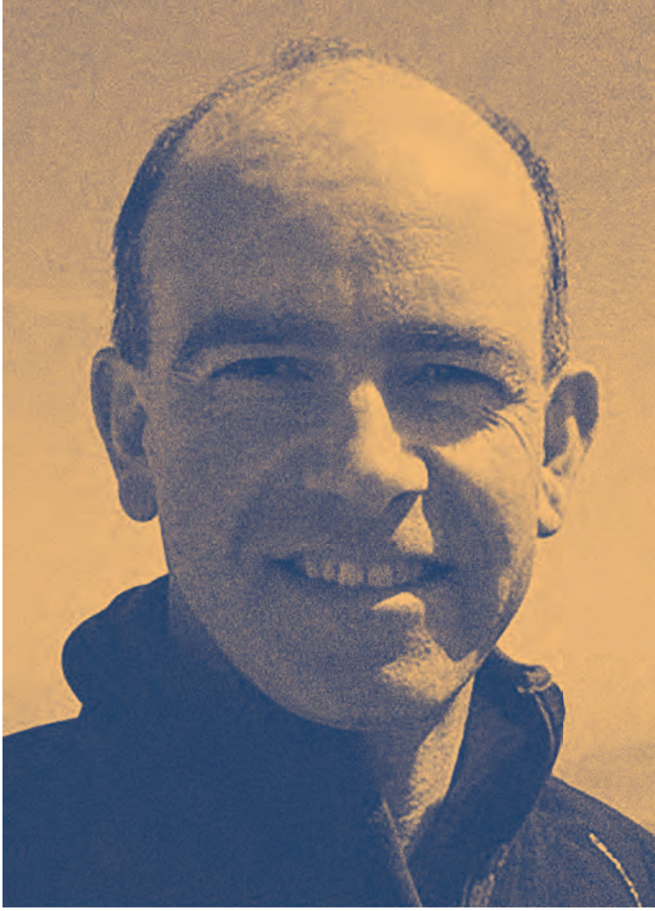
Yours Sincerely,

Joel Mesot
President ETH Zürich

Dear sbe22 berlin
participants

This conference sbe22 Berlin is taking place at a time of great change in European policies for the built environment. Since the arrival of the Von der Leyen Commission, a multitude of policies affecting buildings and infrastructure have been either proposed or revised. This includes initiatives on energy and climate, environment, financing and investment, digital innovation, and even the creative process with the New European Bauhaus. Of course, there are strong drivers for this change. First, our changing climate and Europe's legally binding goal to be climate neutral by 2050. Second, the digital transition which is enabling new business models such as a circular economy. Third, the geopolitical context is also changing before our eyes. The recovery from the COVID-19 pandemic and more recently the Russian war in Ukraine have shone a light on the resilience of supply chains, including for construction, as well as our dependency on fossil fuels.

From now to 2050 the European built environment will undergo a transformation. The majority of buildings standing today need to become energy efficient and decarbonized, as active participants in a renewable energy system. This needs a massive effort of renovation works, which is why the Commission proposed the Renovation Wave, to retrofit 35 million building units this decade, and to continue at that pace through to 2050. At the same time, we need to ensure this increased activity is carried out in a resource-efficient way. Construction generates over a third of the EU's waste, and uses half of all resources extracted. In order to achieve a sustainable built environment, the construction industry ecosystem also needs to undergo a transition. The Commission is therefore developing a Transition Pathway for construction to become more digital, green and resilient. In this context I am looking forward to this conference and all the new ideas it will bring.



Yours Sincerely,

Philippe Moseley
Policy Officer, Sustainable Industrial Policy and Construction European Comission, DG GROW

Dear sbe22 berlin participants

Welcome to sbe22! Issues of building for the future and of sustainable neighborhood and urban development are very relevant today. I am especially pleased that institutions in Austria, Germany and Switzerland have jointly prepared this platform for dialogue with industry, academia and policy-makers, and that the conference has attracted interested participants from around Europe and beyond.

The topics addressed here in Berlin are central concerns of Germany's Federal Ministry for Housing, Urban Development and Building as well. In line with the title of this year's conference, »Built Environment within Planetary Boundaries«, our efforts are focused on preserving the resources on which our lives depend.

One important goal is to make our building stock climate-neutral, which we hope to achieve through sustainable construction. That means paying attention to greenhouse gas emissions over a building's entire lifespan. We are working to establish this as a standard parameter for targets, planning and assessment. Requirements that are not tied to specific technologies or materials give more decision-making discretion to those responsible for building, enabling them to seek cost-effective solutions based on the latest research and technology which are best suited to the individual case. This is one basis for ensuring that prices and rents remain affordable for all segments of society.

Increasing the application of digital technology in the construction value chain is another important goal of mine. The use of digital methods such as openBIM helps to significantly increase the productivity and efficiency of Germany's construction industry.

Through the Alliance for Affordable Housing, the timber construction initiative and our role as national contact point for the New European Bauhaus, we are actively supporting the necessary processes of transformation.

I hope all participants find this year's sbe22 interesting and inspiring, with lively discussions and intensive exchange among professionals in the field.

Yours Sincerely,

Cansel Kiziltepe
Parliamentary State Secretary to the Federal Minister for Housing, Urban Development and Building

Dear sbe22 berlin participants

Considering the climate emergency, decrease of raw materials and scarcity of space for landfills, the construction sector's extensive resource consumption needs to change. Thus, establishing a circular economy that saves natural resources is a key priority of the Berlin Senate. In June 2021, the Berlin House of Representatives adopted the ambitious Waste Management Concept 2030 under the guiding principle of Zero Waste. This concept calls for the consistent expansion of reuse and recycling of material flows, which is to close material cycles and significantly reduce the waste of natural resources.

The measures for sustainable construction that Berlin has initiated have provided an important impetus. Since December 2021, the new Administrative Regulation for Procurement and Environment makes the reuse and recycling of building materials mandatory for the demolition of public buildings. It also stipulates the use of sustainable building materials in new construction and civil engineering.

Furthermore, we have developed a practical decision-making tool for sustainable housing construction. It shows that the substitution of four conventional building elements with climate-neutral building materials alone can save around 50 percent of harmful climate gas emissions. Such measures are now to be implemented for example by the Berlin owned private housing company Stadt und Land in several new multi-storey standard houses in the district of Berlin Neukölln.

Over the next few years, more than 16 new neighborhoods will be constructed in Berlin. The Senate Environment Department recently published a guideline for their resource-efficient development. For instance, the world's largest timber construction project will be designed and realized with the use of resource-saving secondary building materials on the site of the former Berlin Airport »Tegel«.

All these measures have taken us significant steps in the direction of sustainable construction. We would like to share our experience and learn from your research. That is why I am particularly pleased to welcome you on behalf of the Senate to the sbe22 Berlin D-A-CH Conference in Berlin.

Yours Sincerely,

Bettina Jarasch
Senator for the Environment, Urban Mobility, Consumer Protection and Climate Action in Berlin

Dear sbe22 berlin
participants

According to United Nations forecasts, around two-thirds of the world's population will live in cities in 2050. More than 75 percent of Germans already live in urban areas. Berlin's population is also growing – the four-million mark is expected to be reached in 2030.

The dangers of crossing planetary boundaries have been studied scientifically for decades. What is lacking, however, is comprehensive research and innovation to develop systematic solutions to protect our planet and to make those available regionally. Society has to face these challenges as a whole.

The Climate Change Center Berlin Brandenburg is a transdisciplinary center for research and knowledge transfer. Together with representatives from politics, business and civil society, scientists from Berlin and Brandenburg work on the implementation of the climate goals of the Paris Agreement for the metropolitan region. So far, research has not sufficiently considered the subnational effects of the necessary transformation processes between actors, regions and nations. However, these analyzes are indispensable for the social acceptance of such a far-reaching structural change. It is desirable that the results of these trans- and interdisciplinary research projects are also achieved in the short term in order to be able to influence current political decision-making processes. In addition, insights gained must be processed and made accessible to different target and age groups. We place a special focus on the Berlin-Brandenburg metropolitan region in terms of new solutions for networked urban and infrastructure planning, which imply innovative building materials, forward-looking mobility concepts as well as new land use ideas. It is necessary to involve stakeholders and citizens, because climate protection and climate adaptation strategies are tasks for society as a whole.

For this reason, we are particularly pleased to support the sbe22 Berlin D-A-CH Conference sustainable built environment within planetary boundaries as a scientific partner organization and to accompany the transfer of knowledge into practice and politics.

Yours Sincerely,

Anita Dame
Managing Director Climate Change Center Berlin-Brandenburg

Welcome to the sbe22 berlin D-A-CH conference

The sbe22 berlin D-A-CH conference, which will take place under the theme »Built Environment Within Planetary Boundaries«, will provide a platform for the exchange of ideas on innovative design and planning methods, building products, future-proof buildings and infrastructures as well as sustainable neighborhood and urban development. It is primarily aimed at participants from Austria, Switzerland and Germany, as well as from other European countries, and includes representatives from countries of the global south. Participants will be introduced to options for the further development of methodological principles, design, planning and evaluation tools, as well as concrete solutions and examples from the fields of products, buildings and urban planning. The scientific sessions and several special events invite representatives from science, politics and industry to an in-depth exchange of experiences.

Europe has formulated ambitious goals for its sustainable development over the next decades and plans corresponding measures. Many of them directly and indirectly affect the construction and real estate sector, as well as the closely related energy supply. Buildings and infrastructures provide prerequisites for social and economic development and have a major impact on the quality of life of their occupants and neighborhood. However, they are also associated with undesirable energy and material flows, as well as effects on the global and local environment, which to prevent further harm, have to be minimized. Climate protection, resource conservation and health protection measures have to be designed in such a way that issues of economic efficiency, value stability and affordability are taken into account. At the same time, buildings and infrastructures are already affected by the local consequences of global climate change and must be adapted to them. It will be necessary to achieve this by assessment of the respective sites and planning with prevision of the developments of the next twenty years. The fact that the construction and real estate sector causes considerable energy and material flows, as well as environmental impacts, also points to the necessity of looking for potential for savings and reduction. The success of sustainable development thus also depends on the players in the construction and real estate industry, including upstream and downstream sectors. The construction and real estate sector is thus both a cause and a victim of the previous code of conduct of resource management of real estate industry and building sector, as well as a field of action for solutions to change it.

More and more, the realization is gaining ground that economic and social development must take place within planetary boundaries. In selected areas, such as climate protection, the safe operating space has already been enacted, and the risk of serious consequences for humanity is increasing. It is therefore in everyone's interest to preserve the natural livelihood of mankind. The necessary goals have already been developed by science, which lead, for example, to a budget of still feasible greenhouse gas emissions while limiting global warming. But how can these goals be translated into concrete objectives, benchmarks and and target values in the design of buildings? Is orienting on technical and economic feasibility as well as on good examples still sufficient, or will benchmarks in the future also have to be oriented on science-based targets that can be derived top-down from planetary boundaries? This overarching question is one of the focal points of the conference and will be addressed in the sessions on *climate-neutral buildings* and *post-fossil infrastructures*. There will be discussed whether the preconditions for the introduction of binding requirements to limit greenhouse gas emissions in the life cycle of buildings are given and when this has to be done at the latest.

Instruments named in the TAXONOMY, as well as in the drafts of the construction product regulation (CPR) and the energy performance of buildings directive (EPBD), including LEVEL(s), point in the right direction, but do not yet contain binding requirements.

Planetary boundaries do not exist for all discussed topics. Although the model of a »resource-light« society exists as a reaction to the mega-trend of resource scarcity, concrete target values for the design of buildings are still lacking. Nevertheless, a new focus can be identified in the topics discussed at the conference: the circular economy in the »construction« value chain and the recyclability of construction products, buildings and settlements. The possibilities in the fields of recording, evaluating and specifically influencing *material flows in the construction and real estate sector*, as part of *resource management*, will be presented and discussed. Corresponding consequences and approaches to solutions for the development, manufacture and use of products will be debated.

In the context of sustainable development, cities, and neighborhoods are emerging as an important object of consideration, as an influential level of action and – through their administrations and representatives of civil society – also as relevant actors. Using municipal options make it possible to exert direct and indirect influence on construction and development activities. Municipalities can currently react faster and better to new goals and challenges – also by using local building law and public procurement instruments – than it is possible in, e.g., national legislative processes. These topics will be addressed in the scientific sessions and in the supporting program. The topics of further development of national, municipal and institutional *building stock* will also be addressed.

In all areas of material development, building design, as well as neighborhood and urban planning, the trend of *digitalization* provides important support. Current topics and trends will be discussed at the conference, including questions of life cycle analysis with its corresponding data bases and the need for related information, as well as on the use of BIM.

The trend towards the awareness of responsibility towards the environment and society, as well as the need for sustainable production and consumption patterns, is leading to new forms of information exchange and cooperation along the construction value chain and ultimately also has consequences for education and training in these fields. In the »Frames for Transition«, therefore, the possibilities for action for companies in the real estate industry are discussed and educational concepts are presented.

Questions of the future design of living and working environments with the implementation of a sufficiency, consistency and efficiency strategy will be discussed at the conference. This will be reflected, among other things, in a special event on the *New European Bauhaus*.

With the program of SBE22 Berlin, the breadth and depth of topics in the field of sustainable design of the built environment is once again evident. The strong momentum in the further development of scientific foundations, political instruments and business models is also clear. The results of the SBE22 Berlin – as well as those of the other regional conferences worldwide – will be incorporated into the program of the World Conference WSBE23 in Montreal.

Best regards
Thomas Lützkendorf, Eike Roswag-Klinge, Kim Gundlach, Selina Schlez, Alexander Passer, Guillaume Habert

Introduction Student Conference

In summer semester of 2022, the Natural Building Lab and the Habitat Unit, both research centers of TU Berlin, invited students to an open call in the context of the Pop-Up Campus Aachen. Integrated into the discourse on building in the existing fabric, focus of the program is on approaches and processes of circular building, the handling of recyclable materials and on constructions with renewable or natural materials, as well as on research on urban and regional questions on renewable or natural commodity and material cycles. Discussed will be the experimental and future-oriented approaches of students, as well as the challenges and opportunities of research and methodology in architectural teaching. The program is organized at the TU Berlin as the student conference within the framework of the international conference on sustainable building »sbe22 berlin – Sustainable Built Environment Within Planetary Boundaries« and enables the students of the Pop-Up Campus to exchange ideas with international scientists and present their projects.

Since its foundation in 2018, the Natural Building Lab continuously develops its own teaching approach: »Teaching, Research, Practice«. As part of the focus on DesignBuild (focus: Dr. Nina Pawlicki) and Reallabore, several built projects have been realized under the transdisciplinary and collaborative cooperation (focus: PhD cand. Matthew Crabbe) between students, institutional and civil society actors. At the Natural Building Lab, experimental formats are tested in teaching for further methodological and content-related knowledge gain, and teaching research projects are initiated specifically or developed together with students. A special focus lies in the questioning of the potentials and chances of real laboratories in planning and building. Realized projects: Infozentrale Vollgut, Oasis Tropical Moravia, Exil Austellung Anhalter Bahnhof. Prof. Elke Beyer is a specialist in research on the international commodity flows.

In this context, the standards of research in architecture have again come to the fore internationally. On the one hand, there is the question of what demands are made on contemporary research in architecture, not least against the background of the increasingly complex demands on the design process at universities, as well as on planning practice – and, on the other hand, there's the question of what perspectives are still missing or not sufficiently taken into account in the discourse on architectural research and architectural education. The NBL is continuously dealing with these questions in its own teaching practice, especially by including the educational perspective, which can be seen as a missing component in the current debates. The Natural Building Lab participated with Prof. Roswag-Klinge in the conference »Research Culture in Architecture« 2018 at the TU Kaiserslautern and cooperates especially with the Habitat Unit at the TU to further develop the formats of teaching research. Important insight from the teaching practice so far is above all the need to include and diversify scientific methodology in teaching in order to provide students with relevant methodology to identify, analyze and deal with problems and research questions on a theoretical, technical or mathematical level; so especially in transdisciplinary projects (interfaces: construction, economics, landscape and urban planning, sociology). Thus, the research state and question docks with the PUC.

The objective of the Open Call for the Student Conference is, on the one hand, the targeted selection of valuable student contributions on building in existing contexts, resource- and material-conserving construction, and on the other hand, a concrete contribution to the discourse on science and methodology in architectural teaching. The Students Conference enables students to participate and network with scientists from the disciplines of sustainable design and construction and aims to test and deepen scientific methodology and formats. A further goal is to gain knowledge by networking actors from the academic mid-level who actively deal with the interfaces of design and scientific/theoretical work in their teaching. The goal in the area of science communication is the successful implementation of a prototype and poster exhibition of the selected student work at the Students Conference as a representation for a satellite of the Pop-Up Campus.

The Open Call for the Students Conference invites students to address the questions:

What experimental spaces are needed beyond the current building and planning law to test innovative and novel constructions and planning processes in order to derive new rules and parameters for a climate-appropriate building practice? Which processes/construction possibilities are particularly suitable for building in existing structures in the context of a climate-appropriate and resource-saving planning practice? On a process-oriented level, the workshop in Aachen and the Students Conference should contribute new insights to the following question: What formats are needed in architectural teaching to develop approaches to solutions for the complex challenges of the built environment on a theoretical, design and real-world level? How can the learner/student perspective be further integrated into research?

The student conference at the TU Berlin is accompanied by a workshop on »Educational Perspective on Research and Teaching in Architecture« in Berlin as a part of the Pop-Up Campus program. For this event, we announced an open call as part of the Pop-Up Campus. Students applied from all over Germany, with increased entries from Pop-Up Campus partner universities. Students applied with their current semester project or with an older project, based on a short abstract and complementary visuals. An advisory board of faculty and students reviewed the submissions and invited a number of students to prepare a full paper for the conference in Berlin in September.

A workshop on »Educational perspective on Teaching and Research in Architecture« is organized within the framework of the conference as an opening event in Berlin. The workshop is coordinated by the Natural Building Lab and the Habitat Unit and serves the networking of the participating universities in Aachen as well as the exchange between students and teachers on research, methodology and scientific work in architectural teaching. During the workshop (20.09.), the diverse perspectives are exchanged and discussed along with the participating teams of the Students Conference through Input talks and workshop format.

Organizing Committee & Scientific Committee

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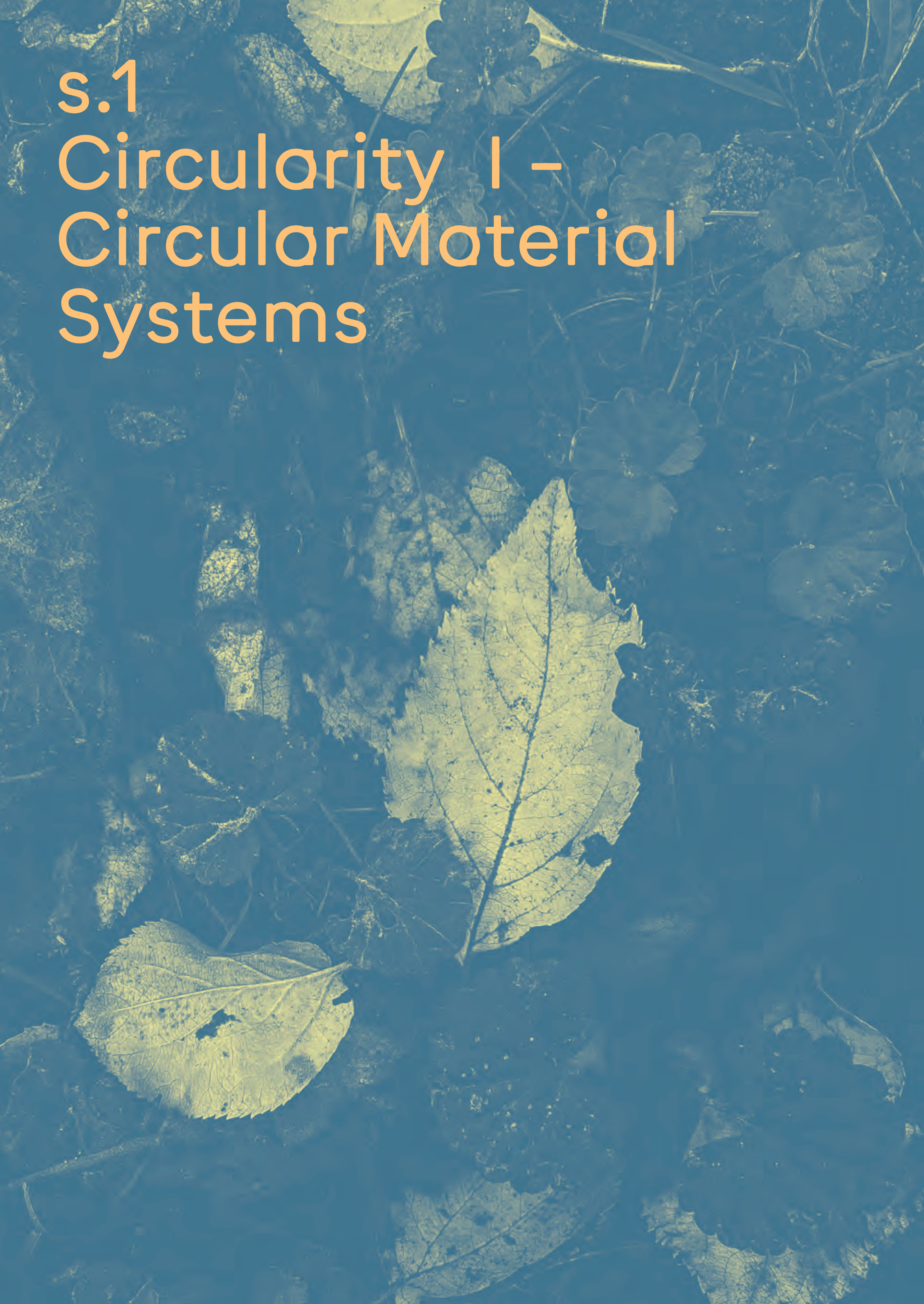
s.1 Circularity I – Circular Material Systems



s.1.1

Surveying the Building Stock of Graz with Regard to a Circular Economy in the Construction Sector

B Hausegger [1], M Raudaschl [1], T Levak [1], G Triantafyllidis [1], E Dengg [1], C Kurz [1], R Riewe [1], J Juhart [2], A Gündera [1], S Haingartner [1], D Schlegl [1], J Regl [2]

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Keywords: City, Scenario Analysis, Circular Economy, Sustainable Construction, Data Analysis

Construction consumes about 40 % of resources globally. The switch to a circular economy model in the building industry can contribute to the reduction of use of resources, and lower the environmental impact by extending the life cycle of building components and materials. However, circular economy principles are not yet established in the buiding instustry, while at the same time the complexity and consequences of such a transition require further research. The objective of the exploratory study »City Remixed«, whose first results are discussed in this paper, is to identify re-use and recycling potentials of Graz's building stock for the city of Graz, in order to initiate the transformation of the building sector of the city towards a circular economy. Considering the city of Graz and its surroundings in a reasonably short transport distance as a closed system, we started by quantifying the existing building stock in form of a digital 3D model as shown in this paper. In addition to the recording of the materials or construction elements present in buildings and infrastructure (networks) and quasi bound in them with regard to type of building material, quantity, condition and position in a geo-information system (»urban cadastre«), the expected future time of availability of the material or construction element is also to be recorded digitally. In the future we will enrich the model with metadata, in order to enable the investigation of re-use and recycling potential of the components and materials, as well as to determine companies, manufacturers testing and certification institutes, that are necessary for these processes. Finally, we will develop renewal scenarios based on the existing building stock, as a result of possible component and material flows. From this process, we identify the fields of action, we settle decision-making bases and provide recommendations with regard to the transformation to a circular economy for different stakeholders, including the citizens. In this context, digital technologies allow the storage, recovery, management and update of large amounts of information, support the development of circular economy scenarios, which in turn offer a simple way towards the re-use and recycle of materials in the building industry.

s.1.2

Circular Material Systems: Anticipating Whole-System Design in Architecture and Construction

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Keywords: Circular Construction, Sustainable Architecture, Circular Economy, Built Environment, Whole-System Design

The construction sector is one of the most resource intense and environmentally damaging industries in the world. A promising approach to counteract this is to use principles of the circular economy (input reduction, reuse, and recycling) to ensure the continuity of value of a building's materials. Thus, we translated the learnings of an in-depth case study analysis, including four buildings and their construction processes into a definition and framework for circular construction. We conceptualize buildings as circular systems that produce reusable components or biodegradable materials by practices operating across a building's lifecycle. These practices do not only include material and design aspects to close biological and technological loopholes, but also immaterial practices such as knowledge and expertise, locality, management and skills, and information. We argue that these organizational aspects that go beyond the current state of the art are critical enablers for circularity in construction. This perspective is relevant for practitioners in the field and allows for a new and holistic look at buildings as »waste generators« or, in a positive scenario, as »material depots«. Designing for recycling and reuse will require architects to build collaborations and knowledge across and beyond material value chains.

s.1.3

Rethinking Recurring Waste Flows: Creating Material Cycles by Identifying New Use Cases for Idle Materials

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Keywords: Recurring Waste Flows, Idle Material Streams, Collaborative Material Workshops, Use Cases, Local Material Cycles

This article presents Collaborative Material Workshops (CMW), aimed at identifying new use cases for commercial waste materials waste materials, which are continuously being generated and have valuable technical properties. With the assumption that such materials habe a high re-use potential, they are defined here as idle material streams. The objective of CMW is to identify scalable and feasible applications for the re-use of idle material streams and to communicate those results to commercial adopters. In cooperation with a local secondary material initiative and a project-related NGO, TU Berlin researchers have investigated the idle materials »printing blankets« and »aluminium composite panels« in two CMWs. Both materials combine valuable technical properties, a short use phase, and poor recyclability. The resulting two CMWs included 1) detailed background research, 2) physical material testing and 3) experimental CMW with material-related experts. With a special focus on the construction industry, the article discusses the barriers of identifying scalable and feasible new use cases for idle materials through the method of CMW.

s.1.4

Circularity and Sustainability in the Construction Value Chain

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Keywords: Buildings and Construction, Business Models, Circular Economy, Construction Value Chain, Sustainability

This paper debates how circularity can contribute to value creation in the construction value chain. In traditional linear business models, value is often limited to financial value for the firm and customers. Here, value is seen more broadly considering a wider range of stakeholders, such as value chain partners, the environment, and the society. Findings from relevant literature and recent research projects are brought to transform linear cradle to grave processes to sustainable cradle to cradle ones. Circularity can contribute to sustainability in many ways: material recovery from existing buildings and reusing, recycling or even upcycling them into new ones and design for disassembly that eases reuse and value retention. Findings indicate that circular economy has significant potential to create and maintain value in the construction value chain. Most of the decisions that affect value creation are done in the design stage, but it is strongly linked to the other stages and affected by business models, circularity platforms, and external influencers, such as financing, client's requirements, regulations and incentives.

s.1.5

Assessing Circular Information Flow in Industrialized Construction: A Framework for Evaluating Data for Circular Construction

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Keywords: Building Firms, Literature Review and Survey, Circular Information Flow, Industrialized Construction Firms, Circular Construction, Circular Data

A circular economy offers a solution for improving both the efficiency and environmental impact of the built environment. As the construction industry transitions to a circular economy, adequate information flow is necessary to keep products in the value chain for as long as possible. Industrialized construction firms show high potential for a successful transition to a circular economy because of optimized information flow through the use of product platforms, the use of information communication technologies, and the integration of actors. However, there is no current framework to assess whether construction firms using industrialized construction methods have a circular information flow. In this research, four characteristics are identified as main descriptors of a circular information flow framework: completeness, availability, accessibility, and incorporation of information into business strategy. Using the framework, industrialized construction firms are asked to self-assess their performance through pre-defined survey questions. The findings from sixteen industrialized construction firms reveal the need for more complete data about recyclability potentials of products and unique materials and product identifiers, with 47 % of firms indicating they have insufficient information. The survey of companies also indicates a need for more feedback about the reuse, recycling, and remanufacturing phases to be available, with only 20 % of firms gathering feedback about reuse, 13 % about recycling, and 20 % about remanufacturing. The stakeholders with the most consistent access to information about design and materials of a project are the manufacturer, engineer, architect, and assemblers. 13 % of firms employed RFID tags. More accessibility of information is needed for actors outside of the firm. Additionally, only 13 % of firms implemented a take-back strategy, emphasizing the need for incorporating these business strategies within the firm. 17 % of firms, however, had CE in mind during strategic development, demonstrating the potential for CE adoption in the industry. Finally, the paper discusses future opportunities for circular information flow, such as employing blockchain technology.

s.1.6

Predicting Material Consumption in a Circular Economy Oriented Design Methodology for Pedestrian and Cycling Bridges

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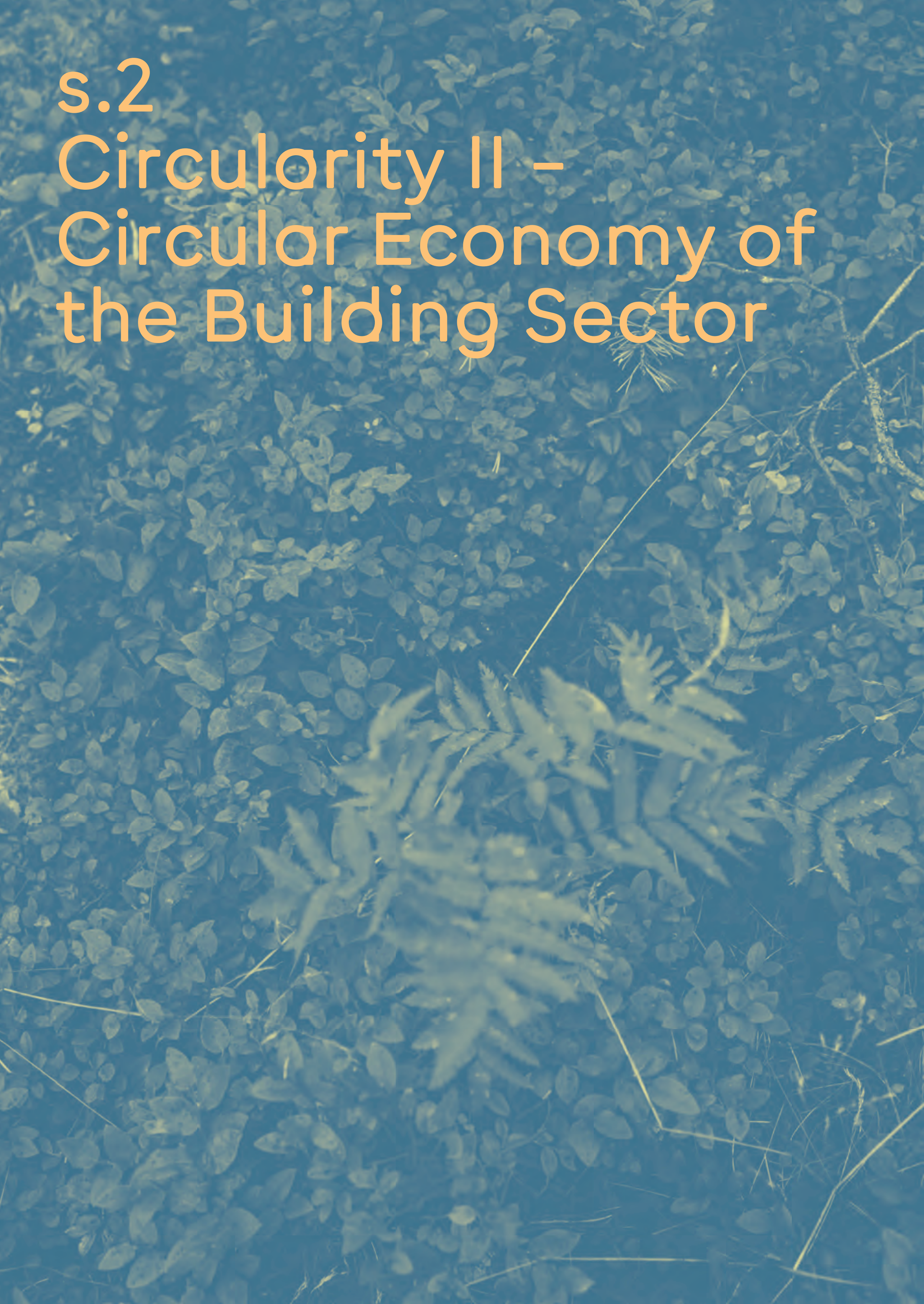
Keywords: Circular Construction, Conceptual Design, Morphological Indicators, Structural Optimization, Material Consumption

A Circular Economy (CE) oriented design methodology for pedestrian and cycling bridges that takes the 4Rs of the CE – Reduce, Reuse, Recycle, Recover- as basis needs to be developed. The first R, Reduce, is mostly neglected, even though it is the most important R in the CE. Nevertheless, a CE oriented design methodology also needs to consider and formalize Reduce. It is proposed to do this by measuring the material efficiency of a structure. Therefore, a reference volume of material needs to be found. This paper proposes a methodology to predict the necessary amount of material needed for the bridge structure. The methodology takes the theory of the morphological indicators as basis. Morphological indicators are used in the conceptual design phase to find the most efficient structural typology and global dimensions. However, it was found that the volume indication that results from these morphological indicators is not realistic. The main reasons are that they consider a fully stressed state for each component, and they do not consider standard profile sections. Therefore, two correction curves are proposed to correct the volume obtained from the morphological indicators into a realistic one. The limitations of this study are that it only focuses on Warren truss bridges and only considers vertical service loads. Further research will have to focus on incorporating other types of trusses and other structural typologies like arched, suspension and cable-stayed bridges. In addition, more loads like wind and snow that can act on bridges need to be considered.

s.2 Circularity II – Circular Economy of the Building Sector



s.2.7

Reconsidering the Assessment Method of Environmental Implications of Circular Economy in the Built Environment

S C Andersen [1, 2], M Birkved [2]

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Keywords: Built Environment Circular Economy, LCA as Decision Support, Prospective Scenario Development, Shared Socioeconomic Pathways

Are we capable of addressing environmental consequences on a societal scale of circular solutions for the built environment, or merely capable of addressing these impacts applying a narrow product/corporation perspective? Considering evaluations and quantifications of envi-ronmental implications associated with implementations of Circular Economy (CE) design processes in the Built Environment, we postulate that these solutions necessitate decision-support tool-advancement, as CE does not allow for business-as-usual (BAU) assessments only. The BAU assessments of environmental impacts in the built environment, seem to paint a certain picture of the circularity paradigm. The question, however, is whether, by relying on simplified assessments, we end up barely making it to the finish line, very late, and risking loosing focus and creating sectoral burden-shifting. Application of LCA has created a paradoxical situation in the building industry. Gaining more experience in application of LCA, the industry steadily increases the complexity level of the questions to be addressed by LCA, thus increasing scale and complexity of systems to be assessed. Hence, currently, large systems such as CE models for the built environment, are often assessed in the same manner as we assess single buildings and building parts, despite that CE models have a much higher potential to generate feedback effects, so that the system under assessment, changes due to the entity/service being assessed. The main question is hence, whether life cycle assessors operating within the built environment are aware of the challenges they are facing when answering questions regarding CE, and if these are addressed, assessment wise, in the /appropriate manner? Secondly, we need to consider how we facilitate assessment of systems at various physical and temporal scales in such a way that it becomes economically and technically feasible for the industry to address complex sustainability questions. This paper discusses possible future application potentials of LCA and propose consistent scenario definition, and thus looks into the question: how come, that we assess almost all systems in a 'static' manner, while being completely aware of the fact that we live in a dynamic world? Are we, within LCA, addressing the need for improving the realism of the models that we derive in a sufficient and applicable manner?

s.2.8

How is the Construction Sector Addressing the Circular Economy? Lessons from Current Practices and Perceptions in Argentina

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Keywords: Construction and Demolition, Circular Economy, Barriers and Opportunities

The construction and demolition (C&D) sector mobilize a significant number of resources and at the same time is responsible for a large fraction of waste worldwide (40%-60%). Although, the environmental impact of these by-products is low, waste generated ends up in landfills, is downgraded and because of its volume it has become a priority at different governmental levels. In this context, the circular economy (CE) provides a set of strategies to improve efficient use of resources, thus reducing the environmental footprint of C&D. Most academic literature has focused on China, Europe, or the US, but knowledge about CE practices and perceptions in global south countries is scarce. To reduce this knowledge gap, this study focuses on Argentina and explores what are the perceptions, challenges, and opportunities for adopting CE strategies by the C&D sector. To achieve this goal, a survey was developed and distributed with support from the Argentinean Chamber of Construction (CAMARCO), among members of the chamber and other C&D relevant networks. The survey was carried out in the Autumn of 2021 and 88 C&D firms representing different size, longevity and business cycle responded. The results of the survey show that most of surveyed firms are trying to engage with the concept of CE. Secondly, a lack of digitalization and information are seen as important barriers to transition to CE. Finally, policy makers should focus on providing financial and tax incentives to secure a better environmental future.

s.2.9

Paving the Way Towards Circularity in the Building Sector: Empa's Sprint Unit as a Beacon of Swift and Circular Construction

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Keywords: Sprint Unit, Life Cycle Assessment, Circular Economy, Sustainability Assessment

In order to achieve the CO_2 targets stipulated within the Paris Agreement, future buildings must be constructed in such a way, that their emission profile will be close to zero. In order to achieve this, a radical shift towards a circular construction manner which encompasses topics like material reuse (i.e., design for multiple lifecycles), design-for-disassembly (allowing for maximum recovery of materials and minimization of construction waste) must be promoted against today's conventional construction practices. Furthermore, the current COVID-19 pandemic has shown that buildings must be constructed in a more flexible manner, in order to be adaptable to changing needs as quickly as possible – including new types of needs. A transition to such a circular construction practice requires also new approaches for Life Cycle Assessment (LCA), taking into account issues such as the circularity or multiple life cycles of materials. Conventional LCA methods fail to deliver trustworthy results as they are designed to assess products and buildings that have only a single life cycle. In this context, a newly constructed unit, set to be the embodiment of the circular construction principle that incorporates all the above-mentioned concepts in the form of a cluster of flexible office spaces, has been integrated into the research building NEST (Next Evolution in Sustainable Building Technologies) – a platform located at the Empa campus in Dübendorf (Switzerland), where novel building technologies can be tested and validated under realistic conditions. Its name: Sprint. In this paper, the environmental performance of Sprint is assessed through LCA, using three different approaches – the EN15804 method, the Product Environmental Footprint method and the Linear Degressive approach – with the latter two approaches considering the circularity of materials, while each one having an own, distinctive allocation rule for the split of the impacts between the current, the previous and the subsequent lifecycles.

s.2.10

The Socio-Spatial Effects of Circular Urban Systems

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[1] Technische Universität Berlin, Berlin, Germany.

Keywords: Sustainable Neighborhoods, Circular Economy, Climate Change, Infrastructure, Urban Political Ecology

This article shows what kind of urban spaces are produced by circular systems. The focus is on the socio-spatial dimension of closed material loops in two neighborhoods (e.g., reuse of grey water, recycling of waste, provision of renewable energy). Although the Circular Economy (CE) narrative is increasingly part of urban transformation policies, there are considerable implementation gaps in how regenerative or self-sufficient systems are operationalized in practice. I argue that the application of circularity principles in the urban context requires conceptual clarification to be useful for urban theory and practice. Therefore, I provide a political ecology perspective of circular urban systems by analyzing two cases: Block 6 in Berlin and Schoonschip in Amsterdam. I explain how such systems were established, who benefits from them, and what kind of socio-spatial conditions they produce. Methodologically, I use several qualitative research methods in the framework of a case study analysis. The results show that the incremental and publicly financed low-tech development of circular systems is socially compatible while privately funded high-tech developments result in stronger levels of sustainability but are reserved to a small exclusive group of people and provoke gentrification processes.

s.2.11

An Urban Hospital Based on the Principles of Circular Economy: The Case of Joseph Bracops Hospital

G Scialpi [1,2], J Declercq [1], L Grisay [1], D Perrotti [2]

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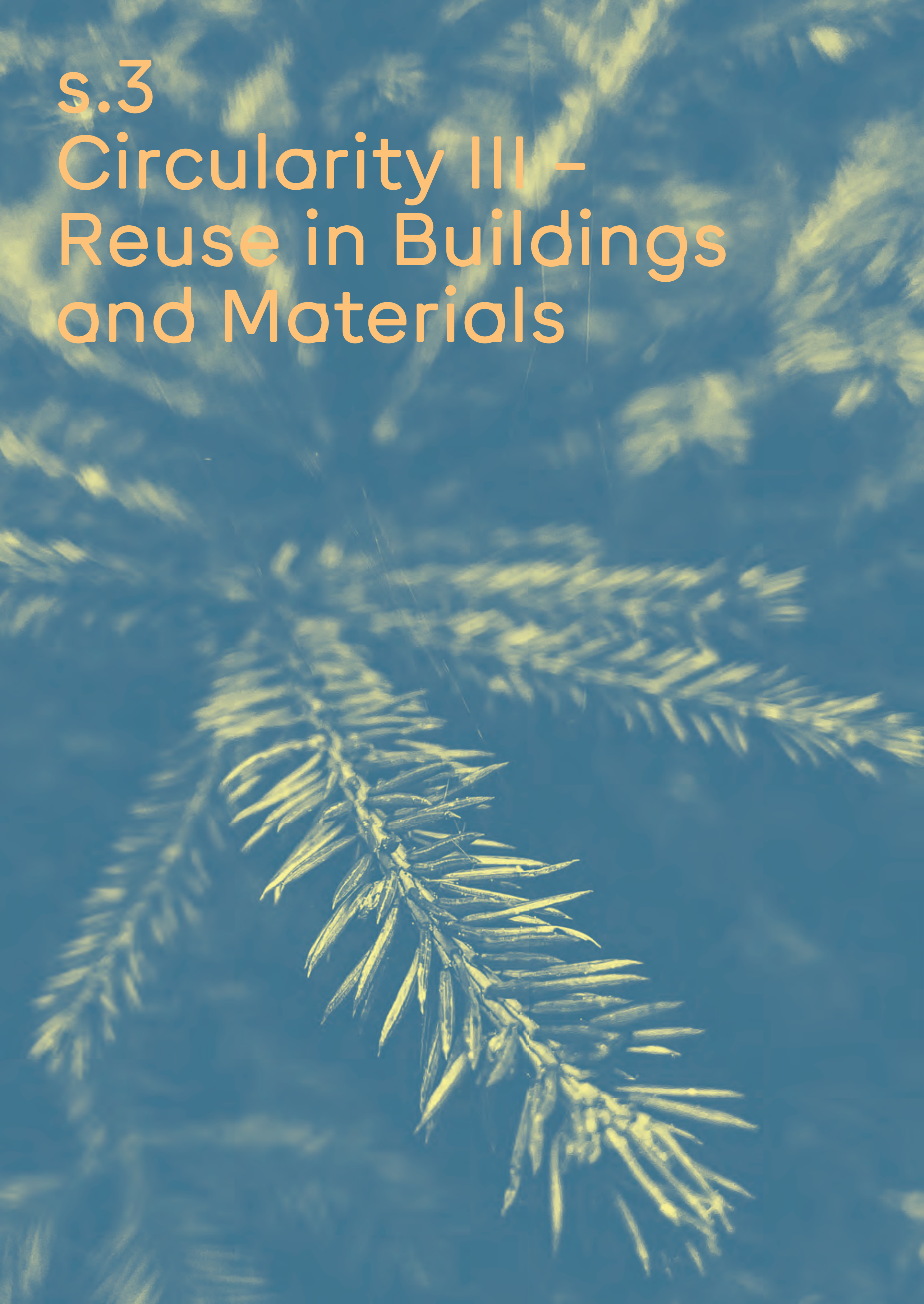
Keywords: Hospital Building, Circularity Assessment, Healthcare, Circular Building, Reversible Building Design Protocol

The building industry has mainly focused on improving operational energy consumption to minimize the environmental impacts of buildings which are major sources of greenhouse gas emissions (GHG). However, considering the full life cycle of buildings, energy use and GHG emissions occur for reasons that extend beyond the operational phase and involve the embodied impacts of construction and disassembly. Circular building design can provide a holistic approach where the building's whole life cycle is considered in a manner consistent with circular economy principles, minimizing global material consumption, reducing waste and insuring a more circular building material stock. To date, research on the wide-scale adoption of circular design and construction strategies in public projects is still lacking. On this basis, the case study of the new Joseph Bracops hospital in Brussels shows that circular building design principles can be applied in the healthcare sector within the framework of a public tender. The project integrates circular economy principles at different scales (city, site, building, element), optimizes different material and energy flows and takes into account different time spans (short and long term). The study also offers insight and guidance for future research into how the urban hospital of tomorrow will be a resilient public venue. Such a venue can enable a more comprehensive approach of health promotion, reflected by the qualitative integration of circular economy principles, both with a social and technical focus, connected to the community and capable to mutate over time.

s.3
Circularity III – Reuse in Buildings and Materials



s.3.12

ScanR: A Composite Building Scanning and Survey Method for the Evaluation of Materials and Reuse Potentials Prior to Demolition and Deconstruction

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Keywords: Building Stock, Survey, Scanning, Lidar, Deconstruction, Reuse

This paper introduces ScanR (Scan for Reuse), a composite method pairing quantitative and qualitative salvage and deconstruction surveying (S&D survey) with LiDAR and photogrammetry scanning in an effort to empower local municipalities and stakeholders in cataloging building materials prior to removal from site (in the case of either demolition or deconstruction), and enabling data collection and the generation of material databases to link local supply with demand – all in support of a shift from linear to circular economic models in construction. The speed of capturing large spaces through 3D scans and the ability to export such models into CAD software allows for a rapid assessment of surface and floor areas to calculate finishing material quantities and other material content, but lacks metadata such as quality and potential hazards that are necessary for a potential deconstruction contractor. Furthermore, information on spaces inaccessible to scanning, such as wall cavities, are necessary to comprehensively assess a building's reuse potential. In supplementing scans with S&D surveys using accessible tools and software, these factors can be noted and referenced in relation to the space and 3D model, providing critical information to inform the harvest of materials and planning of the materials' next use cycles. In testing this method on a building slated for deconstruction, this paper demonstrates the advantages of each method of data collection and how one can be leveraged to support the other to further catalyze local efforts to divert material from waste streams.

s.3.13

Environmental and Economic Analysis of New Construction Techniques Reusing Existing Concrete Elements: Two Case Studies

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Keywords: Cast-in-Place Concrete, Reuse, Life-Cycle Analysis, Construction Cost, Circular Economy

As the most widely used construction material worldwide, concrete is the main cause of greenhouse gas emissions, material depletion, and waste generation by the construction industry. Typically, concrete waste is crushed and, at best, reclaimed into recycled aggregate or used as gravel. This process is energy-intensive and results in a reduction in material properties. In contrast, the direct reuse of concrete elements from obsolete structures offers great potential for significantly reducing the environmental impact of new constructions. To be reused, concrete elements are carefully sawn out of soon-to-be-demolished buildings. Elements are then used without other major transformations for another service cycle in a new assembly. This paper analyzes two recent projects in Switzerland that showcase innovative applications of concrete reuse: a post-tensioned segmented arch footbridge and a parking pavement. Both projects reuse blocks extracted from cast-in-place concrete buildings undergoing transformation or demolition. In this paper, environmental and economic analyzes provide a comprehensive understanding of the alleviations and costs involved. Results are compared to those of alternatives with conventional construction methods. The two projects reusing concrete globally showcase a drastically lower environmental impacts for comparable or higher construction costs, hence calling for future developments of such new circular construction strategies.

s.3.14

F Herrmann [1], H Pürschel [1], J Wörner [1], J Blasius [1], L Lahiri [1], M Böhme [1], V Hartmann [1]

[1] Sauerbruch Hutton / SHift

Restructure, Repurpose, Extend: Design Strategies for Futureoriented Building and for Strengthening the Potential of the Existing Building Fabric

Climate neutrality coupled with an overall positive ecological footprint is still a distant dream for new construction. The German building sector is directly and indirectly responsible for about 40 % of all German CO_2 emissions and has so far failed its CO_2 reduction goals. For the German building sector, the key to climate neutrality lies not only within new construction but in its existing building fabric. The embodied carbon of new construction needs to be reduced, as well as the amount of new construction itself. Hence the reuse of buildings and the extension of their life cycles is a crucial factor in reducing CO_2 emissions and resource consumption. In this paper we present three of our projects (from the office Sauerbruch Hutton), highlighting not only the potentials but also the problems that planners face with existing buildings. Additionally, our project based LCA analysis showcases that retrofitting can have a much smaller CO_2 footprint than a new building.

s.3.15

Current LCA Framework: Impact of Reuse and Reusability in Different Life Cycle Stages

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Keywords: LCA Methodology, Reuse, Case Study, Module D

In the context of circular construction, the (potential) reuse of construction materials and building products is set forward as a general concept to reduce the environmental impact of buildings. But does this really lead to reduced impacts? A standardised framework to calculate the environmental impact of buildings over their life cycle is available through the European standards EN15804+A2 and EN15978 for life cycle analysis (LCA) in construction. The concept of reuse does however intrinsically focus on multiple use or life cycles. A correct quantification of the environmental impacts of reuse in buildings, requires a better understanding of the different mechanisms and issues at play. By means of critical assessment of the LCA methodology, in combination with a simplified case study, this paper provides insights in how different reuse options for products are valorised (or not) when calculating the environmental impact. It is shown that the LCA standard EN15804+A2 allows to quantify the impact related to different concepts of reuse at the beginning or the end of the considered life cycle. In general reused products will lead to larger environmental gains as the production stage (A1-A3) can be avoided. The environmental benefit related to the reusability of a product is typically reflected in a smaller difference in the end-of-life (EOL) stage (C1-C4). Also the relevance of existing concepts, such as module D, is discussed for each of the considered reuse options. Results show that module D can provide insights in the future potential of reuse (at EOL) for virgin products, but that the numbers are difficult to interpret and even misleading for reuse products. The results and discussion show the limitations of the current LCA framework for these types of products and identify the need for the integration of additional concepts to correctly valorise the potential of reusable products using LCA.

s.3.16

Evaluating 'Reuse' in the Demolish or Reuse? The Balance Between Operational and Embodied Emissions in the Retrofit of Commercial Buildings

D Abbey [1], H Arbabi [1], C Gillott [1], W O C Ward [1], D Densley Tingley [1]

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Keywords: Embodied Carbon, Operational Energy, Whole Life Carbon, Retrofit, Demolition

There are two clear options for reducing the emissions of poorly-performing buildings: refurbishment of the space to a higher standard or demolition and replacement with a better performing building. Non-residential buildings are subject to the latter of these options more than dwellings due to higher rates of ownership changes. This study assesses the carbon emissions of each of the above options for a poorly-performing retail building in Sheffield, UK. The embodied carbon and operational performance of each scenario are calculated to identify the most sustainable option over a 50 year lifespan. The scenario with the lowest emissions is found to be a retrofit case study relying upon electricity as its sole fuel source. The new build scenarios emitted significantly more carbon over the building's lifespan despite performing better operationally than the refurbishment scenario.
It was also found that, due to the decarbonization of the national grid, relying on gas boilers instead of electric fuel sources would make carbon emissions approximately 2.5x bigger in the refurbishment model, despite being legal under UK building regulations.

s.3.17

GMIT and the Systematic Environmental Assessment of Secondary Materials

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Keywords: Secondary Materials, Urban Resource Centres, Simplified LCA Integrated to a Digital Inventory Tool, Open Source, Idemat, Online Catalogue

This article reviews the development of a digital inventory tool developed specifically for secondary material markets. Unlike other available inventory tools, this tool aimed at including environmental assessment features, that would allow warehouse managers to have an estimation of their environmental contribution associated to their sales performance without having to engage environmental experts regularly. The resulting open source software allows to keep an inventory of items available at the warehouse, export to an online shop and generate reports of the sales and environmental benefits of reusing some of the secondary materials sold. This article explains how the tool was developed, how the simplified LCA calculations were done and integrated to the tool, the difficulties encountered when compromising ease of use with the need for reliable data to do the environmental calculations, and reflects on the reliability and scalability of the developed tool.

s.4 Building Stock I – Refurbishment and Retrofitting

s.4.18

Reno-DM: A Knowledge Model to Support the Decision-Making Process in the Context of Residential Building Renovation Projects

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Keywords: Decision-Making, Building Renovation, Knowledge Representation, Ontology

The decision-making process to select solutions in residential building renovation projects is a complex task. These projects encounter rigid governance and ownership structures, participation of multiple stakeholders, diverse requirements, and a lack of consensus regarding methodologies and tools used within the decision-making process. Addressing some of these challenges requires a shared understanding of this domain. Therefore, this paper presents the Renovation-Decision-making (Reno-DM) model mapping key knowledge from the decision-making in renovation projects. It considers project characteristics, context information, building features, and their relation to aspects of the decision-making itself. The development of the Reno-DM model relies on an existing decision-making representation and the extraction of new concepts from interviews with stakeholders taking part in renovation projects and related literature. The interviews are analyzed following an inductive content analysis approach. The Reno-DM model is developed in the form of an ontology. It provides a basis from which future knowledge management and reuse applications can be developed and deployed to support improvements in the decision-making process in the renovation field.

s.4.19

Investigating the Role of Emissions Deriving From User Transport in Sustainable Refurbishment Strategies for Buildings Relying on Low-Carbon Energy

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Keywords: Building Stock, Built Environment, Travel-Induced Emissions, Location, Institutional Buildings, Municipality

Refurbishing existing buildings constitutes a significant role in reducing emissions from the built environment. Their optimization simultaneously demands time to the urgency to fulfill the sustainable development goals 9, 11, 12, and 13. Therefore, actions taken at the municipal level are deterministic for future outcomes as many municipalities manage large building portfolios and thus hold significant mitigation potential. This paper investigates the role existing institutional buildings have for greenhouse gas abatement when the scope is expanded from building scale to include the urban environment. The aim is to determine the importance of considering the location of buildings when evaluating refurbishment strategies. There is a potential for a more significant reduction of emissions when including user transportation. The role of travel-induced emissions from users, visitors, and employees in institutional buildings is potentially more critical than refurbishment for buildings already operating on low-carbon energy. Parts of a previously developed theoretical framework are tested to aid a Norwegian municipality in its emissions abatement strategy. The study assesses the carbon emissions deriving from refurbishment and the location of an institutional building. Inventory data from building, transport routes, and transport modes are assessed with a case study approach, while generic data derives from literature. The result indicates the importance of addressing locations of institutional buildings within the urban form rather than optimizing separate entities. Truncation errors can offset the benefit of building optimization in areas dependent on low-carbon electricity if travel-induced emissions are omitted from the assessment. The framework reveals that it is better to build a new building at another location in some instances when transport-related emissions are reduced.

s.4.20

Building the Future Using the Existing Building Stock: The Environmental Potential of Reuse

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Keywords: Circular Economy (CE), Life Cycle Assessment (LCA), Reuse, Construction and Demolition Waste (C&DW), Embodied Greenhouse Gas Emission (EG)

Immense amounts of natural resources are consumed and processed by the construction sector every year resulting in a significant climate impact. In return, the resource and environmental value of these resources is lost due to the vast amounts of construction and demolition waste (C&DW) that is down-cycled. Thus, the potential of transitioning the construction sector from a linear to a circular economy (CE) is expected to be significant. In Denmark, C&DW make up 40 % of all waste. Although 88 % of the C&DW is recycled, only 36 % is upcycled (i.e., recycled with an equal or higher quality than the original resource), while 52 % is down-cycled (e.g., crushed for road filling). More recently interest in direct reuse has increased, as a better way of exploiting the remaining technical service life of the materials and retaining the inherent value of the materials and avoiding environmentally heavy material processing. In coming years, a large number of homes on Denmark's 'ghetto list' (i.e., socio-economically disadvantaged residential areas) corresponding to 1,360,300 m^2 are to be demolished. At the same time, a large number of new buildings is to be built in the same affected areas. The Resource Block project seeks scalable reuse solutions that can link the large amount of resources in the existing buildings to be demolished with the need for resources to build the new buildings in these areas. On the basis of a life cycle assessment (LCA), the paper at hand assesses the environmental benefit of the reuse solutions found from the Resource Block project. The results show that reuse of these elements may on average potentially save 49 % of the new buildings' greenhouse gas emissions compared to building solely with virgin materials depending on the availability and degree of reuse and which types of virgin materials the reuse is combined with.

s.4.21

Drivers and Challenges for Implementing Sustainability-Oriented Upgrading in Social Housing in Brazil

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Keywords: Social Housing, Sustainability, Upgrading, Drivers, Challenges, Prioritization

Social housing (SH) development is, in general, triggered by policies and regulations, which stimulate interventions, create financing mechanisms, and designate agents conducive to retrofit processes. European directives for energy efficiency and the recent call for a »retrofit wave« have an evident influence. In Brazil, delivery and management of SH are based on the public offer of housing units and their immediate ownership transfer. National or state housing agencies are responsible for basic maintenance for five years, but other post-delivery interventions depend exclusively on the effort and expenses of the occupant. SH budgets leave little or no margin for extra spending and bringing SH to international sustainability standards is not yet mandatory. The issues that arise to implement upgrading in this context are therefore related to the following questions: What are the prioritized actions in upgrading processes? What type of financing would be required or is available? What is the project execution model and who are the stakeholders involved? This article focuses on the issue of prioritization of actions for upgrading SH. A systematic literature review examined reported sustainability-related housing improvements. A critical review of a Brazilian building label and two international sustainability assessment methods then supported ranking the upgrading actions according to the relevance assigned in their respective contexts. Finally, a panel of construction professionals provided insights regarding the technical feasibility and intrusiveness of their implementation in both single- and multi-family SH projects. Findings show that minor upgrading actions, such as changing hydraulic or electrical fixtures or landscaping, usually do not cost more than implementing them from the beginning and are equally applicable to single- and multi-family SH projects. But, when high-level (deep upgrading) interventions are on the table, costs rapidly increase due to the need to substantially change existing systems or supporting structures, which makes them often financially and/or technically unfeasible.

s.4.22

New Angles for Adaptive Building Reuse Research

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Keywords: Suggesting New Approaches for Adaptive Building Reuse Research Through Literature Review and Evaluation, Embodied Carbon, Building Lifespans, Sustainability

This paper seeks to establish the current state of research into adaptive building reuse with the view to highlighting new approaches and opportunities for expanding the collective knowledge on this subject. This approach focuses on appraisal and evaluation of current methods by looking through a structural engineering lens and considering the most beneficial options in terms of reducing additional embodied carbon intensity in our built environment.

s.5
Building Stock II – Refurbishment and Retrofitting

s.5.23

Exploring Long-term Building Stock Strategies in Switzerland in Line With IPCC Carbon Budgets

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Keywords: Carbon Budgets, Building Stock, Carbon Targets, Emissions, Mitigation

Stringent limits and reduction strategies paths on greenhouse gas (GHG) emissions are being defined at different levels for long-term temperature stabilization. Given the nearly linear relationship between warming and cumulative net emissions, a carbon budget approach is required to limit global warming, as stated by the IPCC. In this setting, the built environment, as a cross-sectorial and transnational area of activity, plays a crucial role in today's carbon emissions and future reduction potentials. Previous research showed the need for effective and aligned carbon-targets to support and guide all actors in the construction sector towards these challenging global goals. In this context, previous research compared top-down derived carbon budgets for the Swiss built environment with a preliminary estimation of future cumulative emissions of the sector. Findings showed the misalignment of current best practices and the significant magnitude of effort that would be required to comply with such objectives. Nevertheless, limitations in the preliminary work emerged, such as the lack of dynamicity of the parameters included in the model restricting the representativity of its results. The current paper brings further this previous work by integrating the dynamic evolution of the energy supply, the materials' production, and the renovation rate. Results are then presented by means of a parallel coordinate interactive graph. This interactive component allows the parametric exploration of the compliance with limited global budgets by varying the input parameters. This way, the influence of macro-level strategies to decarbonize the Swiss building stock can easily be visualized with reference to the IPCC carbon budgets. Ultimately, the available interactive tool might support policy makers in decisions taken at the building stock level.

s.5.24

Life Cycle GHG Emissions of the Austrian Building Stock: A Combined Bottom-Up and Top-Down Approach

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Keywords: Building Related Emissions, Life Cycle Assessment, Input-Output Based LCA, Process-Based LCA, Building Stock

Construction and operation of buildings are responsible for 37 % of global greenhouse gas (GHG) emissions. In contrast, the Austria's National Inventory Report attributes a mere 10 % of national emissions to buildings – including only direct operational emissions of residential and service sector buildings. This narrow definition of the buildings sector neglects important environmental hotspots attributable to building-related life cycle emissions and calls for a comprehensive analysis of GHG emissions of Austrian buildings. In this study, we assess annual building related GHG emissions for the Austrian building stock from a full life cycle perspective (i.e., including operational and embodied emissions). For embodied emissions, we model emissions using both a process-based and an input-output based life cycle assessment (LCA) approach. Building LCA case studies and statistical building stock data are used to estimate embodied emissions from a bottom-up perspective, which are complemented by estimated emissions from the input-output based LCA approach. Our work illustrates the importance of adopting a life-cycle perspective on building-related emissions to inform the different stakeholders and advance climate action in the built environment. While both the chosen system boundaries and methods significantly determine the results, we argue that emission reduction measures should be based on a comprehensive system boundary of building-related emissions to contribute towards the achievement of a climate-neutral built environment and the stringent climate targets. By adding indirect emissions and non-residential buildings to the officially reported building emissions, the operational emissions alone increase by a factor of 2.4. As expected, the process-based LCA yields lower embodied emissions than the input-output based approach. Depending on the method, they can be responsible for up to 40 % of total buildings related emissions. Summing up, total buildings related emissions rise by a factor of 3 to 4 when extending the system boundaries to comprise the whole area of action buildings, and go from 7 Mt CO_2-eq/a (direct operational emissions, 10 % of national emissions), to 22-31 Mt CO_2-eq/a for the case of Austria.

s.5.25

Enhanced Productivity for the Future of Retrofitting

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Keywords: Productivity in Construction, Roof Retrofitting, Panel Insulation, Process Improvement

With the growing effects of climate change, it has become of great importance to reduce emissions from the building stock. Climate friendly retrofitting of dwellings has emerged as an important role since then. Based on a case study in the Netherlands and scientific research on the associated processes, it is concluded that the state of the current retrofitting process is not productive enough to meet European climate goals. To satisfy the increasing need for retrofitting, the Axiomatic Design Method is used to track down the key findings to improve the output of the retrofitting process from a holistic perspective. The aim of the research is to contribute to increase the current output of 50.000 residential retrofits per year by 300 % for the Dutch construction industry. The results give opportunities for improvements that should be made within the process, product, and regulations in the industry. The elimination of manual labor in roof renovation is the finding that has the greatest impact on process productivity. In addition, the changeover of the process has an impact, whereby scaffolding, fall protection and weather no longer have an influence or are no longer required. It can be stated that efficiency could be significantly increased with low manual labor roof retrofitting.

s.5.26

Comparison of Building Thermography Approaches Using Terrestrial and Aerial Thermographic Images

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Keywords: Building, Digitalization, Life Cycle Assessment, LCA Tools

Thermography is commonly used for auditing buildings. Classical manual terrestrial thermography records images of individual buildings at a short distance. When auditing a large number of buildings (e.g., whole city districts) this approach reaches its limits. Using drones with thermographic cameras allows images to be recorded automatically from different angles, with faster speed and without violating property rights. However, an airborne camera has a significantly greater distance and more varied angles to a building compared to terrestrial thermography. To investigate the influence of these factors for building auditing, we perform a study evaluating seven different drone settings of varying flight speed, angle, and altitude. A comparison is drawn to manually recorded terrestrial thermographic images. While we find that a flight speed between 1m/s and 3m/s does not influence the thermographic quality, high flight altitudes and steep viewing angles lead to a significant reduction of visible details, contrast, and to falsified temperatures. A flight altitude of 12 m over buildings is found to be the most suitable for the qualitative and quantitative analysis of rooftops and a qualitative analysis of façades. A flight altitude of 42 m over buildings can only be used for qualitative audits with little detail.

s.5.27

BTPFlux: A Building Material Flow Analysis Model to Enhance the Urban Metabolism on French Territories

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Keywords: Building Stock, Material-Flow Analysis, Construction Sector, Circular Economy, Material Building Stock

Worldwide, the construction sector is the principal consumer of raw resources (50 % of the natural resources) and the leading producer of solid waste (2.2 billion tons per year). Because of their quantity and their potential for development, construction wastes constitute a catalyst for establishing strategies and action programs aimed at making the management of resources circular at several territorial scales. Performing these strategies needs a detailed and structured knowledge of flows. In this context, the CSTB has developed a macro-component bottom-up-based model: BTPFlux, that aims to characterize the materiality of the building stock and the associated demolition, and renovation waste flows. A national database with generic information for every building on the metropolitan French territory was used. This database gathers information such as the surface, the typology, or the year of construction of the buildings and is then linked with a specific database characterizing existing construction products. This method provides a detailed characterization of the building material stock available on the French metropolitan territory. So, the environmental impacts, the treatment costs, and the valorization potentials can be estimated by implementing different management scenarios for each category of waste assessed. The model was already successfully applied to the »Ile de France« region and can be replicated to any other French territory. The results will allow the stakeholders to better understand the materiality of their territory, giving them the possibility of making optimal decisions to implement the reuse and recycling of secondary resources. However, some improvements can still be made in the description levels of macrocomponents or in the description of infrastructures that BTPFlux does not currently model.

s.6
Buildings – Urban Timber Construction

s.6.28

Fringe Timber: Informing Regional Mass Timber Urban Environments with Biodiverse Forests

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Keywords: Mass Timber, Biodiversity, Resource Management, Case Studies, Renewable Materials

Trees present a vast array of performance in density, growth speed, height, fibre strength, and rates of carbon absorption. This paper begins by exploring how biodiverse mass timber is not only a way to support an emerging pluralist point of view about the forest, but also to improve the health conditions of the most vulnerable and those who have experienced the pollution of mineral-based materials for generations. This symbiotic relationship between forests and urban environments incentivizes better care of forests to meet a range of tree species' needs. In the project Fringe Timber, a biodiverse supply of mass timber informs regional mass timber urban environments and supports the role of resource pooling in reducing our collective carbon footprint. Using three case studies in New York City, Denver, and Tulsa, this paper posits city-specific, species-driven supply chains beyond softwoods for mass timber, including hardwoods and hybrids, to support the appropriate scale and speed for urban development.

s.6.29

Climate Impacts of Wood/Timber as a Building Material – Investigated on Three Urban Quarters in Germany (CIW)

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Keywords: Climate Impacts of Wood/Timber as a Building Material, Life Cycle Assessment, Timber Construction, Carbon Neutral Buildings, LCA, Timber-Quarters/Holzbauquartiere

Due to the current discussion about the shortage of resources and the excess of greenhouse gas emissions, timber construction is experiencing a renaissance in Germany. As a renewable resource, wood can replace emission-intensive building materials and, if left long-term in the construction, lead to negative balances, i.e., carbon sinks at the construction phase (LCA phase A1-A3). This means that more carbon could be stored in the construction than is emitted during production. This study analyzes different buildings ranging from row houses to high-rise buildings that are envisioned as envisioned as envisioned as envisioned as envisioned as timber construction of three so called timber-quarters (Holzbauquartiere). For all buildings, the current design/construction, a conventional as well as a timber+ construction (maximum possible timber use in construction) variant have been evaluated. The calculations were conducted with eLCA the LCA tool of the Bewertungssystem Nachhaltiges Bauen (BNB) (German Green Building System) and the data sets of the German ÖKOBAUDAT[11]. The results are given per m² gross floor area per user, per building and per neighborhood. The investigations show the importance of the material choice regarding the climate gas emissions of the buildings and how large the proportion of wood must be in order to design the building envelope (KG 300 (cost group for architectural elements) in a climate gas neutral way. Planning parameters for a climate gas neutral design and construction of buildings are derived from the analysis.

s.6.30

CircularWOOD – Towards Circularity in Timber Construction in the German Context

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Keywords: Timber Construction, Analysis, Circular Economy, Prefabrication, Cascade utilization

The circular economy can pave the way to achieve ambitious sustainability goals. A major perpetrator of resource and material waste is the building sector. A lot of research results already provide innovative technologies and solutions for circular construction. However, what many of the circular economy initiatives in the construction sector have in common, is a certain malaise in moving from pilot projects with high individual engagement to actions on a larger scale. Prefabricated timber construction is one of the most promising key technologies towards a more resource efficient Europe. Despite this potential, downcycling or an early thermic utilization is common practice. Valuable resources are wasted and already captured CO_2 is released. The research project circularWOOD aims to provide a better understanding for potentials and barriers in a first step. This paper outlines first findings. Prefabrication and element design facilitate circular construction approaches. The context in which stakeholder implement circular construction approaches is widened. A wide range of economic and ecological aspects is supplemented with cultural, political, and regulatory conditions. Under the premise of reuse with a minimum of necessary adaptation, structural aspects are evaluated. The results show a current concentration on new construction with easy-to-implement design approaches. Further efforts towards strategies for the reuse of existing construction and experiences to facilitate the diffusion within the timber construction sector are required.

s.6.31

Benefits of Wooden Structure Reuse: The Case of an Austrian Building

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Keywords: Wooden Construction, Life Cycle Assessment, Circular Economy, Material Flow Analysis, Multi Cycling

The building sector is responsible for 39 % of greenhouse gas (GHG) emissions; thus, it has a significant amount of potential to reduce the effects of climate change. Several active- and passive solutions and strategies have been developed and proposed in the literature. Among them, wood is highlighted as a promising solution to minimize GHG from buildings. However, the benefits, especially in the circular economy, are not fully evaluated due to methodological choices. Motivated by this knowledge gap, this article aims to evaluate the benefits of wood reuse compared to traditional building construction solutions. For this purpose, we have calculated the environmental impacts of a building situated in Graz, Austria. Four different scenarios are considered. The first scenario is a fully reinforced concrete building. The second scenario is a structural beam-column made from reinforced concrete with walls made of concrete blocks. The third scenario is a beam-column made from reinforced concrete with external walls based on clay blocks. Finally, the last scenario is a full wooden building. Following the standardized life cycle assessment (LCA) method, global warming potential (GWP) is calculated through a 0/0 approach. These evaluations were made possible by correlating the impacts released from producing wooden elements and the uptake of biogenic carbon from the forest. Without considering the possibility of material reuse, the wooden structure has a 5 % lower GWP value than the reinforced concrete building. Comparatively, the other building scenarios have almost similar impacts as the building in reinforced concrete. In the case of material reuse, the wooden structure building shows potential to develop projects with 44 % less environmental impact.

s.7
Sufficiency

s.7.32

Designing Sustainable Oce Spaces: How to Combine Workspace Characteristics With Sufficiency Strategies

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Keywords: Sufficiency in Construction, Conceptual Framework, Sustainable Workspaces, Sufficiency Principles, Development Strategies

Contemporary workspace and office concepts are part of many major commercial real estate projects and have been continuously developed over many years. With a rising awareness for sustainable development, workspace and office concepts are increasingly being considered in terms of their environmental performance. Sustainable design strategies therefore traditionally differentiate between efficiency, consistency, and sufficiency, whereas the latter approach is the least explored in the construction industry. Sufficiency can be described by a user behavior characterized by frugality and modesty, as opposed to wasteful consumption. Moreover, the strategy of sufficiency is linked to a high and critical awareness of using natural resources and environmental impacts which also affects the built environment. The aim of this paper is therefore to combine these two subject areas in a structured way and derive potentials for the sufficient development of office concepts.
Based on a literature review in the field of workspace design and flexible workplace management, design features of office spaces are conceived and compiled according to planning aspects in office concepts based on employee needs. Another literature review in the field of sufficiency in the building sector provides the corresponding structure for the considered sufficiency strategies. Sufficiency measures follow recurring principles for the reduction of resource consumption. Essential principles of impact are identified and presented in this paper. The investigated topic areas are compiled together in a logical model based on a developed mapping framework. This forms the basis for defining sufficient measures that can be derived to sufficiency strategies in the project development of office buildings. The basis of all measures is to strive for a minimum level of resource consumption that is necessary to satisfy the needs of the users and that is considered valuable by them, following the basic idea of the sufficiency approach. The results are validated using an office building in the planning stage. The paper leads to a common understanding and structuring of design features of future office spaces and their environmental impact. Furthermore, the approach provides guidance for concepts on how design features can be considered regarding sufficiency strategies.

s.7.33

Sufficiency as a Criterion for Sustainability Assessment

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Keywords: Sustainability Dimensions for Sufficiency Measurement in Sustainability Assessment for Buildings, Sufficiency, Sustainability Assessment, New European Bauhaus

Key instruments of the German sustainability strategy for federal buildings are the »Guideline for Sustainable Building« (LFNB) and the 'Assessment System for Sustainable Building' (BNB). Based on the three pillars of sustainability (ecological, economic and social dimensions) and expanded by building related cross-sections (technical, process and location), sustainability research is opposing sustainability strategies of consistency, efficiency, resilience and in particular sufficiency. Likewise, the New European Bauhaus (NEB), initiated by the EU-Commission in 2021, acknowledges the recognition of the finite nature of resources and introduces the term sufficiency as a relevant aspect. This requires a consistent rethinking of the way we plan, construct, and operate buildings. However, sufficiency is often not or only partially addressed in sustainability assessments. The available research points towards a necessity to rethink the classic pillars of sustainability. Sufficiency should not be seen as relinquishment, but the basis for a successful efficiency and consistency implementation.

Up to now, the environmental impacts of buildings have usually been determined and evaluated as area-related parameters, omitting saving effects of area reduction. This paper proposes a reconsideration of reference values and evaluates possibilities for a BNB system integration of sufficiency criteria. The investigation does not aim to determine specific valuation criteria, but outlines possible locations for adaptation or inclusion within the pillars of sustainability.

s.7.34

Mitigating Climate Change Through Healthy Discomfort

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Keywords: Thermal Comfort, Health, Mechanical Ventilation

Amid the climate change and the worldwide catastrophes, witnessed on a daily basis, we find ourselves in a time in which we need to start justifying any recourse and energy consumption, at least of which is not truly renewable. While the outside temperatures become more extreme, the inside environment becomes more relevant. The way we design and operate our buildings is directly influenced by current building standards and as we spend almost all our time indoors, our comfort, wellbeing and health are crucially affected by such. The last five decades have seen many approaches in establishing guidelines for a comfortable indoor environment. But while current standards favor the narrow temperature ranges of static homogeneous environments, they have been criticized for their high energy consumption and long-term health implications. The paper compares a typical office space with mechanical cooling with that of a passive strategy, by evaluating the energy consumption and health over comfort. The results show a 64 % cooling potential within the mechanically cooled scenario as well as the passive strategy complying to standard without any cooling energy.

s.7.35

Effect of Neighborhood Courtyard Design on the Outdoor Thermal Comfort in a Tropical City

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Keywords: Outdoor Thermal Comfort, ENVI-Met Simulation, Courtyard Landscape, Tree Coverage, Shading

In the tropical city of Ha Tinh (Vietnam), the number of new developed neighborhoods in the courtyard layout is increasing while the city is experiencing annual severe heat stress. The paper quantitatively analyzes, by means of ENVI-Met simulation, the effect of neighborhood courtyard landscape on the outdoor thermal comfort (OTC) in the tropical city of Ha Tinh (Vietnam). A sample 9-ha residential block was at first experimentally configured with four scenarios of courtyard, including (1) bare grass and perimetry location of high plants, (2) grass ground, fully occupied high trees, (3) water body and surrounding location of high plants, and (4) mixed ground surfaces of water, hard pavement and grass, and partly occupied high trees. The adding of tree canopies to the entire courtyard, consequently sufficient shades, as in case 2, contributes to the better OTC among the chosen scenarios by triggering the reduction of mean radiant temperature (Tmrt) (2.9oC) and physiological equivalent temperature (PET) (3.5oC) at the hottest hours as compared to the original configuration (case 1) during the summer days. Application of perimetry plants with either water (case 1) or bare grass (case 3) results in higher PET though full occupation of water body lowers the air temperature by roughly 1oC. The limited impact on OTC of local water body is counter-intuitive, yet important result to the practice of urban design. The worst OTC was observed in case 4 where almost half of the garden was sun-exposed and intended for hard-paved playground and water body. Increasing shades against solar radiation is the most important measure to deal with intensive heat problem. The study is an essential part of translating academic knowledge on urban climate into interventions on urban design for better climate resilience of neighborhoods in Vietnam and by extend in other tropical countries.


55

s.8
Critical Digitalization

s.8.36

Measuring the Cityscape: A Pipeline from Street-Level Capture to Urban Quantification

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Keywords: Building Stock, 3D modelling, Street-Level Capture, Computer Vision

Any solution to achieving climate targets must be performed at scale. Data driven methods allow expert modeling to be emulated over a large scope. In the UK, there are nearly 30 million residential properties, contributing to over 30 % of the national energy consumption. As part of the UK Government's requirement to meet net-zero emissions by 2050, retrofitting residential buildings forms a significant part of the national strategy. This work addresses the problem of identifying, characterising and quantifying urban features at scale. A pipeline incorporating photogrammetry, automatic labelling using machine learning, and 3-D geometry has been developed to automatically reconstruct and extract dimensional and spatial features of a building from street-level mobile sensing.

s.8.37

Piezoelectric Textile Facade for the Energy Supply of Active Sensor Technology With Regard to Data Management for Circular Economy in Building Construction

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Keywords: Facade System, Concept Development and Tests, Circular Economy, Construction Technology, Piezo Technology

The high GWP potential of construction requires a holistic approach such as circular economy. Currently, common joining, construction and planning practices result in heterogeneous assemblies of different components that are difficult to deconstruct. Furthermore, there is currently little information and data on building components used and the climatic impacts on them. In this context and with the intention of recording long-term (circular) processes in construction, the Piezo-Klett basic research project (FFG no. 879459) funded by the Austrian Research Promotion Agency (FFG) deals with the energy supply of active sensor technology in construction by combining the hook and loop fastener with piezoelectric components. The aim is to open new perspectives on sustainable energy production systems by transforming buildings into energy carriers and generators, analogous to a »battery«. To this purpose, the result presented in this conference paper is a description of the constructive structure (climatic impacts, construction, piezo technology) of a »Piezoelectric Textile Facade«, as well as test results on piezo tapes. This opens new possibilities in the context of the application of hook-and-loop fasteners, the energy supply of active sensor technologies as well as in the field of data acquisition and data management.

s.8.38

Deep Multimodal Learning for Residential Building Energy Prediction

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Keywords: Residential Building Energy, Deep Multimodal Learning, EPC, Google Street View

The residential sector has become the second-largest energy consumer since 1987 in the UK. Approximately 24 million existing dwellings in England made up over 32 % of the overall energy consumption in 2020. A robust understanding of existing buildings' energy performance is therefore critical in guiding proper home retrofit measures to accelerate towards meeting the UK's climate targets. A substantial number of predictions at a city scale rely on available data, e.g., Energy Performance Certificates (EPCs) and GIS products, to develop statistical and machine learning models to estimate energy consumption. However, issues with existing data are not negligible. This work adopted the idea of deep multimodal learning to study the potential for using Google Street View (GSV) images as an additional input for residential building energy prediction. 20,031 GSV images of 5,933 residential buildings in central Barnsley, UK, have been selected for a case study. All images were pre-processed using a state-of-the-art object detection algorithm to minimize the noise caused by other elements that may appear nearby. Building specifications that cannot be easily determined by the appearance are extracted from existing EPC information as text-based inputs for prediction. A multimodal model was designed to jointly take images and texts as inputs. These inputs are first propagated through a convolutional neural network and multi-layer perceptron, respectively, before being combined into a connected network for final energy prediction. The multi-input model was trained and tested on the case study area and predicted an annual energy consumption with a mean absolute difference of 0.01kWh/m² per annum on average compared with what is recorded in the EPC. The difference between the predicted results and the EPC may also provide some hints on the bias the certificates potentially contain.

s.8.39

Suggestions for Solution Space Exploration in the Early Stage of Architectural Design Based on a Literature Review

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Keywords: Buildings, Early Design, Design Space, Decision Support, Interactive Exploration

Early design decisions have higher potential to influence building performance compared with the decisions made at later design stages. Performance simulation and optimization algorithms have been integrated to assist early design in reducing carbon emissions, improving indoor thermal comfort, etc. However, early decision making within a limited time frame is still challenging due to the large number of design options, the lack of decision-making guidance, and the trade-offs among various requirements. Selecting appropriate methods to explore design space is the key to find an ideal solution. This paper reviewed the challenges and identified the key questions to access the ability of existing decision-making methods to cope with different challenges. It is concluded that the interactive exploration of design space could be more effective and efficient by (1) combining the surrogate models and the automated optimization algorithms to improve the efficiency of the building performance calculation and the optimal design space position; and by (2) extending the optimal design space to increase the solution diversity, and (3) filtering the near optimal design space with consideration of the stakeholders' preferences and values. Further integration of tools for building performance simulation, diversity description and decision - making guidance is needed to support the decision-making process.

s.8.40

Stochastic Solar Irradiance from Deep Generative Networks and their Application in BIPV Design

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Keywords: Urban Solar Potential, Data-Driven Model, BIPV, GAN, VAE

Building Integrated Photovoltaics (BIPV) is a promising technology to decarbonize urban energy systems via harnessing solar energy available on building envelopes. Nevertheless, handling the trade-off between effort, speed and spatial-temporal resolution for 3D BIPV solar potential evaluation in a complex urban context has always been a challenging task. Existing physics-based solar simulation engines require significant manual modeling effort and computing time to obtain high-resolution deterministic results. Yet, solar irradiation is highly intermittent and representing its inherent uncertainty may be required for designing robust energy systems. Targeting these drawbacks, this paper proposes a data-driven model based on Deep Generative Networks (DGN) to efficiently generate high-fidelity stochastic ensembles of annual hourly urban solar irradiance time-series data with uncompromised spatial-temporal resolution at the urban scale. It requires only easily accessible data inputs, i.e., simple fisheye images as categorical masks, such as captured from Level of Details (LOD) 1 urban geometry models. Our validations exemplify the high fidelity of the generated solar time series when compared to the physics-based simulator. To demonstrate the model's relevance for urban energy design, we apply it to the resilient design of a district multi-energy system (MES) with several hundreds of BIPV surfaces. Furthermore, we showcase the models' potential for generative design by parametrically altering the urban environment and producing corresponding irradiation time-series in real-time.

s.8.41

Automatic Verification of Urban Index Compliance: A Case Study for Brazilian Buildings

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Keywords: BIM, Automatic Code Compliance, Computer Design, Urban Index

Urban planning has become an essential tool for regulating the cities' growth, maintaining the local urban identity and providing a good quality of life for its inhabitants. In Brazil, the master plan is the primary policy instrument for urban development and expansion. It defines the common requirements that designers must follow when preparing building projects. Up to date, such projects are verified in a project's latter stages and eventually approved by the city halls, with a manual calculation and assessment process. This procedure creates both the need to assess project compliance earlier to avoid rework and changes, as well as to automate project verification compliance, to reduce human errors. The emergence of new technologies and computational systems, such as Building Information Modeling, creates the opportunity for process automation by providing the required data to support decision-making. It also creates the opportunity to automate the calculation process for both designers and municipalities. Thus, this research aims to develop an assessment procedure which automates the compliance assessment of a set of urban requirements from Vila Velha, Brazil. A BIM model was developed in Autodesk Revit to prove the procedure functionality and Dynamo was used to automate data collection and the calculation of three different indexes from Vila Velha's building code. By providing a fast and reliable analysis, the research framework provides designers with a realtime decision support tool, which indicates building compliance in the project's early stages. It also provides municipalities with a calculation tool, which can be used to assess the compliance of submitted BIM models, sparing time and avoiding assessment errors. Overall, the procedure has the potential to support building project design, increase process efficiency and accelerate the verification of mandatory requirements. It also offers the possibility for replication by adapting the routine to the mandatory requirements of each location.

s.9
Optimization

s.9.42

Optimizing the Balance Between Flexibility and Structural Mass for Lower Short- and Long-Term Embodied Carbon Emissions in Mass Housing

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Keywords: Embodied Carbon, Structural Mass, Flexibility

The building construction industry is one of the largest contributors to global greenhouse gas emissions. One solution to reduce the industry's carbon footprint is to design structures efficiently, thus using less structural mass. However, over-designing is a fundamental aspect of flexibility; a building's capacity to make physical changes in the future – which is key for domestic buildings in particular. It is therefore important to strike a balance between structural efficiency and high flexibility, to limit both short- and long-term embodied carbon emissions.
This balance was investigated using a mass housing case study, creating a series of design iterations to explore the trade-off between flexibility and structural mass. An optimum solution illustrated that this case study can be redesigned to have double the flexibility, lower structural mass, and less carbon-intensive materials. Therefore, this research concluded that it is possible to significantly reduce the short-term embodied carbon emissions of this housing design, whilst simultaneously reducing long-term emissions too. Although these findings might be specific to this case study, the duplicate nature of mass housing means that the carbon savings of this one housing design can be multiplied many times across a whole development. Applying this research to other mass housing designs could significantly reduce the embodied carbon of future developments and improve the carbon footprint of the building construction industry.

s.9.43

An Integrated Form-Finding and Automated Fabrication Approach for Exploring Sustainable Shell Structures

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Keywords: Shell Structures, Thrust Network Analysis, Computational Design, Flexible Formwork, Wasted Materials, Sustainable Construction

Latest advances in computational design and automated fabrication provide opportunities for form-finding and precise development of shell structures in an integrated design to fabrication context. Implementation of these techniques cannot be completed without considering the negative effect of construction in the environment and the urgent need for environmental impact reduction through reusability and recyclability. This paper deepens into this direction by presenting a form-finding/automated fabrication approach of shell forms in combination with a recycle material implementation. The process starts by examining form-finding possibilities of funicular forms by producing a series of case studies based on a number of controlled parameters, physical attributes and static performance criteria. Then, an alternative use of construction materials is presented, in order to achieve sustainable properties, and adequate static performance of both, the overall structure and the individual structural components. In order to achieve this, cylindrical samples of different recycle material combinations are produced, tested under compression and their implementation is discussed. The suggested integrated form-finding to automated fabrication approach offers the opportunity for a holistic sustainable approach towards shell structures development, aiming at shape and performance viability through the selection of recycle materials.

s.9.44

The Cost-Optimal Optimization of Public Buildings in Cold and Warm Climates: Two Case-Studies in Germany and Italy

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Keywords: Cost-Optimal Analysis, Building Simulation, Energy Refurbishment, Office Buildings, Multi-Objective Optimizations

Directive EU 844/2018, in the matter of energy performance of buildings and future goals of energy efficiency for the EU Member Countries, extends the standard of nearly zero-energy building goals to the existing building stock, with the mandatory aim of almost complete decarbonization of the whole sector within 2050, and thus a strong reduction of greenhouse gas pollution of about 80-95 % compared to the levels of '90s. In this frame, the present study purposes the multi-objective optimizations of two office buildings, located in Berlin (Germany, European backcountry, »Cfb« climate in the classification of Köppen and Geiger) and Naples (Italy, Mediterranean coast, »Csa« climate classification), with the aim of finding the best trade-off between two couples of contrasting targets, representative of private and public interests, respectively: minimization of indoor thermal discomfort and operational costs, and minimization of indoor thermal discomfort and environmental impact. In addition, an investment cost analysis is performed by optimizing operational costs and total construction costs. The explored and investigated energy conservation measures, to apply during the building retrofit, involve the main levers of energy efficiency, and thus the building envelope, and the active energy systems. The results underline that the cost-optimal energy measures to apply during the building refurbishments deeply differ based on the building usage, the intensity of required indoor comfort, and depending on the climatic peculiarities and building construction technologies.

s.9.45

Clustering Strategies for Defining Archetypes to Support Integrated Simulations of Environmental Impacts

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Keywords: Neighborhood LCA, Hybrid Modeling, Clustering, Benchmarks, Data Gap Filling

Life cycle assessment (LCA)'s inherent data-intensiveness hampers application to neighborhood environmental assessments, particularly for built stock modeling. Data collection can be reduced to a manageable amount by grouping a large number of buildings into a limited set of aggregates with similar characteristics and defining exemplars (archetypes) that represent each group. LCAs would be performed for the archetypes only and their results extended to the represented buildings. As archetype definition is seldom detailed in the literature, this paper tests, and details different procedures that could enable neighborhood LCAs. K-medoids and CLARA partition algorithms, as well as agglomerative hierarchical clustering techniques, were applied to group over 300 buildings into a limited number of clusters. A building representative of each cluster was identified to proceed to bottom-up LCA. K-medoids clustering stands out for the quality of clusters and their representatives. Restraining the maximum number of clusters to keep subsequent LCA work manageable imposes some quality loss yet allows for achieving satisfactory division results. Regardless of the clustering technique used, data was best divided the larger the number of clusters used was for the various factors in the database depicting the studied area resulted in several possible data combinations. Although detailed representation is desirable in LCA modeling, limiting the number of variables facilitates data pre-treatment and an optimal balance should be pursued in future studies.

s.9.46

Smart Logistics for Urban Construction Sites (CCC)

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Keywords: Construction Logistics, Case Study, CCC, Kitting, Sustainability

The traditional construction logistics is managed in silos, which leads to time losses on sites and increased project costs due to repeated handling/moving of materials. Moreover, these uncontrolled flows of deliveries also have a proved environmental impact. Alternative approaches intend to centralize these flows using a Construction Consolidation Center (CCC), which allows to deliver material just-in-time as a kit, directly at the workplace. The purpose of this research is to evaluate if this supply chain management methods can drive the construction sectors towards more efficient and sustainable practices. Therefore, this paper describes, from the General Contractor's perspective, the implementation of a CCC between 2019 and 2020 for a Residential Tower project, for the first time in Luxembourg. Increased productivity, reduced costs, and reduced carbon footprint of the transportation flows were observed based on measures throughout the entire project. Beyond these evidences that more sustainable practices are achievable in construction, the paper discusses adherence of workers and subcontractors, as well as organizational and technological prerequisites and perspectives. Accordingly, this collaborative model appears as a relevant way to build and strengthen partnerships between the construction stakeholders by improving day-to-day work. Therefore, CCC and kitting appear as a practical solution for the current economic and environmental challenges and more awareness should be put on this topic to allow its diffusion to the whole sector.

s.10
Climate Neutral Buildings I – GHG Reduction Strategies

s.10.47

FutureBuilt Zero: A Simplified Dynamic LCA Method With Requirements for Low Carbon Emissions From Buildings

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Keywords: Building, LCA, Low Carbon, Dynamic Factors, Emission Intensities

FutureBuilt is a voluntary program for ambitious low-carbon construction projects. To incentivize measures that lead to the lowest climate change impact from all aspects of buildings and according to national Paris agreement pledges, FutureBuilt Zero introduces an ambition level and a novel calculation methodology for net climate change impacts over the life of a building. The ambition level is tightened over time to help Norway achieve its climate goals. A comprehensive simplified calculation method is introduced, which considers how the timing of emissions during the building life affects the contribution to global warming. Both direct and indirect emissions throughout the lifetime are included; energy use in operation and at the construction site, material production and transport of materials to the construction site, and waste management (incineration). In addition, the climate-positive effects of biogenic carbon uptake, carbonation of cement, potential for future reusability, and exported energy are included. This paper presents the criteria, describes the method and the scientific basis as well as the principles and logic behind the choices made.

s.10.48

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Keywords: Single Family House, CO_2 Sustainability Assessment, Energy Exchange, Dynamic Building Simulation, Energy System Analysis

Plus Minus Zero: Carbon Dioxide Emissions of Plus Energy Buildings in Operation Under Consideration of Hourly German Carbon Dioxide Emission Factors for Past, Present and Future

The energy supply of private household buildings accounted for 16 % of the total German CO_2 emission in 2020. To fulfill the targets of a climate neutral building sector in 2045, both, energy efficiency as well as on-site use of Renewable Energies in buildings are needed. One concept of a climate neutral building is the so-called Efficiency House Plus, that features large photovoltaic systems, making it seemingly energy self-sufficient and CO_2-negative by feeding in more electric energy into the grid than needed for its operation on a yearly basis. In fact, houses of this type are highly grid dependent especially during winter months due to their solely electrically based energy supply and a missing long term energy storage. This paper analyzes the CO_2 emission of Energy Efficiency Plus houses more in detail on a timely resolved basis for the German electric supply system of the year 2013, 2021 and a perspective one 2030. An alternative calculation approach for simplified normative evaluation of such buildings is proposed.

s.10.49

A Holistic Perspective on the French Building and Construction GHG Footprint

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Keywords: Emissions Accounting, Carbon Footprint, Input-Output Analysis, Life-Cycle Approach, Climate Policies, Building and Construction

In order to deliver on the Paris agreement, the decarbonization of the building sector is critical. An accurate assessment of its life cycle GHG emissions is essential to identify emissions hotspots and decarbonization potentials in order to prepare future policies such as sectoral carbon budgets. However, today a lack of common GHG emissions accounting exists between climate policies and building environmental assessment. The first one relies on the production-based accounting system of national inventories, while the second one takes a life cycle approach, thus accounting for cross-sectoral emissions. As a result, at national level, there is no holistic assessment of the building and construction GHG footprint, which is detrimental to prepare decarbonization pathways. This research aims to characterise the life cycle emissions of the sector, taking the French case as an example. A thorough analysis of operational direct and indirect emissions as well as embodied emissions allows the identification of emissions hotspot, both at sectoral and geographical levels. The methodology enables an integrated cross-sectoral perspective that is essential for national assessments and future policy interventions. Results show operational emissions represent 65 % of the sector GHG footprint. Embodied emissions are mainly due to industry and energy upstream emissions, with roughly 60 % imported from abroad. The results can help to identify main decarbonization levers to reach net-zero emissions by 2050.

s.10.50

Greenhouse Gas Reduction Strategies for Building Materials: A Reality Check With the Climate Targets

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Keywords: Buildings, Life Cycle Assessment (LCA), Greenhouse Gas Emissions (GHG), Future Technologies, Mitigation Strategies

The increasing importance of the embodied emissions in the life cycle of buildings has led to a growing interest in strategies supporting their mitigation. In this paper are presented the environmental impacts of 10 variants of a single-family house assessed with the life cycle assessment (LCA) method. A set of potential technological improvements and strategies are applied at the material level. Their influence at the building level is discussed and the resulting global warming potentials are compared to the COP21 targets for Austrian buildings. Finally, potential trade-offs in 9 other environmental impact categories are explored. The results show that, when incorporating all of the assessed strategies for emission reduction, the embodied greenhouse gas (GHG) emissions could be reduced up to 87 % at the material level and 50 % at the building level. Carbon capture and storage and the use of bio-based materials are to be credited for the highest share of these reductions. However, there is no version of this building that fulfills the COP21 targets. Other pathways, which do not solely rely on material-related technological improvements, should be investigated. A more radical change of the building industry might even be necessary. Overall, the implementation of the strategies decreased the environmental impacts in almost every impact category, except for freshwater aquatic ecotoxicity.

s.10.51

Development of Sustainable Building Standards: Next Steps Towards Climate-Friendly Buildings in the City of Graz

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Keywords: Building/Constructed Asset, Sustainability Assessment, Case Study, Architectural Competition, Buildings Standards, Sustainable Construction

To make efforts for climate protection in the City of Graz (Austria) as effective as possible, the city has established a climate protection fund, from which the KNB (Klimafreundliche und Nachhaltige Baustandards) project emerged. In the KNB project, a new approach was developed on how the city can already request and implement sustainability criteria for its public buildings in architectural competitions. This paper presents the methodology for evaluating the climate friendliness of building concepts based on the developed form »sustainability and climate protection«. Moreover, an evaluation algorithm for assessing the competing works and ranking the building concepts is presented. To demonstrate the applicability and validate the form and the evaluation algorithm, we applied the procedure to a real architectural competitions. The results show that all participants were able to consider the required aspects and that the external experts for sustainability assessment were able to evaluate the competition works using the developed evaluation algorithm. The City of Graz set the goal to apply this methodology in all further architectural competitions and thereby take a further step towards sustainable procurement of buildings.

s.11
Climate Neutral Buildings II – Benchmarks ZEB

s.11.52

Net Zero Emission Buildings: Next Generation of Benchmarks and Calculation Rules

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Keywords: Buildings, Target Setting, GHG Emissions, Planetary Boundaries, Remaining Budget

The definition of ambitious life cycle-based benchmarks and target values to limit the GHG emissions of buildings is seen as one of the most important steps in pushing the construc-tion and real estate sector in significantly reducing its contribution to global warming. Especially target values are no longer only developed from a bottom-up perspective. There is now an inter-est by governments and sustainability assessment system providers in supplementing bottom-up approaches with science-based top-down approaches as part of their responsibility to respect planetary boundaries. The creation of GHG emission budgets in combination with target values, as well as the introduction of strict enough legal binding requirements already today is critical for achieving a climate-neutral building stock. Achieving these tasks requires tackling still open methodological issues. Following the work of IEA EBC Annex 72 and current developments in Germany, the paper presents main questions, key steps, modeling aspects that can cause varia-tion and uncertainties, as well as clarifies key terms and definitions. It is highlighted that although a net zero emission requirement is a universal benchmark, information on system boundaries and calculation rules are still necessary to provide evidence of its fulfillment.

s.11.53

Next Generation of Life Cycle Related Benchmarks for Low Carbon Residential Buildings in Germany

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Keywords: Residential Buildings, LCA, Benchmarks, GWP, PENRT

Germany's national climate targets are in line with the Paris Climate Agreement and set the ambitious goal of becoming net zero emissions by 2045. The construction and real estate sector play an important role for sustainable development. In a cross-sectoral approach operational and embodied emissions of buildings account for 40 % of GHG emissions in Germany. In order to contribute to climate protection, it is necessary to both pursue a strategy for decarbonizing the national building stock and to develop benchmarks for assessing greenhouse gas emissions in the life cycle of individual buildings. In Germany, benchmarks are used in sustainability assessment systems for more than 10 years to assess primary energy non-renewable (PENRT) and global warming potential (GWP) in the life cycle of buildings. Therefore, these need to be regularly reviewed and further developed in order to (1) adapt them to more ambitious reduction targets, (2) consider the current database, (3) include the state of standardization, and (4) follow the state of scientific discussion on methodological issues. This paper identifies new benchmarks for PENRT and GWP and shows the scale of current levels of performance. These can form the basis for funding programs and contribute to the discussion on the introduction of binding legal requirements.

s.11.54

Existing Benchmark Systems for Assessing Global Warming Potential of Buildings: Analysis of IEA EBC Annex 72 Cases

F N Rasmussen [1], D Trigaux [2], E Alsema [3], M Balouktsi [4], H Birgisdóttir [1], R Bohne [5], M Dixit [6], D Dowdell [7], N Francart [8], D Satola [5], R Frischknecht [9], G Foliente [10], A Lupisek [11], T Lützkendorf [4], T Malmqvist [8], L Ramseier [9], A Garcia Martinez [12], C Ouellet-Plamondon [13], A Passer [14], B Peuportier [15], Z Szalay [16], M Wiik [17], S Seo [10]

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Keywords: Buildings, LCA, Benchmarking, Global Warming Potential

Life cycle assessment (LCA) is increasingly being used as a tool by the building industry and by actors to assess the global warming potential (GWP) of building activities. In several countries, life cycle based requirements on GWP are currently being incorporated into building regulations. After the establishment of general calculation rules for building LCA, a crucial next step is to evaluate the performance of the specific building design. For this, reference values or benchmarks are needed, but there are several approaches to defining these. This study presents an overview of existing benchmark systems documented in seventeen cases from the IEA EBC Annex 72 project on LCA of buildings. The study characterizes their different types of methodological background and displays the reported values. Full life cycle target values for residential and non-residential buildings are found around 10-20 kg CO_2e/m²/y, whereas reference values are found between 20–80 kg CO_2e/m²/y. Possible embodied target- and reference values are found between 1–12 kg CO_2e/m²/y for both residential and non-residential buildings. Benchmark stakeholders can use the insights from this study to understand the justifications of the background methodological choices and to gain an overview of the level of GWP performance across benchmark systems.

s.11.55

Towards Indicative Baseline and Decarbonization Pathways for Embodied Life Cycle GHG Emissions of Buildings Across Europe

M Röck [1,10], K Allacker [1], M Auinger [2], M Balouktsi [3], H Birgisdottir [4], M Fields [5], R Frischknecht [6], G Habert [7], L Hvid Horup Sørensen [5], M Kuittinen [8], X Le Den [5], K Lynge [5], A Muller [2], S Nibel [9], A Passer [10], F Piton [11], F N Rasmussen [4], M Ruschi Mendes Saade [10], N Alaux [10], D Satola [12], A Sørensen [5], M Spitsbaard [13], S Tikka [14], B Tozan [4], B Truger [10], M van Leeuwen [13]; M Vesson [9], A Viitala [15], R Zonnevijlle [16], T Lützkendorf [3]

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Keywords: Buildings, Construction, Data Analysis, Embodied Carbon, GHG Emissions, Benchmarks, Reduction Pathway, Decarbonization, Roadmap

Buildings' construction and operation are major contributors to global greenhouse gas (GHG) emissions, and the substantial reduction of GHG emissions across their full life cycle is required to enable meeting international climate targets. For effective climate change mitigation – as recent studies have shown – a special focus has to be put on lowering embodied GHG emissions, i.e., emissions related to construction production manufacturing and construction processes, maintenance and replacement, as well as end-of-life processing.
As the importance of reducing embodied GHG emissions rises, so does the need for understanding both the baseline and pathways for reduction across the full life cycle of buildings. In this paper, we offer insights into the data-driven analysis of embodied GHG emissions across the whole life cycle of buildings and related visualizations. Our investigation builds on the data collection, processing and harmonization of around 1.000 building LCA case studies. We offer an integrated perspective on GHG emissions across the life cycle of buildings, considering historical trends, current baselines and indicative reduction pathways for embodied GHG emissions in different countries across Europe. This serves to inform our current 'decade of action' and the transformation to a regenerative built environment by 2050.

s.11.56

Level(s) Compared to European and Norwegian Standards for Life Cycle Assessment of Buildings

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Keywords: Building, LCA, Level(s), Standards, Norway

Launched in 2021, the EU Level(s) calculation method for Global Warming Potential (GWP) of buildings could get increasing attention and complement the standards that are currently used in Europe and Norway, EN 15978 and NS 3720. To understand the potential and consequences of using Level(s) in Norway, we assess how the Level(s) GWP calculation method differs from EN 15978 and NS 3720, and whether it is more specific and provides more guidance. Comparing fifteen methodological aspects, eleven were treated differently in the three methods. Both Level(s) and NS 3720 are based on EN 15978, hence they provide more, though different, specifications and guidelines than EN 15978 for most of the aspects, such as scope of building elements, life cycle stages to include, and reference study period. Level(s) provides more guidance for the development of scenarios for the operational and end-of-life stages, and for assessing data reliability. NS 3720 lists the scope of building elements in detail and accounts for operational transport (stage B8). Overall, a building GWP calculated with NS 3720 would need some adjustment to reflect the prescriptions of Level(s). These findings inform LCA assessors about key differences, supporting the broader use of Level(s) in Norway as in Europe, and helping towards a harmonization of NS 3720 to Level(s).

s.12
Education in Architecture and Planning

s.12.57

Cards for Circularity (CFC): Reflections on the Use of a Card-Based Circular Design Tool in Design Education

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Keywords: Circular Economy, Circular Design, Design Education, Architecture, Sustainability

The transition to a Circular Economy (CE) requires designers to, more than ever, concurrently develop a circular design, supply chain and business model, and anticipate how products and buildings function over time. To address these challenges, recent studies identified specific knowledge and competencies for designers. However, it remains unknown to what extent future designers (students) are prepared to address the CE in design practice. Therefore, this study investigates how architecture students currently interpret the CE concept and whether that aligns with how they apply the concept in a design assignment. For two years, a workshop was organized with a total of 320 architecture students. The students utilized a card-based circular design tool to conceptualize circular solutions for cases varying in scale and context. According to the students, the main challenge of design for a CE relates to holistic perspectives and systems thinking. The students associate the CE strongly with the reuse of existing (waste) materials, yet results of the design assignment show holistic and diverse approaches of incorporating CE principles. The study identified slight discrepancies between experienced challenges and reported necessary knowledge.

s.12.58

RoofKIT - Circular Construction and Solar Energy Use in Practice at the Solar Decathlon Europe 21/22

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Keywords: Circular Building Construction, Urban Mining, PVT Collectors, Passive Cooling

The contribution of the RoofKIT team to the SDE 21/22 competition is the extension for an existing café in Wuppertal, Germany, to create new functions and living space for the building with simultaneous energetic upgrading. The energy concept targets all renewable resources available on and in the building for energy supply: mainly solar energy which is used via PVT collectors, as well as waste heat from ventilation and grey water which is recovered for pre-heating. As part of the competition, a demonstration unit will be built, representing a small cut-out of the extension. An integral building and energy concept combines physical properties of the building with adapted building services technologies to achieve maximum indoor comfort – particularly considering possible overheating of the lightweight construction during summer – and minimum CO_2 emissions. The latter extends to the whole lifecycle of the building unit and one of the major goals of the project is to realize an almost completely mono-fraction and circular building construction as a contribution to the urban mining concept.

s.12.59

Investigating Passive Strategies in a Cold Climate – Teaching EDDA in Architectural Education

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Keywords: Passive Building Design Strategies, Building Energy Simulation, Cold Climate, Iceland, Architectural Teaching

This paper describes the results of an architectural teaching module investigating passive building strategies in cold climatic conditions on the case study of Iceland. Focusing on thermal comfort in buildings, usual case study tasks are located in cooling-dominated climates – as vernacular design for hot climate zones offers more passive strategies than for cold climates. As part of the architectural education program at Jade University of Applied Sciences, students investigated the impact of passive strategies in a building design concept for a hotel in Iceland by applying numerical simulation within the initial design phase. The aim was to develop a holistic energy efficiency strategy and to optimize their initial design propositions exploiting its full potential for high thermal comfort in the guest rooms. Although each student started with an individual research question for a specific passive strategy, i.e., investigating varying construction materials, buffer zones, window-wall-ratio, Trombe walls, etc., all design concepts finally included multi-storey glazed buffer zones contributing to comfortable room temperatures by high solar gains from April to September, resulting in a significantly reduced heating load. Furthermore, the study identified several design metrics for passive solar buffer zones to ensure the positive impact throughout the months with varying solar intensity. The teaching module called EDDA (Environmental Digital Design Analysis) is based on simplified 3D models in McNeels Rhinoceros 3D, undergoing thermal simulation with a Grasshopper–Ladybug-Honeybee workflow. This allowed the students to iterate their building designs for maximum thermal comfort before adding HVAC systems. Ultimately, EDDA fostered to design climate-sensitive buildings by identifying a suitable set of passive strategies for the predominant climatic conditions as a first – but essential – step towards climate-neutral buildings. At the same time, prospective architects are Empowered to leading the building sectors towards a carbon-neutral future.

s.12.60

On Reflection: Learning, Meaning and Identity in the Design Studio

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Keywords: Design Studio, Autoethnographic Enquiry, Architectural Education, Collective Learning, Communities of Practice, Transdisciplinary Collaboration

Successfully transitioning to a more sustainable building sector will require schools of architecture to explore new methods, approaches and formats for learning. Challenging some of the outdated values and assumptions at the core of the architecture profession starts in the design studio, where early professional identities, relationships and understandings of collaboration are forged. While there is an increasing focus on inter- and transdisciplinary learning in today's higher education landscape, investigations into the pedagogy of the design studio are both relatively limited and disproportionately dominated by theory based on Donald Schön's ideas on the »reflective practitioner«. In reality, the lack of any kind of coherent training for teaching staff means that, most often, approaches tend to reproduce that which the teachers themselves experienced during their own studies. The paper uses a series of autoethnographic vignettes to describe design studio teaching at Natural Building Lab from the perspective of a university educator, based on the example of a masters design studio in winter 2021–22. Etienne Wenger's Communities of Practice model, and specifically the four dimensions of design for learning, are used to unpack and discuss some of the dialogues at work in studio learning. The study should be seen as a form of practice-based research, using teaching formats as a way to actively gain new insights into new forms of practice with a focus on sustainability and student-empowerment. The paper provides an intimate and personal insight into some of the questions and challenges facing educators, students and project partners as participants in emergent and collective learning processes.

s.12.61

Unboxing Urban Infrastructure: Three Methodologies for Infrastructure-Oriented Urban Design and Architecture Education

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Keywords: Infrastructure, Architecture, Urban Design, Research-Oriented Design Education, Transformation Towards Sustainability

Although the exploration of infrastructure has become a main focus of urban-centered studies and urban theory over the last decade, it has only been partially adopted into design and planning education. Here, the traditional curriculum of architecture, urban planning, landscape architecture, and urban design offers emerging professionals limited guidance and tools for exploring and analyzing the complex assemblages and constituting systems that create, run, and shape cities. However, in times of dramatic need for systemic transformation, the critical and research-based analysis of the city's externalities and the flows underlying urban life will become more relevant by the day. Thus, the following article outlines three teaching methodologies for analyzing »infrastructural regimes« as key levers and contexts to embed a reflected and responsive design work directed at transformation towards global sustainability.

Scientific Sessions Student Conference

sc.1 Transformative Spaces – Experimental Large-Scale Projects

sc.1.1

Superumbau 2035

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Keywords: Structural Change, Regional Development, Resilient Communities, Redensification, Urban Mining

Alongside EU green deal political action lignite mining becomes obsolete. Mining regions are affected by fundamental structural change that require new and optimistic narratives.
We envision those regions in a creative process of »Superumbau« in which environment is shaped collectively. It opens transformation to positive interpretation, expresses the belief to use the existing physical and socio-spatial context and connects to our case study Hoyerswerda in Lusatia. This knowledge could become exemplary for other European cities in structural change.
Recently federal and state governments have declared Lusatia an European model region for structural change. As part of this program, research facilities dealing with climate change and increasingly scarce resources are supposed to be located in the area and create new prospects for the region.
As cost of living keeps rising in metropoles, people find attractive living spaces in the countryside. However, single family housing trends are still a predominant reaction and call for new proposals as they pose a threat to long-term sustainability objectives.
After a phase of large-scale deconstruction in the town district of Neustadt, Hoyerswerda-, this effort should not be lost to further urban sprawl. Therefore, we suggest redensification from the inside out, starting by creating new urban hubs and additionally, special certificates rewarding the active desealing of areas, which has the potential to become a new planning strategy for shrinking cities.
We propose an urban mining concept: Buildings that have to be demolished outside of the new perimeter will be carefully dismantled, taking advantage of the modular slab system. After minor repairs, they will be stored in a material hub and can be used for new building projects.

sc.1.2

Reanimate the Shed!

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Keywords: Conversion, Reactivation/ Transformation, Redensification, Timber Construction, Recycling

Reanimate the Shed! is an experimental urban design taking up the challenge of transforming a mono-functional commercial area in Schöneweide, Berlin, into a future-oriented residential quarter. In doing so, the handling of mega-typologies is questioned. What qualities do these structures have? How can they be repurposed in a post-fossil society? In Schöneweide, two architectural styles collide: On one hand, the neighborhood is characterized by the historic AEG factory site, whose production halls have already been partially repurposed by artists, offices and businesses, on the other hand, modern consumer complexes characterize the district. The latter have surpassed the human scale, do not interact with the urban space and create spaces that potentially trigger anxiety.
The design explores the possibility of transforming one of these non-places (see Marc Augé).
The goal is to create a diverse micro-neighborhood through redensification, mixed use, and short distances. By ways of a profound analysis, we identified a variety of strategies for dealing with existing buildings. These enable us to break up the mega-typology and transform it into a small-scale center for sports, cultural events and leisure. The supporting structure, as well as parts of the façade, remain intact and become permanent witnesses of the transformation. Through this process, residential and office buildings planned in modular timber construction complement the existing structure. Alternative infrastructures, diverse usages and housing interweave life, work and leisure. The result is a sensitive design that uses the existing building structure to establish differentiated streets, pathways and plazas.
We believe that the discussion about the reuse of building fabric and the repurposing of building structures should not stop at these mega-typologies. The design criticizes capitalist and profit-oriented architecture and rethinks the city from the perspective of its inhabitants.

sc.1.3

revierBunt: Transformation of Rhenish Power Plant Sites

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Keywords: Radical, Regional, Revolutionary

The coal phase-out is scheduled for 2038. It has been vehemently demanded in the politically charged discourse about the Rhenish coal mining area, the largest opencast mining region in Europe.
While the open cast pits attract a lot of attention in the development of visions for sustainable spatial use for the region, the neighboring coal-fired power plants often go unnoticed as essential engines of the coalfield. But what will become of them when the phase-out is finally completed? What will become of the megastructures, which will keep on scattering the prevailing village settlements? And what might new utilization concepts look like?
As part of a master's project at RWTH Aachen University, we created the »revierBunt« to find answers to these questions.
One thing is certain: The shaping of a new self-image for the Rhenish mining area, which has always been characterized by energy-political interests and globally operating corporations, must be driven forward by planning that closely cooperates with the local residents. By that, a communal identity space was created that is socially and economically functional in itself, as otherwise little depending on external influences.
Within this field of consideration, we used participatory planning methods to develop an overall spatial strategy and to identify perspectives for the transformation of the power plant sites, which we were able to deepen in terms of design at the Niederaußem and Neurath sites.
At the sites, we call for a transformation toward infrastructurally networked, carefree settlements, for the recycling of all demolition products without exception, for a full stop to the sealing of any new areas, and in turn for a renaturalization of large parts of the area. We hope to establish colorful diversity through broad mixed uses and to dissolve prevalent boundaries for new accessibility!
Isn't the idea of educating, living, working and co-designing in a former coal-fired power plant in the future a fascinating vision?
And all this within the framework of a radical democracy, in a regional circular economy and with revolutionary ways of life!

sc.1.4

The Sustainable Transformation of University Campuses

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Keywords: Climate Change, Environmental And Social Sustainability, Nature-Based Solutions, University Campuses, Public Spaces

In the sustainability debate, university campuses, too, take a crucial role with their physical settings, their resources, and potentially action-taking communities. Fostering environmental sustainability on campuses can provide physical settings that will help combating climate change. Some measures will be to outline a mini-pilot city for future urban initiatives, as well as to enhance the use of suitable campus spaces as communication platforms with comfortable outdoor use for its communities. This article studies how campus areas tackle climate change with environmental sustainable action, with physical settings supporting sustainability and dialogues on the issue among campus societies. It investigates campus spaces in terms of climate suitability and degree of comfortable practicability. It does so by the assessment of several physical elements and their review by inhabitants in the scale of the city, the campus and particular spaces in use. The research reviews RWTH Aachen University, Germany, and the outcome highlights that the campus requires multiple ways of action of various scale and a timeline for the adaptation of the green campus. The concept of Living Lab envisions realization of the co-creation and real-life experimentation in a pre-scaling approach, from city Aachen to university public spaces. The Living Lab strategies are inspired by Nature Based Solutions (NBS) and explained under NBS families, solutions and details in a toolkit. The toolkit of NBS applications also highlights the transition of multiscalar and multidisciplinary approaches. The research presents spatial applications with case study RWTH Aachen in different scales of campus initiatives and concludes with recommendations on the short-, mid- and long-term sustainable transformation goals. Through the research and design project, the aim is to encourage the university campuses to the sustainable transformation of climate change combat.

sc.1.5

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Keywords: Urban Sustainability Transitions, Anthropocene Cities, Deep Experimentation, Post-Capitalism, Transformation

Deep Experimentation: An Ethnographic Inquiry into the Haus der Statistik in Berlin

In the quest for sustainability in the Anthropocene city, urban experiments play a key role in facilitating the translation of ambitious policy targets into tangible projects that can show how other worlds are possible. However, existing theorizations of urban experimentation in the literature of sustainability transitions and transformation research either appear to be apolitical and ontologically naïve or to lack practicability and orientation. By systematically intersecting perspectives from both scholarly communities, this paper proposes a framework that offers a new, third way to study urban experiments, structured along three analytical entry points: emergence, functioning, and tensions. The paper demonstrates the usefulness of this framework by means of an in-depth ethnographic case study of the Haus der Statistik (HdS) in Berlin, an award-winning urban experiment whose innovative character has hitherto not been subjected to comprehensive analytical scrutiny. Seeking to understand how the HdS reenvisions, practices, and negotiates urban experimentation towards sustainable cities, the paper reveals that new forms of urban change can be both action-oriented, pragmatic, and targeted whilst striving towards a more radical, politicized and imaginative ontological politics beyond capitalism. Building on these theoretical and empirical contributions, the paper introduces the concept of »deep experimentation«. The concept contributes to »deepen« an ongoing shift in transitions research that has recently been striving to equip itself with the analytical and intellectual tools to address the influence of capitalism on sustainability transitions, and vice versa.
The paper concludes with an outlook on further research.

sc.1.6

Rechenzentrum Potsdam: Minimum Makes Maximum

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Keywords: Conversion, Existing Building, Circularity, Lca

The Rechenzentrum Potsdam is one of the last existing GDR buildings in Potsdam's city center. After a long practice of demolition and historical reconstruction and years of discussion, the Rechenzentrum (RZ) is now to be preserved. The current users of the RZ are art and culture professionals, who have been able to temporarily use the space since 2015.

Our method of achieving maximum effects with minimal interventions is intended to provide users with a permanent solution for the buiding's sustainable preservation and renovation while ensuring its continuous use for its occupants in Potsdam's city center. So can, by taking necessary energy measures, such as renovating the façade and waterproofing the roof, the use of resources massively be reduced compared to demolition and new construction.

In our view, ecological sustainability cannot stand alone and must be linked to the social fabric of the building. In this regard, a staged renovation by fire section allows for no one having to move out of the building. Small structural interventions along the characteristic central corridor on the regular floors will enable users to enjoy new spatial qualities that will ensure that the data center can be used for many years, even when demand changes. The responsibilities for the process organization and the new common areas will be recorded in a new operating system.

The expansion of the public space is also to be experienced by the urban population. With the help of event spaces, as well as the canteen on the open first floor, visitors can become part of the cultural diversity and network with the artists. The green roof, which invites passers-by through eye-catching access, not only serves to improve the urban climate: This way, the nonhuman actors are also integrated into the circularly conceived design.

sc.2
Material Flows and Commodity Chains

sc.2.1

RE.MATERIAL: An open studio for circular building

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Keywords: Circular Building, Sustainable Architecture, Open Studio, Citizen Science

The building industry is one of the world's biggest sources of pollution and waste production. Huge amounts of non-renewable resources are used by the building industry. At the end of a building's life span, its materials become waste in a linear process.
Our project is challenging this conventional practice. We are looking for perspectives and alternative ways to transform the process of building into a material cycle.
At the »Hochschulwettbewerb im Wissenschaftsjahr 2022 – Nachgefragt!« by Wissenschaft im Dialog (WID), our idea was selected as one of 15 winning teams out of 270 submitted student projects from all over Germany. Supported by WID, we draw a special focus on science communication and realized an open studio format in the city center of Bremen. Through the windows of a former shop that was vacant for seven years, we get in touch with people passing by and raise awareness for the building industries' responsibility towards sustainability.
A goal of the project is to connect different stakeholders and to use as well as strengthen the city as a network. Planers, constructors and consumers of architecture shall be brought together as each one of these groups plays a significant part in transforming the common practice. Throughout workshops and podium talks, local stakeholders and experts are being invited to inspire and support the process with their practical knowledge.
The results of the participative investigations are collected throughout the project and curated into a growing exhibition in the open studio space.

sc.2.2

»Material Matters«

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Keywords: Material, Raw Materials, Construction, Climate Disaster, Mapping, Systematic Thinking

»Material Matters!« In the Anthropocene era humans are significantly altering the earth's surface and biosphere, thereby accelerating climate catastrophe. Construction production, an activity of humans, extracts raw materials from nature in various places or regions, processes them, transports them to their destination, and assembles them into structures there.
We are students of architecture at the University of Applied Sciences Bremen and of urban geography at the University Bremen and we are exploring the (construction) materials used in different quarters of Bremen. Researching and observing case studies, we reconstruct material flows that are most distinctive in these research areas.
Using theoretical approaches such as »follow the thing« from geography and social sciences and the interdisciplinary approach of systemic thinking, we aim to develop a new reading for architecture. We exemplarily analyze the built environment and unravel the complex interweavings of building material with space. Spatial and temporal dimensions are considered across scales, revealing social relations, building and cultural practices, as well as technical developments interwoven with the material. The results are visualized in mappings, infographics and diagrams.
Pressing questions about the sustainability of construction and architecture require new formats of research, representation and communication. The results of our experimental investigation seek to discuss how architecture is linked to the historical or current organization and structure of material flows and which chances and potentials for more sustainability are hidden in the current 'system' of architecture.

sc.2.3

Clay Building Culture and the Prejudices Toward It

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Keywords: Adobe Building, Colonialism, Racism, Architectural History

»Now we are already building like in Africa« (min. 9:35, in Andrea Rieger-Jandl, Anton Auer, Roland Meingast, Lightaspect, 2020): These and other colonial racist comments are strongly interwoven with earth building in Germany and Europe. While there is a growing appreciation in professional circles for the rediscovery of the oldest building material, the general public, project developers, housing associations and private builders often have strong prejudices against earth as a building material. Earth building experts express their bewilderment over Europeans ever losing track of using this building material and accuse the building industry of being culturally blind or suffering from cultural amnesia. (Dethier 2019) Following the call of Crutzen and F. Stoermer (2000) to reflect on one's own practice with regard to the Anthropocene, this thesis wants to work through the prejudices towards earth building in the context of European colonialism, the ideals of modernity and structural racism. It analyzes and discusses the representation of earthen architecture at colonial exhibitions in the late 19th and early 20th centuries, and in travelogues about architecture in colonized regions. Building within planetary boundaries requires not only technical solutions but also cultural reflections that draw attention to the values that drive us to the limits of our exploitation of the planet. Working through this is an important step in planning the socially just and ecological cities of tomorrow.

sc.2.4

Brick and Concrete: Material Estimates for Berlin's Building Stock

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Keywords: Material, Typology, Brick, Concrete, Plattenbau, Altbau

The building industry is in search for new construction methods that may be able to reign in the persistently high emissions of the sector that are largely coupled to the production of building materials themselves. Renovating an existing building is considered to almost always be more carbon- and material-efficient than constructing a new building of comparable size. But how much material is actually embedded in existing buildings? Using two building typologies common in the city of Berlin, Germany, we have calculated the amount of different materials present in existing buildings from different periods of rapid construction and expansion of European cities. The »Altbau« and the »Plattenbau« types together represent a major share of the building stock of the former German Democratic Republic. Figures were gathered from existing sources and gaps filled by analysis of archival documentation and detail registries. This methodology could be applied to further building typologies, both in Berlin and in other contexts.
These figures can be used as the base of an inventory of materials in cities where these two typologies constitute a considerable segment of the building stock, enabling calculations of the contained carbon, as well as paving the way toward urban mining practices as we transition to a more circular de-, re- and construction process.

sc.2.5

Syncing Urban-Rural Cycles: Cycles of Urbanization, Carbon Storage and Forest Growth in Berlin-Brandenburg

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Keywords: Urban-Rural-cycles; wood to the city; carbon sinks

Climate change requires an immediate and radical transformation of the building sector. Climate-positive and recyclable materials, such as wood, will play a significant role in this. Urbanization processes, new construction, conversion and deconstruction are subject to cycles that control the dynamics of the construction sector. For many years, there has been pressure to build a large number of apartments in Berlin. In this housing demand lies the great potential to build climate-positive residential buildings made of wood, which store CO2 over their entire life cycle. The development of forests is also characterized by sequences of planting and deforestation. Currently, a large stand of Brandenburg's forests is at a harvestable age. In terms of sustainable forest conversion, it is obvious to replace the widespread pine monocultures by climate-resistant mixed forests.
To date, the two cycles have not been thought of in relation to each other. For a wood-based building and urban development policy oriented towards sustainability and circularity, an intertwined view of urban and forest development is needed. Such an entanglement allows to understand both cities and forests as long-term CO2 reservoirs and to explore ways of an ecological urban-rural metabolism.
But how can urban and forest development be considered in relation to each other and spatial, systemic and societal potentials of their interlinking be tapped into? Based on a historical analysis and the comparison of growth and shrinkage processes of urban and forest development using the example of Berlin-Brandenburg, insights for the future will be gathered that will provide information about the correlation of the two systems in mapping and further visual representations.

sc.2.6

Assessing the Potential of a Modernized Natural Dimension Stone Economy for a Sustainable and Circular Built Environment

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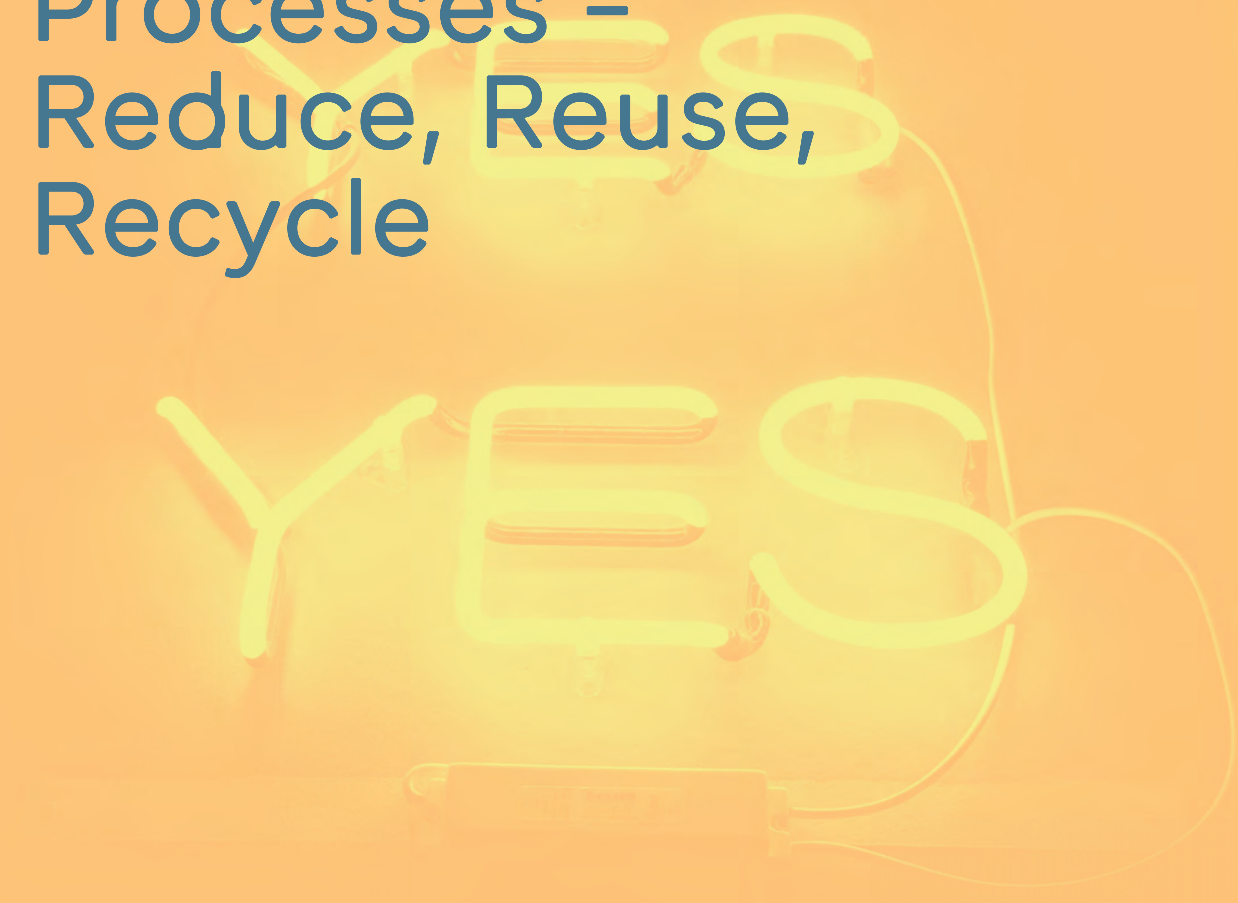
Keywords: Dimension Stone, Mineral Based Materials, Circularity, Longevity, Low GWP

This review paper aims to provide a preliminary critical assessment of the fundamental potential of load-bearing natural dimension stone for the present challenges the building sector is facing, including the climate emergency, low productivity, resource depletion, low longevity, high lifecycle costs, and a low level of circularity.
In multiple regions of Europe, various groups of practitioners have emerged, claiming that massive natural stone is a solution to the current problems of the industry and will be part of the future of construction. This paper aims to find out if these claims can be backed up by science and current research on the topic, by providing:
1. a critical summary of the fundamentals of the material; extraction, availability, whole life global warming potential, circularity, longevity, architectural and structural qualities.
2. a discussion of modern stone technologies; tensioned stone, modular load-bearing stone construction, wood and stone hybrid construction, next-generation mining, extraction site reuse, 3D scanning, automated design, circular marketplaces and automated fabrication.
Historic references will be made to show how the relationship of AECO, an industry consortium dedicated to the productivity, sustainability and profitability of the relevant sectors, to stone has changed throughout time and how it came to the current depletive relationship. Furthermore, comparisons to standard materials will be made. By using a systems thinking approach, a broad view of the topic will be offered.
This paper will provide a preliminary understanding and assessment from which further research can be undertaken on the question: Can load-bearing stone, as a partner to bio-based materials, be part of the circular and sustainable future of architecture?

psc.1
Design and Processes – Reduce, Reuse, Recycle



psc.1.1

Design to Production Project »Der Raum. Questioning documenta 15«

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Keywords: Communal Resource Sharing, Upcycle, Design To Production, Refiguration, Principles Of Collectivity

As part of our design to production project »Der Raum. Questioning documenta 15« in the winter semester of 2021/2022, we realized a venue in collaboration with documenta 15 and the Georg-Christoph-Lichtenberg-Schule. It was designed by the students in terms e of the Design to Production, the implementation planning was developed. Next, students and teachers set up the showroom on the school grounds together. The pavilion, as a new meeting place, offers various usages in the context of the program. On one hand, events such as exhibitions can take place here, and on the other hand, it offers students a meeting place outside the structure of the classroom. By using the most simple possible construction elements, as well as recycled materials, it was possible to build a cost-effective, sustainable pavilion in a self-construction process. Since the beginning of the summer semester of 2022, a second part of the project has been dealing with an exhibition on the facility, as well as with the implementation process of the self-construction project.
We are currently working on an offshoot of that pavilion, which is meant to be used solely for pure exhibition purposes. This one will also, after a preceding competition to chose the design to be realized, in all areas (detailed planning, approval planning, costing and material procurement) be worked out in a collective process and then the joint construction will take place.
Thus, on the one hand, the process of the first construction is reflected and optimized by the students, and on the other hand, the characteristics for the use of the most simple possible construction elements and recycled materials, as well as cost-effective, sustainable construction, are directly questioned and, if necessary, adapted.

psc.1.2

Research on the Benefits of Paper as Building Material: Good for Global Climate and Indoor Climate?

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Keywords: Cardboard, Renewable Building Materials, Building Climate Performance

Extraction of fibrous materials from wood enables the production of a wide range of different and specific paper materials. The fibers as the »row material« for paper products can be reused with only a minimal loss of quality. This recycling process can be repeated up to 12 times and opens up new opportunities in the use and reuse of wood. Therefore, paper as a building material could contribute to move towards a building industry which is based on renewable resources and a circular oriented economy while also reducing greenhouse emissions. The research project is dealing with the potential of paper as a building material for wall constructions and its building physical properties. Thereby, we not only want to gain insights into the building-related physics of the wall construction, but also into the potential to contribute to the regulation of the indoor climate. In this respect, aspects of inside climate, such as comfort and energy use (for heating/ ventilation), are taken into account. Thus, we want to test different wall constructions (mock-ups) in an adiabatic envelope (test box) to simulate hygrothermal effects. The test box is equipped with sensors to measure air velocity, temperature and relative humidity inside the box and the mockup. The results of these examinations are intended to provide information on the hygrothermal behaviour of paper wall structures. The goal is to develop a wall using mainly paper products and optimize the performance regarding heat and moisture transmissions.

psc.1.3

Leichtes Gepäck

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Keywords: Recyclates, Reuse, Reuse, Building With Reclaimed Wood, Architecture, Climate Change, Sustainability

As the construction sector is known to be a major contributor to global CO_2 emissions and waste generation, we, those working in the building industry, must now finally rethink and initiate the building turnaround. The first step toward this is to develop concepts of how to define sustainable architecture, and to then work out strategies on how to implement that knowledge.
In the winter semester of 2020/2021 and the summer semester of 2021, master's degree students from the Chair of Design and Timber Construction at the Technical University of Munich have made precisely these considerations and attempted to transfer these strategies into an architectural task in various ways. Initiated by ArchitectsForFuture – Munich chapter, in the context of the seminar Special Topics in Wood Construction, information stands that can be used at protests were designed, planned and finally built.
Fourteen students investigated the question of how the idea of sustainability can be consistently implemented in the entire planning process, from the beginning to the execution, and how sustainable architecture can be (re)presented in an appropriate manner, with what architectural expression. Because of the necessity to think of material cycles being closed in the future in the building industry implies that already used materials are further used or reused, constructions with recycled or reused materials with easily detachable connections were created in the context of this project.
The individual documentations of the projects show the different methodical approaches and how the students reacted to typical problems of availability and quality of the used materials while building the prototypes in scale 1:1.
The project shows on a small scale how the sourcing materials from recyclates affects the design and execution process, as well as the architectural result.

psc.1.4

Potentials and challenges of Robotic Spray Earth Printing

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Keywords: Robotic Fabrication, Earthen Construction, Additive Manufacturing, Robotic Spray Earth, 3d Printing

Our urgent demand for a more sustainable way of living compels us to consider how the combination of natural materials and advanced technology might lead to the advent of novel and innovative construction methods. Due to the fact that the construction industry emits around 40 % of the world's greenhouse gas emissions, optimizing energy consumption and reducing material extraction are essential in achieving sustainable productivity.
Developing a circular economy based on natural and recycled resources represents an enormous challenge, both for the construction industry and for large industrial processes characterized by mass production and standardization of materials and products.
As such, Robotic Earth Printing, when coupled with advanced design methodologies, offers the possibility to create products and processes that can adapt to the emerging concepts of circular economy and mass customization, while ensuring high productivity, low production costs, and design optimization.

Lately, it has been possible to fabricate various functional and habitable earthen structures using 3D printing technology. Despite the fact that these projects have demonstrated the general feasibility of 3D earth printing in construction, further exploration of topics, such as functional integration, material optimization, as well as disassembly and reuse, will be necessary in the future. In this context, a team of students and researchers has been examining design and fabrication parameters that are essential to the realization of additively manufactured earthen structures. The paper investigates the potentials of Robotic Spray Earth Printing on a 1:1 component scale, as well as its implications for scaled up functional and feasible future implementations.

psc.1.5

Witzenhausbau

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Keywords: Clay, Participation, Recycling, Reuse, Try And Error

Witzenhäuschen is a self-sufficient summer house in the countryside around Witzenhausen. The main volume imitates the dismantled garden house and is complemented by connectable textile rooms, which include a wet room and a work room, and provide a wide covered terrace in the south. The building can thus be in winter be used as a compact retreat for two people and in summer as a party accommodation for the whole family and thus acts flexible in interpretation concerning building regulations. Under an economic (EUR 10.000 budget) and ecological aspect, the dilapidated hut was completely dismantled, its structure reinterpreted, improved and rebuit; the workable material was recycled. Severely distorted square timber was almost completely reinstalled, tongue and groove boards were reused in place of roof slats, and the existing foundation was trimmed to fit and straightened. The windows and corrugated sheets used were purchased second hand. Due to the compact floor plan, the windows were installed upside down to open to the outside. The house is based on a wooden stand frame construction made of mostly reclaimed squared timber. The structure was then reinforced on site with a stamped light wood clay. The light- weight wood loam used has the advantage of providing a good to ensure a good thermal insulation value. In consultation with the builders, the conscious decision to use a visible facade was taken. Recycled tongue and groove panels divide the façade horizontally – they serve as erosion protection and to ensure targeted, minimal removal of the clay. In the slightly raised plinth area, trass lime was added to the lightweight wood clay to further increase the strength. Rainwater is collected through the sloping roofs, which, filtered through two tanks, allows self-sufficient use.

The entire construction process, from the initial conceptual design to the planning to the joint self-construction realization, was a great experiment. Due to the economic situation, existing materials had to be as much as possible. The visible wood-light clay façade is a self-developed prototype to enable a contemporary façade that can be built together, locally and ecologically.

psc.1.6

Museumspavillon und Wissenspfade TU Berlin

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Keywords: Waste Wood, Circular Justice, Renewable Raw Materials, Material Efficiency, Energy Efficiency

The projects »Museumspavillon und Wissens-pfade« (museum pavilion and knowledge trail) is conceived in a participatory and transdisciplinary process from within the university. It is thus intended to become a forward-looking model project for ecologically sustainable and climate-appropriate planning and building practice. The special, integrative process of development, the permanent anchoring in courses as well as the resulting intersections between teaching and practice ultimately make the project socially sustainable as well. Various projects and visions for the project were developed in different courses with different thematic focuses. The participatory process from within the university culminated in the winter semester of 2021/22 with the work of the project office. As part of the »Projektbüro«, we became planners of the early phases of the project. Contrary to common procedures in planning and contracting processes, the preliminary design is developed through this collaborative process in a real experiment.
The university as a place, as well as academic formats through which science is communicated, are not equally accessible to everyone. With the Museumspavillon und Wissenspfade of TU Berlin, the university will be made accessible to all interested parties at a low threshold.
New topics of research or technological progress should not only be shown in and around the building, but can also be experienced throughout the building itself.
This design is a temporary building that flexibly serves various use requirements. In order to continue to use the materials in the future, we developed only reversible, recyclable connections with renewable and recycled raw materials. Material efficiency in structural design, as well as energy efficiency in cubature, floor plan and façade design were integral parts of our planning process.
The Hertzallee is a clear axis, functional and recreational space, and at the same time, with its lush tree population, a recreational and green space. We want to create an attractive research and learning environment on the university campus for the urban community, students, teachers and tourists in collaboration with the Projektbüro »Museumspavillon und Wissenspfade«.

psc.1.7

Torre De La Almazara: Recovering an Abandoned Industrial Site and Reusing Obsolete Materials to Create Architecture

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Keywords: Reuse, Material, Recover, Management, Transformation

The Tipaume Nature Reserve on the foothills to the Andes of Chile was once a place where olive trees were grown and an industrial process was carried out by building a series of irrigation channels to irrigate an olive tree plantation and obtain olive oil. Today, these structures are nothing more than vestiges. Now, the old »Almazara« plantation is being recovered by the reserve to become a museum.

The project tries to be a small-scale built answer to the questions: How can we build on the existing fabric and by doing that, give a second life to a built infrastructure? How can we do that while respecting the history of these premises? How can we reuse materials seen as waste and thus contribute to less emissions? How can we add an architectural structure just with the remains of the site at hand?

The design recovers one of the old irrigation channels on the hill, turning it into an extension of the future Almazara Museum. The architectural structure, which is is anchored to the pre-existing one, consists of a vertical body that seems to emerge from the hill and float above the level of the vestige, screening the space.

The project was built with materials at the end of their life cycle which had been dismantled from a building for renovation. A shell of reused zinc plates adds to the work a reference to its history that makes it stand in dialogue with its context. The construction is complemented by a staircase that invites users to descend and investigate the vestiges underground, then climb up and rediscover the central valley of Rengo.

psc.1.8

Architecture as a Living System: Towards a Regenerative Design

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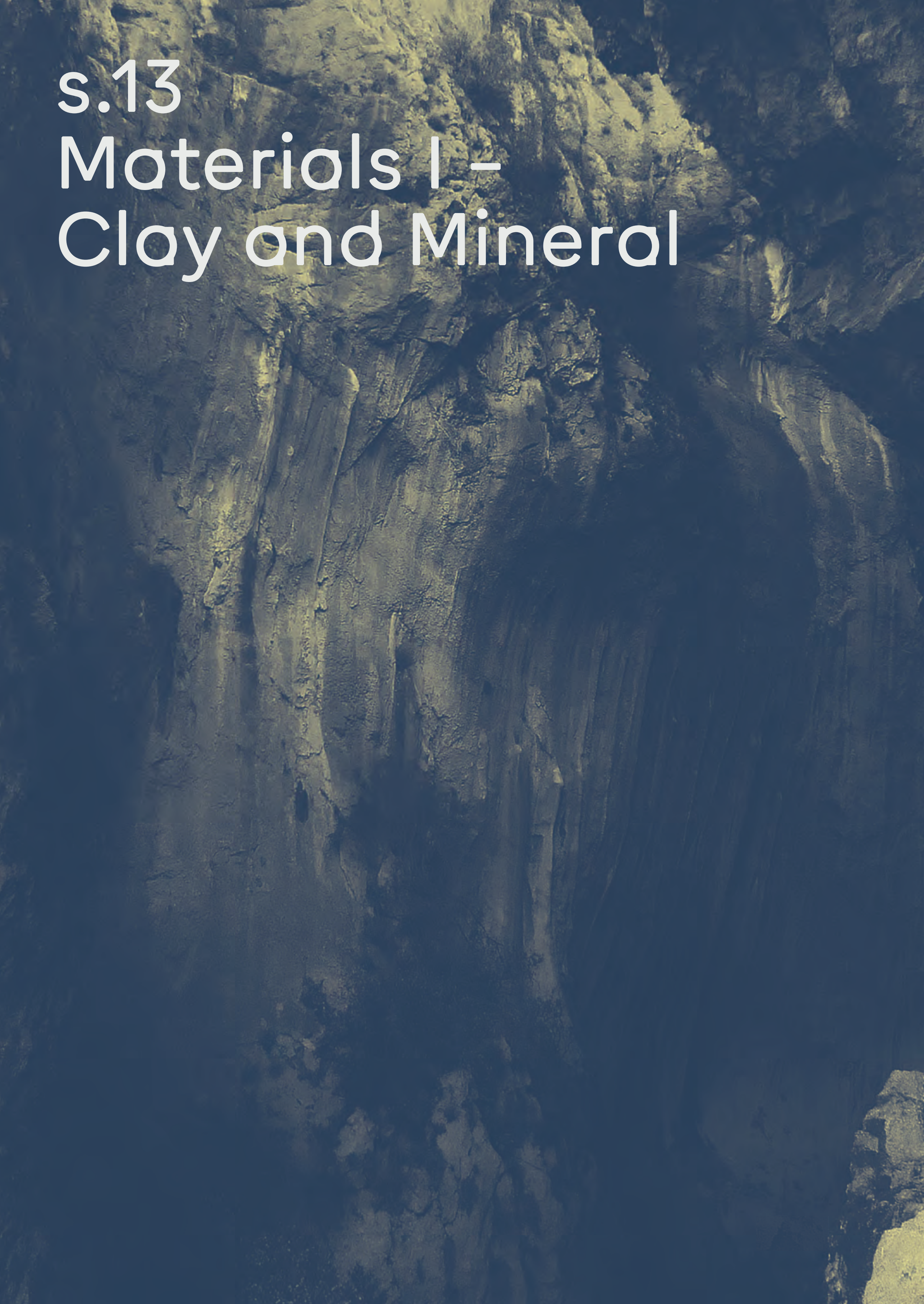
Keywords: Living Systems, Regenerative Design, Ecological Design, Design Principles, Shifting Perspectives

Current discourses within the built environment increasingly underline the need for a shift in perception, thinking and values as a prerequisite to moving from sustainability to regeneration.
This paper discusses how rethinking the position and role of architecture within the human nature-architecture system can be an essential step in this transition. While the theory of regenerative design offers a precise understanding of what architecture should achieve within the ecology of a place to be regenerative, it does not provide an understanding of how a designer's thinking can become ecological, nor how this different perspective can be applied to the design process. To explore this question, I draw upon Fritjof Capra's living systems theory and its application to the field of architecture, discussing how viewing architecture as a living system can be the answer to acquring the deep ecological awareness needed to start designing regeneratively. Through the layering of design principles, the research synthesis becomes a theoretical framework for thinking and making regenerative architecture that can be applied to the design process of any design question. To showcase how this tool can be put into practice, I further propose a method to study places by mapping the local human nature-architecture system. The resulting map assists in understanding how our culture and relationship with the ecosystem in a given place serves to shape its architecture. Finally, this paper encourages the introduction of these tools to design education and practice as a way to build the bridge between the regenerative theory and the practice of building.

s.13
Materials I –
Clay and Mineral



s.13.61

Digital Design and Fabrication Strategy of a Hybrid Timber-Earth Floor Slab

J Trummer [1], M Schneider [2], M Lechner [2], T Jarmer [3], T Demoulin [4,5], G Landrou [4,5], F Nagler [3], S Winter [2], K Dörfler [1]

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Keywords: Floor Slabs, Digital Fabrication, Timber, Earth, Net-Zero

The production of floor slabs with their high requirements for fire protection, thermal mass, and sound insulation is a central challenge in multi-storey timber construction. The research presented in this paper explores the possibilities of a timber-earth slab (T.E.S.) that can meet such high demands while being fully recyclable. T.E.S. comprises a hybrid structure, which aims to combine the strong tensile properties of wood with the beneficial properties of earth in terms of thermal mass, thermal activation capabilities, fire resistance, and sound insulation. It integrates a novel material technology capable of casting earth with low water content and combines it with robotic technology that enables the bespoke fabrication of a filigree wooden structure tailored to mechanically interlock with the earth infill. The proposed method makes it possible to place the earth infill in the lower part of the floor slab and thus expose it to the interior space, whereby its storage mass and component activation can be fully utilized. This paper presents the concept and design principles, initial findings on the system's load-bearing behaviour, as well as the experimental validation of the novel fabrication process in 1:4 and 1:1-scale demonstrators, in which the general feasibility of the system in assessed. The paper finally discusses the proposed methods and results of the experiments and outlines further steps for transferring the system into building practice.

s.13.62

The Astysphere: A Concept to Overcome the Polarity Between Cities and Nature and to Develop Sustainable Urban Raw Material Fluxes

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Keywords: Astysphere, Urban Systems As Part Of Natural History, Urban Chemical Element Flows, Sustainable Management Of Urban Resources

The lion's share of anthropogenic material and energy consumption is caused by cities. Some global chemical element fluxes are already more influenced by human beings as by non-human biological and geological forces. Climate change is produced to a large portion by urban processes. Worldwide, the surface morphology is currently determined by anthropogenic activities. Urbanization has become a major global exogenic geological factor. Nevertheless, catastrophes such as the flooding in the Ahr valley, Germany, or the lava emission on La Palma, Spain, in 2021 are reminding human beings of their vulnerability. The concept of the Astysphere is a further development of the concepts of global spheres such as the lithosphere and the biosphere as it was invented by the Geochemists V. M. Goldschmidt and V.I. Vernadsky. This concept describes the global urban system as balancing zone for chemical element and energy fluxes. Within this concept, cities are reservoirs of specific chemical elements in ratios never occurred in natural history before only created by human activity. It is one of the main tasks of geochemistry to understand why which chemical element occurs where. This knowledge enables to identify raw material resources. Transferring this concept to urban systems is meaning to identify the chemical element resources in urban systems accumulated here by human beings and to explore whether these resources are worth to be extracted. Currently, there is some knowledge available on the amounts of construction materials used in urban systems, such as gravel, asphalt, steel or concrete. Only little knowledge is available on the amounts and speciations of specific chemical elements in urban systems such as, e.g., molybdenum, germanium, neodymium or mercury, just to mention some of those. But sustainable development of cities means to know, which chemical elements occur in cities and whether they can be recycled or whether they are a danger for human health. The concept of the Astysphere provides an approach to understand the meaning of cities for global chemical element fluxes and to raise the awareness to control these for a sustainable development of the earth.

s.13.63

Steered Erosion: A Differentiated Approach on Weather Protection for Exposed Rammed Earth Walls

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Keywords: Process, Scenario Analyzes, Rammed Earth, Erosion, Material Cycle

For environmental as well as aesthetic reasons, the use of rammed earth has become increasingly popular in the last years. However, there is still a lot of insecurity among clients, planners and contractors concerning the material's weather resistance, which impedes its wider application. Starting from here, the paper investigates different construction-related strategies of weather protection that build upon the idea of Calculated Erosion described by rammed earth pioneer Martin Rauch. Through the development of a typology of techniques as well as application studies, the paper shows how on one hand, increased protection can ensure the durability of a wall even under heavy rain impact, while on the other hand – in case of little exposure – erosion can explicitly be permitted, allowing for a strong aesthetic expression of the natural process. Introducing the concept of Steered Erosion as an extension of Calculated Erosion, weather protection techniques are conceived as both functional and design-related interventions in the erosion process, which together are able to significantly promote the use of rammed earth as a sustainable building material.

s.13.64

Earthen Construction Materials as Enabler for Circular Construction

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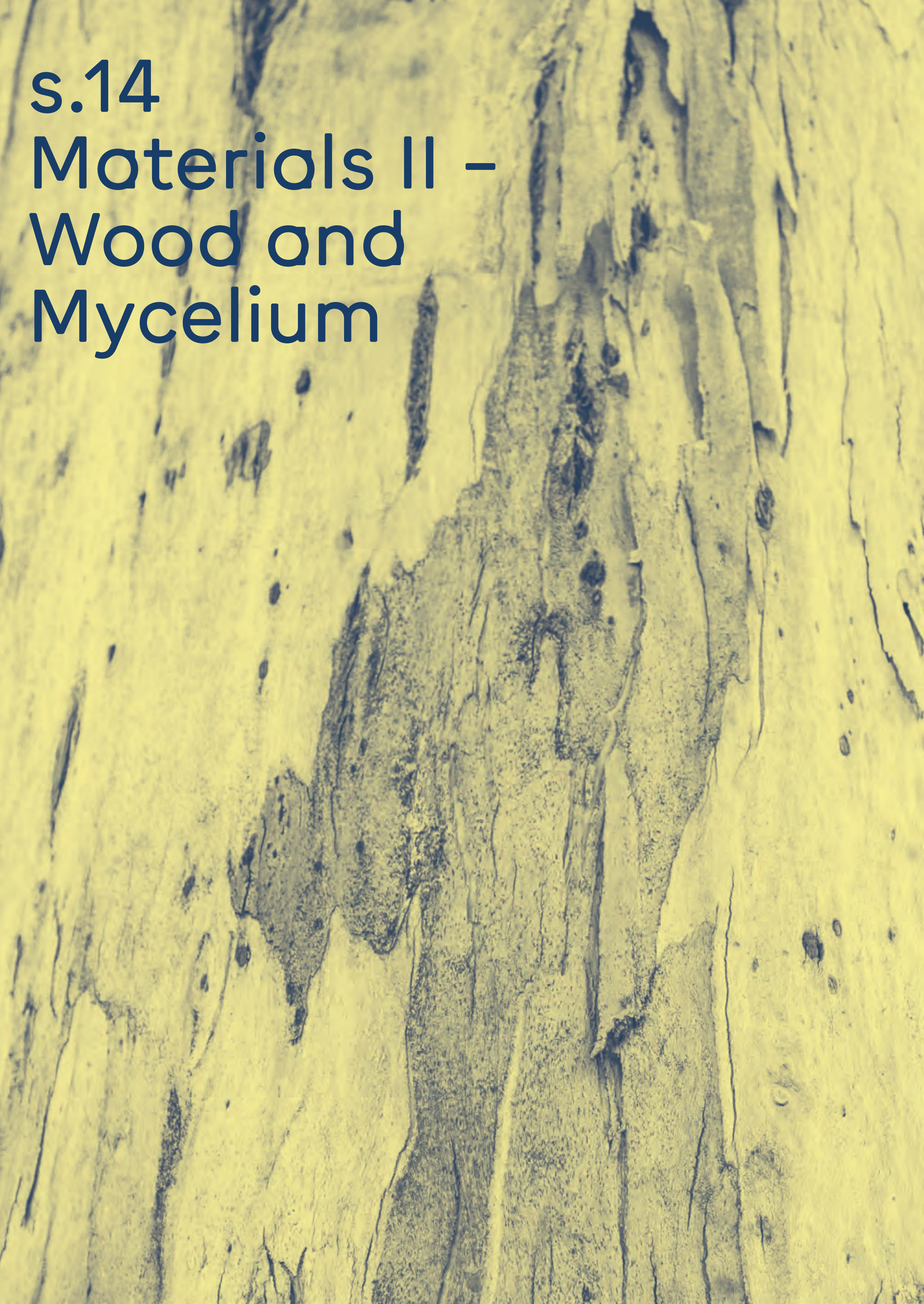
Keywords: Construction Product, Case Study, Circular Construction, Earthen Materials, Reduction of CO_2 Emissions

The construction sector in Germany is one of the largest contributor to climate change. The majority of waste generation, resource consumption, as well as CO_2 emissions, relate to the construction and operation of buildings [1][2][3]. In order to tackle such negative impacts, the construction industry has to undergo a major transformation. Circular construction is the most promising answer to close material cycles effectively and to reduce CO_2 emissions related to the manufacturing of construction materials. Stakeholders involved in construction have to review the entire life cycle of buildings and develop new approaches that address such shortcomings and turn the linear way of construction into a circular one. Nowadays, mainly the strong focus on economic considerations as well as the lacking knowledge impede this transformation process. To demonstrate the benefits of earthen materials with regards to circular construction, this study analyzes the potential of two different internal partition wall systems, based on earthen as well as conventional building materials in a holistic way. Several aspects have been taken into consideration, evaluated through the physical dismantling of both wall systems as well as a LCA assessment. Construction cost as well as other material benefits, such as the hygroscopic performance of construction materials have been investigated as well. The results demonstrate that earthen materials reduce both construction and demolition waste, as well as CO2 emissions. CO_2 emissions, whereas the economical assessment shows lower construction cost for the wall system based on conventional materials.

s.14 Materials II – Wood and Mycelium



s.14.65

Wood as a Carbon Mitigating Building Material: A Review of Consequential LCA and Biogenic Carbon Characteristics

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Keywords: Buildings, Consequential, Life Cycle Assessment, Wood, Biogenic Carbon

Buildings can potentially be carbon sinks by use of wood under correct circumstances because wood sequesters CO_2, i.e., biogenic carbon, from the atmosphere by photosynthesis during growth. Consequential life cycle assessment (CLCA) works as a decision support tool to assess consequences from a change in demand by including only the processes that are affected by this demand through market-based modeling. This study aims to review current research about CLCA on wood in buildings. First, by examining methodological approaches linked to CLCA modeling and biogenic carbon accounting of wood in buildings. Second, to evaluate conclusions of studies using CLCA on wood in buildings. We conducted a literature review of 13 articles that fulfilled the criteria of stating to conduct a CLCA concerning either buildings, components, or materials where wood is one of the materials.

The application of the reviewed studies include: method development, reuse, testing end of life aspects, CLCA inventory modeling, and comparison of ACLA and CLCA. The CLCA inventory of small-scale studies comprise a wide spectrum of methods ranging from simplistic to advanced methods, often retrospective. All large-scale studies integrate sophisticated modeling of prospective analysis. Dynamic time-dependent biogenic carbon accounting and indirect land use change (iLUC) are rarely represented, although both aspects have an impact on whether wood buildings respectively work as carbon sinks or provide net GHG emissions. Wood multi-storey buildings generally perform environmentally better than concrete and steel buildings, due to wood displacing these materials and residues substituting fossil energy. End of life scenarios, choice of substituted production, retro- and prospective data, and the share of recycled steel further influence carbon mitigating potential of wood in buildings.

Research of CLCA on wood in buildings are many-fold. Some studies partially evade inclusion of some CLCA aspects, i.e., market delimitation, market trend, affected suppliers, and substitution. A simultaneously high integration of both CLCA, time-dependent biogenic carbon accounting, and iLUC in the same study is almost absent. Consequently, more empirical and methodological CLCA studies are needed while including dynamic time-dependent biogenic carbon accounting to improve the understanding of implications of policy decisions in transitions towards increased use of wood in buildings.

s.14.66

Wood in Buildings: The Right Answer to the Wrong Question

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Keywords: Bio-Based, Carbon Storage, Straw, Bamboo, Resource Availability

Reducing the embodied emissions of materials for new construction and renovation of buildings is a key challenge for climate change mitigation around the world. However, as simply reducing emissions is not sufficient to meet the climate targets, using bio-based materials seems the only feasible choice as it permits carbon storage in buildings. Various studies have shown that bio-based materials allow turning overall life cycle impacts negative, therefore, having a cooling effect on the climate. In recent years, scholars and policy makers have focused almost exclusively on the advancement of wooden buildings. Timber structures stand out as they can be prefabricated and used for high-rise buildings. Yet, one important aspect seems to be overlooked: the consideration of supply and demand. Large forest areas that allow sustainable sourcing of woody biomass only exist in the Northern hemisphere, notably in North America and Europe. In these regions, though, urbanization rates are mostly stagnating, meaning new construction rates are low. The largest amount of material requirements in these regions are derived from the refurbishment of the existing stock. Moreover, in areas where structural material is needed for new construction, in Asia, Africa and South America, rain forests need to be protected. Therefore, we need to rethink the desire to find one solution and carelessly implement it everywhere. Instead, we need to consider locally available material and know-how for grounded material choices. This paper explores the supply of a range of bio-based materials and matches it against the material demand of global building stocks. It is based on various previous studies by the authors, of South Africa, China, Portugal, and more. The analysis divides between structural materials for new construction, such as wood and bamboo, and thermal insulation materials for the refurbishment of existing buildings, such as straw and hemp. The results emphasize the need for diversifying bio-based material solutions.

s.14.67

HOME: Wood-Mycelium Composites for CO_2-Neutral, Circular Interior Construction and Fittings

A Rossi [1], A Javadian [2], I Acosta [3], E Özdemir [1], N Nolte [1], N Saeidi [2], A Dwan [3], S Ren [3], L Vries [2], D Hebel [2], J Wurm [3,4], P Eversmann [1]

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Keywords: ARE MISSING Building, Digitalization, Life Cycle Assessment, LCA Tools

Office and retail interior fittings have a relatively short service life of 5–7 years. In this context, composite materials are often used, hindering possibilities of reuse or recycling. This research explores novel bio-composite materials and subsequently a construction method for CO_2-neutral, circular interior fittings for office spaces. Based on the potential of fungal mycelium as a rapidly renewable, regenerative, affordable, low-carbon building material, bio-composite construction methods are explored in conjunction with timber-based additive manufacturing using continuous fibres. As mycelium has potentially excellent sound-absorbing properties but low load-bearing capacity, composite construction of timber veneer and mycelium allows to increase the structural capabilities of resulting components, while relying entirely on bio-based value chains. We describe the production process as well as the material development, including robotically aided processes for additive manufacturing of veneer reinforcement grids and compatibility studies of different mycelial species and substrates, and their bonding capabilities with veneer. We further present initial results on the mechanical characterization of the composite material, and its comparison to conventional mycelium composites. Minimal structural, acoustic, and functional requirements for different interior fitting elements are studied and compared to the characteristics of the proposed composite, highlighting the range of applications of the presented wood-mycelium composites.

s.14.68

Hygrothermal Characterization of Bio-Based Thermal Insulation Made of Fibres From Invasive Alien Lake Plants Bounded With Mycelium

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Keywords: Bio-Based Insulation, Mycelium, Hygrothermal Test

The European program »Renovation Wave« aims to fasten the energy retrofit of the building stock by increasing by a factor 4 the current renovation rate. Mycelium-based materials gained momentum as insulation solutions in recent years due to their 100 % biological composition. However, their durability issues, particularly the risk of fast decay due to high moisture content, need to be investigated to promote a safe use in construction. Two bio-composites were set up at a lab scale, a combination of hemp shives and mycelium and a novel mixture based on the combination of mycelium binder and fibres from a lake plant, Lagarosiphon major, an alien invasive species locally available in many EU internal waters. Samples with different dimensions were used to characterize through experimental tests the thermal conductivity, water absorption (capillarity) and vapor permeability. The results show that these mycelium-based composites present both hydric and thermal properties similar to other bio-based material used in construction. The capillarity tests highlighted that hemp composites absorb more water than lake plant ones. The thermal conductivity is similar for both biocomposites, i.e., around 0.05 W/m.K, while the moisture buffer position both analyzed biocomposites in »WS 3« according to the German classification DIN 18947 for water regulators.

s.14.69

MY-CO SPACE: An Artistic-Scientific Vision on How to Build With Fungi

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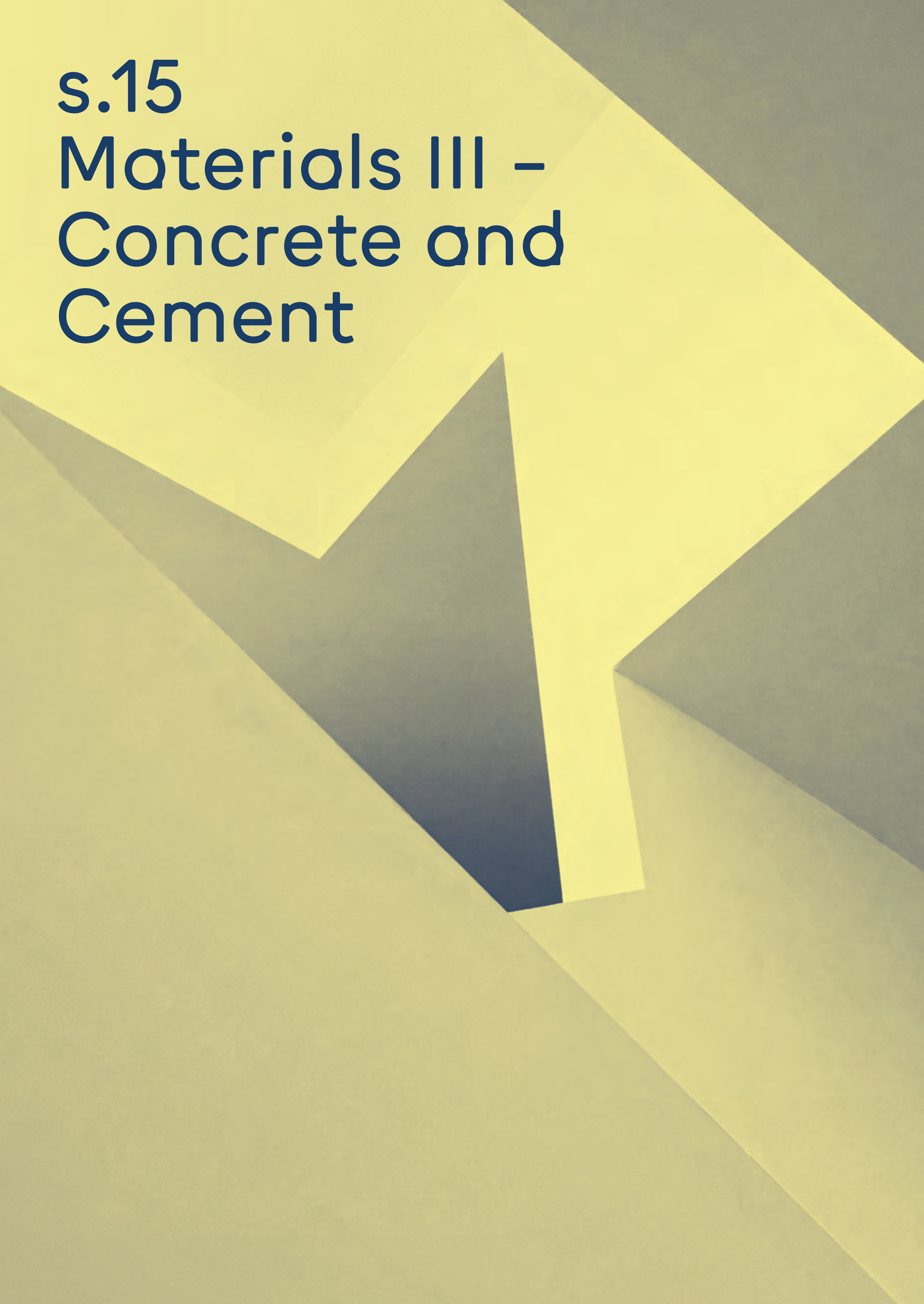
Keywords: Circular Architecture, Digital Design And Fabrication, Fungal Biotechnology, Fungal-Based Materials, Lca

MY-CO SPACE is a collaborative work of the interdisciplinary SciArt collective MY-CO-X, that enables an artistic-scientific discussion about a future social significance of fungi for the creation of places and spaces. MY-CO SPACE is a wooden fungal sculpture that was built from biological materials and is biodegradable. The living space of approx. 20 m² can be divided by the guests themselves into sleeping, reading, and working areas. It is not a completely enclosed space but a retreat and study space that lives from and deals with the contact with the outside world. This architectural artwork strives for a different point of view and a process of interaction in which humans are involved in a conscious as well as unconscious conversation with their environment, a point of view that tacitly implies a flattening of hierarchies between the different agents and authors - human as well as non-human. MY-CO SPACE is therefore a built reflection on a cooperation with biological systems that store, transform, and recycle organic matter and energy, and an exploration of fungi as a future lightweight building material resistant to fire, shock and water, and whose modification through biotechnology is possible. It is the urgency of the planetary situation and the issues we now face that require a holistic approach and close collaboration between art and science.

s.15
Materials III – Concrete and Cement



s.15.70

Individualized Standardization as the Overarching Principle in the Context of Planetary Boundaries

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Keywords: Individualized Standardization, Case Study, Lightweight Aerogel Concrete Technology, Adaptability, Sustainability Assessment

To drive forward a fundamental change in the construction sector to achieve environmentally friendly progress in the construction processes, one promising approach is the synchronous implementation of the three main drivers technology, construction, and design. The key to this transformation is end-to-end digitalization. Our approach aims to achieve a new architectural quality by linking digitized design tools, ecological and environmentally friendly concepts, and serial production processes. Against this background, two research projects were advanced to enable adaptive prefabricated systems based on combined additive manufacturing. Two case studies illustrate the research results. In the first, a digital assessment tool is being developed to improve planning processes. With the tool, standardized yet adaptive constructions can be evaluated according to their sustainability impact in an early design phase. The second approach focuses on delivering a customized material composition realized with additive manufacturing methods. In an automated co-extrusion process, the dimensions and buildingphysical quality of story-high wall panels (floor-to-ceiling) can be adapted to individual requirements. The optimum balance of standardization vs individualized building solutions will introduce a novel flexibility for the architectural design process as well as a higher production efficiency. This strategy of individualized standardization is based on integrative collaboration and visionary research.

s.15.71

Environmental Impact Assessment to Support the Development of New Photonic Metac-Concrete

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Keywords: Photonic Meta-Concrete, Environmental Impact Assessment, Radiative Cooling

The cooling demand in buildings has increased over the past decades due to global warming, the heat-island-effect in cities and the increased airtightness and thermal resistance of the building envelope. This led to an increased use of conventional air-conditioners, which now account for 7 % of global greenhouse gas emissions and 10 % of the total energy consumption. In this context, the MIRACLE project aims at developing a new Photonic Meta-Concrete (PMC) with remarkable photonic properties to reduce the CO_2 footprint of buildings, mitigate the heat-island-effect and global warming. Besides the positive effect that this innovative material can have on the environment during the use phase of buildings, also the environmental impact of the production needs to be minimized. Environmental impact assessment (EIA) is used along the development process of this innovative material to guarantee a low material environmental impact. This paper discusses how EIA is used along the development process and presents the preliminary results in the early stages of the development of the PMC. To investigate the impact of this new material, a cradle-to-gate analysis of the resources, energy and machinery needed to create the concrete mixture is performed. The broad set of environmental indicators of the EC PEF (Product Environmental Footprint) method, such as climate change, acidification, eutrophication, particulate matter, ecotoxicity, water depletion and human toxicity are being considered. Considering such a large set of indications ensures that burden shifting is avoided. The environmental impact of the PMC is moreover compared to the impact of conventional concrete to understand how both perform.

s.15.73

Functionally Gradient Concrete: The Development of a Seismically Resistant Joint for a Functionally Graded Concrete Wall-to-Floor Connection

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Keywords: Concrete Connections, Precast Concrete, Case Study Analyzes, New Connections, Development, Functionally Graded Concrete, Seismic Resistant Joint, Wall-to-Floor Connection

Concrete is known to have a large carbon footprint; however, its versatility and durability are unparalleled. These qualities pertain to the usefulness of concrete in an ever-increasing population, and therefore demand our attention. By optimizing and improving the performance of concrete through innovative technologies, such as functionally graded concrete, the carbon footprint can be reduced. In construction, the weight of a conventional concrete structure accounts for approximately 70 % of a building's total mass. In comparison, functionally graded concrete (FGC) is 50-60 % lighter, accounts for reduced emissions (45-60 %), and has improved insulative properties. These factors are achieved by its increased porosity and efficiency of material. Additionally, in comparison to a conventional concrete system, less raw material would be needed to achieve the same structural requirements and therefore less resources would be required. By varying its density, FGC creates a purely mineral, multifunctional, mono-material element that is fully recyclable. Investigations into implementing FGC as a building component in seismic areas have not yet been carried out. The development of a seismically resistant joint for a FGC wall-to-floor connection is necessary due to seismic requirements present around the world. The project presents a review of existing seismic resilient connection technologies, their classification to small scale and largescale building typologies, and the development of concepts for FGC seismically resilient wall-to-floor connections.

s.15.74

Comparison of Different Post-Demolition Autoclaved Aerated Concrete (AAC) Recycling Options

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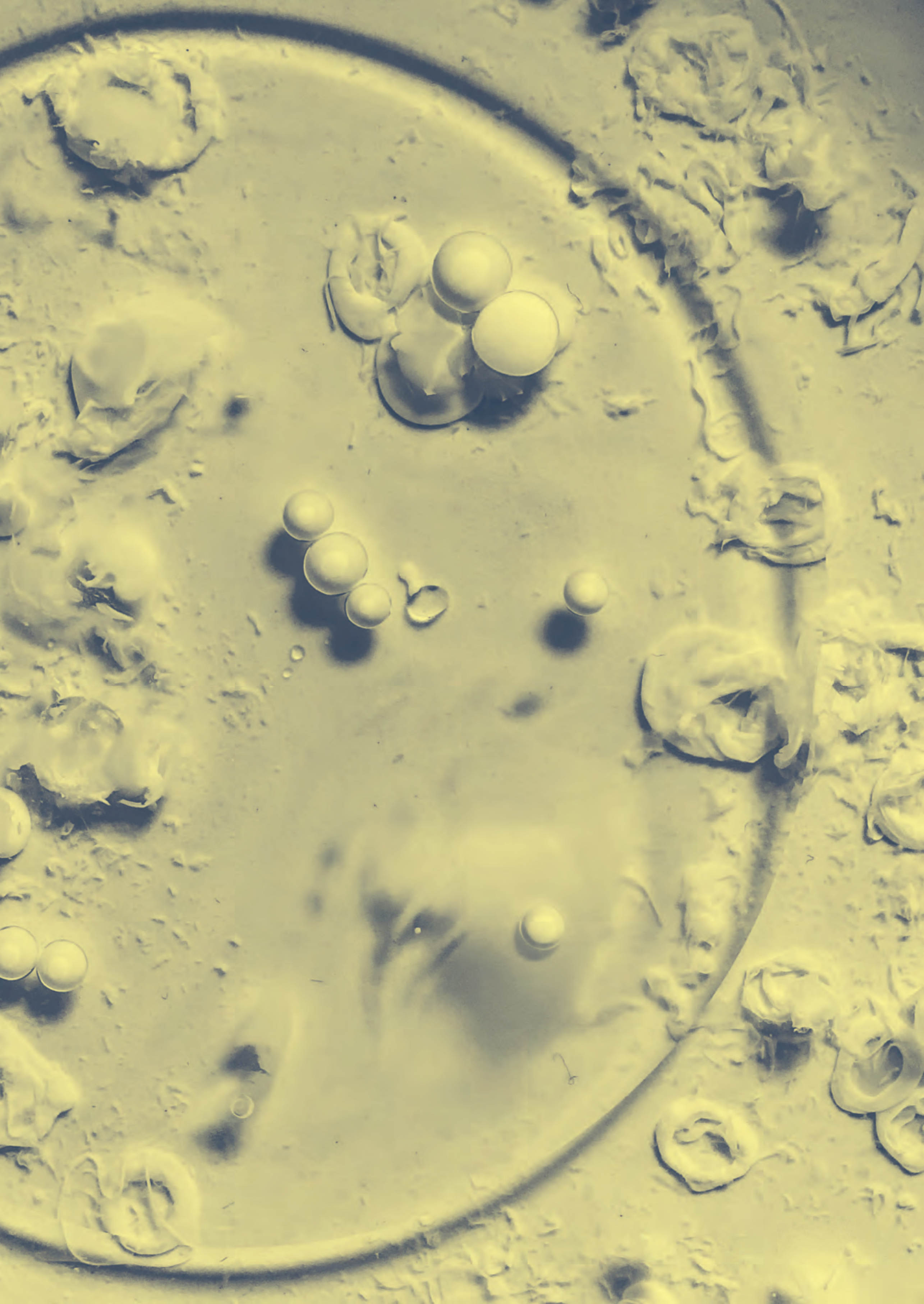
Keywords: Autoclaved Aerated Concrete, Post-Demolition Recycling Options, Assessment, Closed-loop

Autoclaved aerated concrete (AAC) is used as masonry blocks and prefabricated reinforced elements preferably in residential buildings. Due to its porous structure and mineral composition, it combines low thermal conductivity and fire resistance properties. Consequently, the popularity of AAC increases. However, due to significant AAC production volumes in many European countries since the 1960s and 1970s and given building lifetimes, strongly increasing post-demolition AAC waste volumes can be expected in the following decades. Recycling these post-demolition AAC wastes could protect primary resources and landfill capacities and reduce greenhouse gas emissions. But, recycling of post-demolition AAC is not yet established. The majority of the waste is landfilled even though landfill capacities have decreased and the legal framework conditions in Europe regarding a circular economy are becoming stricter. Therefore, new recycling options are needed. Current research approaches propose different open-loop recycling routes for post-demolition AAC, e.g., lightweight aggregate concrete, lightweight mortar, no-fines concrete, floor screed, animal bedding, oil- and chemical binders, and insulating fills for voids and interstitial spaces. Additionally, closed-loop recycling is possible and under research. Finely ground post-demolition AAC powder can be directly used in AAC production or can be chemically converted to belite (C2S) clinker to substitute primary cement in AAC production. These promising recycling options are compared regarding environmental and economic aspects. We find that the resource consumption is lower in all recycling options since post-demolition AAC helps to save primary resources. Furthermore, greenhouse gas emissions associated with the substituted primary resources are saved - especially when substituting primary cement in closed-loop recycling. In economic terms, increasing landfill costs could be avoided, which leaves a considerable margin for the cost of pre-processing, transport and recycling. The results can help decision-makers to implement circular management for AAC by fostering post-demolition AAC recycling and reducing its landfilling.



s.16
Urban Planning I – Housing Strategies

s.16.75

Towards a Climate Neutral Housing Strategy for Egypt: Performance-Based Living-Action Levels and Responsibilities

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Keywords: Climate Neutral Design, Egypt, Housing Strategy, Performance-Based Living

Egypt's population has recently exceeded 100 Million inhabitants; a figure that is anticipated to double within the coming 20–30 years. At a current 2 % annual growth rate, changing socio economics needs, and anticipated demographic change; more than ever, has housing provision become a challenging proposition. Residential construction in Egypt amounts to 21 % of the total construction output by value in 2015 in Egypt (9.548 Billion LE) which is almost equivalent to the construction output by value of power plant (EGP 9.67Billion LE). In addition, the construction and demolition waste accounts for 44 % of the total solid waste of 94 Million tons produced in Egypt. Given the scarcity of resources, the resultant CO_2 emissions and pollution, in addition to Egypt's commitment to the World Sustainable Development Goals (SDGs); this paper, adopts a qualitative approach – literature review, to identify Egypt's major housing challenges and potential solutions in light of SDG11. In this context, the concept of climate neutral design is investigated, different assessment tools are critically reviewed; and major components for strategy development are concluded in terms of levels and responsibilities. These are then used as a reference to reflect on Egypt housing strategies issued in 2016. This paper is exploratory in nature and is anticipated to furnish the ground for the following phase of the research to devise an action driven climate neutral housing strategy for Egypt.

s.16.76

Life Cycle Assessment of Recently Constructed »Climate Protection Neighborhoods«: Which Lessons can be Drawn?

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Keywords: Climate Protection Neighborhoods, Life Cycle Assessment, Decarbonization of Heat Supply, Demountable and Reusable Construction, Renewable Materials

The results of a life cycle assessment of five recently finished housing projects in Northern Germany - all of them part of two certified climate protection neighborhoods - point out the necessity of combining a variety of different carbon reduction approaches in order to reach carbon neutrality. The analysis presented here focuses on both, embodied and operational carbon emissions, as well as embodied and operational energy, over a period of 50 years. Both residential areas examined do not tap the full potential of their environmental impact reduction as they focus on single strategies only: one development limits the reduction of carbon emissions for heating and domestic hot water supply to a max. of 7.5 kg GHG emissions per m² and year, by means of conventional solid construction. For the other estate the developers encouraged timber construction by requiring a minimum share of the construction volume of 70 % timber. Comparing both approaches shows, that climate friendly construction can only be achieved by combining different ways and means, e.g., easily demountable hence reusable timber structures with a high level of energy efficiency and a carbon free heat supply. The results drawn from this study are designated to serve as a basis for discussion of the development of ambitious and climate responsible housing standards in Bremen.

s.16.77

Development of Environmental Benchmarks for the Belgian Residential Building Stock

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Keywords: Residential Buildings, Life Cycle Assessment, Bottom-Up Benchmarks, Embodied Impacts, Operational Impacts

Over recent years various steps were undertaken to integrate Life Cycle Assessment (LCA) in Belgian building practice, including the development of a national LCA method and a calculation tool for architects. Environmental benchmarks are still lacking and are seen as an important step to support policy makers and building practitioners in the definition of environmental targets for buildings. In this research, benchmarks are defined for new residential buildings in Belgium. A bottom-up approach is followed consisting of a statistical analysis of reference buildings to define limit, reference and best practice values. The buildings are based on four representative typologies for Belgium, ranging from detached houses to apartments. Different variants are assessed including various energy performance levels and construction types (solid versus timber). The buildings' life cycle impacts are calculated including the embodied (material) and operational (energy) impacts. Results are reported both for an aggregated environmental single-score and for Global Warming Potential (GWP). The calculated reference values for life cycle and embodied GWP (20 and 7 kgCO_2eq/m^2.year) are comparable to existing benchmarks in the literature. The results further highlight that building compactness provides the largest impact reduction, followed by construction type. Finally, limitations are discussed and recommendations are formulated for developing future benchmarks.

s.16.78

Filling the Gaps: Circular Transition of Affordable Housing in Denmark

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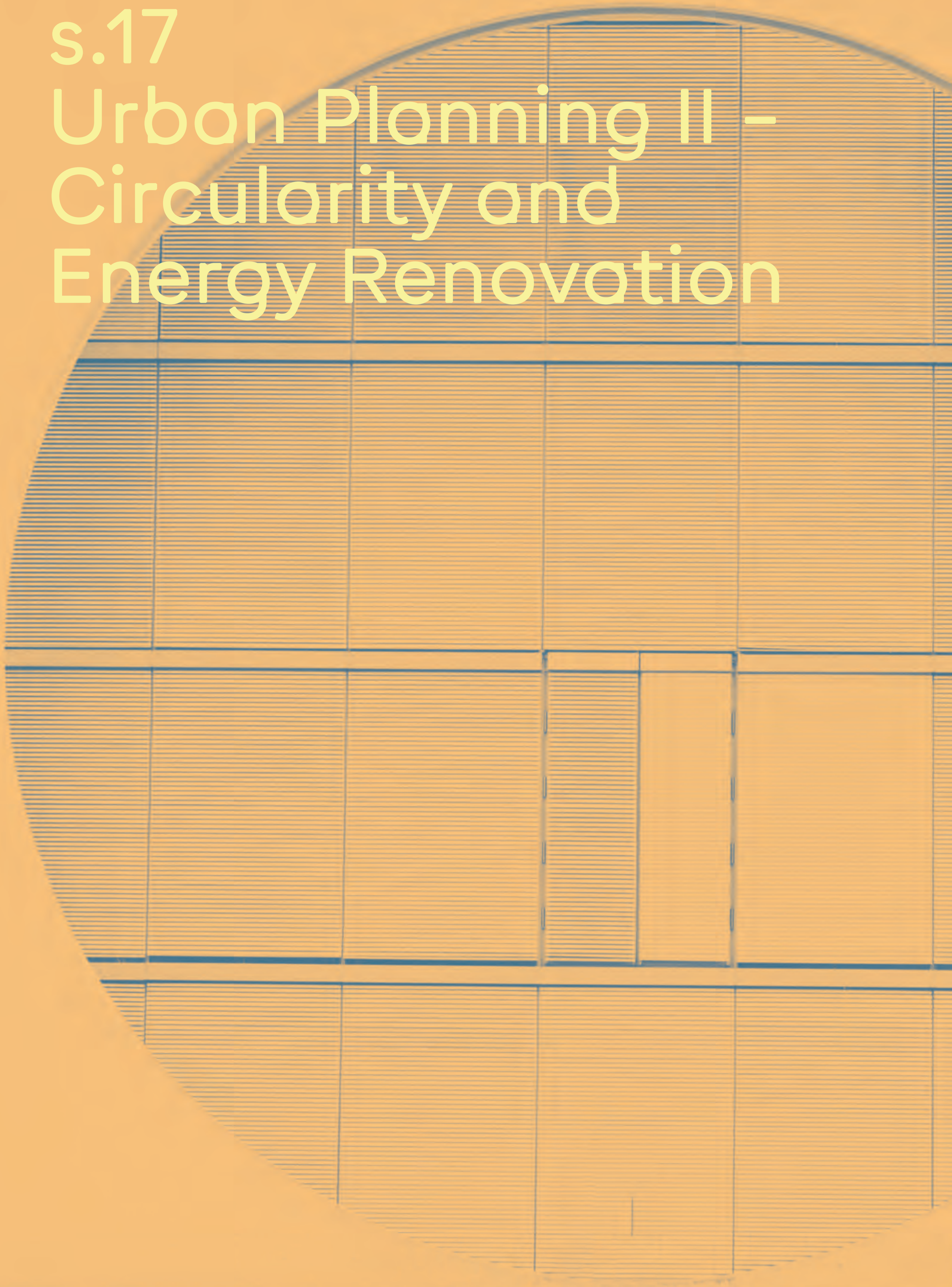
Keywords: Social Housing, Affordable Housing, LCA, LCC, S-LCA, LCSA, Circular Economy

The building industry accounts for about 40 % of all climate impacts, stemming from construction and renovation processes, use of buildings and demolition, disposal and recycling of buildings and building materials. The Danish Parliament passed a Danish Climate Act in 2020 to reduce greenhouse gas emissions by 70 % by 2030, and an action plan in 2021 to create a Circular Economy (CE) in DK that can support the achievement of climate neutrality by 2050. About 20 % of the Danish housing stock is affordable housing with approx. 560.000 affordable housing homes, inhabited by nearly 1 million out of 5.8 million people. In 2020 the Danish Government decided on the most significant overall housing agreement to set aside EUR 5,5 billion for 'Green renovations' and the building of new affordable housing. Building and renovating affordable housing in Denmark can thus become significant drivers for the Danish building industry's transition to CE. Therefore, developing integrated tools and methodologies for life cycle thinking and CE assessment for the built environment is necessary. We have identified four significant gaps in this endeavour in a previously released literature review: For CE to succeed, it is necessary to take a circular view of the life cycle of buildings, which includes the service life phase, the reuse phase and the recycle phase; To achieve CE, it is necessary to continue research regarding the possibilities of integrating Life Cycle Assessment (LCA), Life Cycle Cost (LCC) and Social Life Cycle Assessment (S-LCA) into Life Cycle Sustainability Assessment (LCSA); S-LCA needs further maturation and development; It is imperative to focus upon operationalizing LCSA for practitioners in all phases of a building's life cycle. This paper aims to outline a strategy for analyzing and discussing these four gaps and their interrelation in-depth and suggest an action research proposal to understand better how to bridge the gaps from a research perspective.

s.17
Urban Planning II – Circularity and Energy Renovation



s.17.79

The Potential of Vertical Extension at the City Scale

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Keywords: Housing, Geographic Information System (GIS), Building Reuse, Vertical Extension, Permitted Development

The UK construction sector is central to the climate and housing crises and must now deliver vast amounts of residential accommodation whilst reaching net zero emissions by 2050. Housing provision through the vertical extension of existing buildings offers opportunity to achieve this, reducing embodied carbon emissions and creating more efficient high-density settlements. In England, permitted development (PD) rights allow for residential vertical extensions without the requirement for conventional planning permission. Despite this, and due to limited uptake of PD rights and a lack of existing studies, the potential for housing provision through widespread extension is unknown. This paper develops a framework to assess the ability of vertical extensions in providing housing at different scales and applies this to Sheffield, England. The generation of new dwellings through PD vertical extension could house up to 175,000 in Sheffield, with detached buildings and those in residential use being most suited to extension. PD rights favour the enlargement of existing dwellings over the generation of new residential units, potentially limiting their effectiveness in tackling the housing crisis.

s.17.80

A Circular and Bio-Based Renovation Strategy for Low-income Neighborhoods

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Keywords: Neighborhoods, Circular And Bio-Based Renovation, Revolving Fund, Reusability

The impact of climate change is expected to increase in the following decade. Possible effects on the built environment are identified as urban heat stress, air pollution, extreme weather conditions, etc. As a result, there is an increase in disease and mortality specifically in the cities among the vulnerable citizens such as elderly people and children. Moreover, many cities worldwide are in the evolution of urbanization which leads to increased carbon emissions as well as a demand for more material production and waste. Consequently, the construction industry embodies great potential for reaching the energy and carbon mitigation goals. For regeneration of the built environment, the European directives requires for the renovation of existing building stock as quick as possible. In Flemish context, cities stimulates renovation projects on a systematic and planned basis, by defining »urban renovation districts« which received special financial facilities and subsidizing. Consequently, there is a growing demand for affordable housing in combination with a shortage of qualitative and energy efficient housing opportunities. In the last decades, there has been an intensive effort to develop different retrofit strategies, but there is a lack of comprehensive approach that delivers innovative technical solutions such as circular and bio-based construction methods as a solution to the increased housing demand of vulnerable people. For this purpose, this study combines the efforts of two initiatives, (1) Interreg Circular Bio-Based Construction Industry (CBCI) and (2) the innovative financial policy instrument of subsidy retention for low-income groups (refers to citizens living in poor quality houses with insufficient economic means & social skills to renovate). The study has the ambition to explore the coherence between technical, economical, legal, social aspects for circular urban retrofit strategies. Circular building materials and methods were developed and tested in real-life setting with construction of a prototype living lab (LL) in Technology Campus, Ghent. Depending on the results from the LL, an urban renewal strategy for Flemish districts is proposed by using subsidy retention on macro-economic and social level. The scenario is envisaged as a collective approach with the local community in which the vulnerable users also benefit as direct participants to the research.

s.17.81

Implementation Strategies for Renovation Concepts Based on Participative Planning

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Keywords: Small Urban Unit, City, Case Study, Energy Renovation, Energy Master Plan, Participation

The potential for reducing Greenhouse gas (GHG) emissions by district renovation is largely untapped. It not only requires a thorough Energy Master Planning (EMP) of the district but also support of the decision-making processes. This can not only contribute significantly to reducing energy consumption and securing the location of energy infrastructure (generation, distribution, storage), but also to long-term sustainable development and climate neutrality. Understanding the different solutions for district renovation which include combinations with energy supply and consumption is important in districts. A technical as well as economical analysis is proposed that combines reduction of GHG emissions potential with an economic appraisal. A district near Winterthur, Switzerland was analyzed in respect to the aforementioned aspects. Site visits and structured interviews with key stakeholders were used to collect data which was then analyzed. Different renovation options were simulated, and investment and energy costs were calculated. The results show that the technical potential for a decarbonization is large. However, financial and social aspects are significant and lead to a delay in implementation.

s.17.82

The Voices of Vulnerable Tenants in Renovation

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Keywords: Housing Renovation, Tenant Perspectives, Elderly, Disabilities

This paper focuses on the intersection between agendas for housing renovation and social politics for ageing-in-place and social integration of people with psycologial disabilities. The aim is to understand how elderly tenants and people on a longer sick leave are affected by a renovation. In a sample of 79 interviews, 34 tenants decided to permanently relocate as a results of a renovation. When the renovation is a driver for permanent relocation, tenants do so to avoid disturbances and temporal evacuation. If the home is subjet to a comprehensive or deep renovation, rent increases is another reinforcing factor to relocate. While tenants that move prior to a renovation worry about how the renovation will affect their daily life and their economy, tenants that move after the renovation do so because they are dissatisfied with the results of the renovation. The findings calls for awareness for how housing renovation will affect vulnerable tenants and highlights the need for the design or appropriate communication strategies.

s.17.83

Circularity Evaluation as Guidance for Building Design

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Keywords: Circular Buildings, Circular Economy, Sustainability Assessment Method, End-of-Life Phase, Ecological Design Strategies

Resource scarcity and global warming call for ambitious strategies in the construction sector to meet the ever-growing demand for indoor spaces with minimal resource consumption and positive environmental impacts. In line with the need to introduce circular economy in the construction sector, the German Public Sustainability Certification System (BNB) is revising its indicator for disassembly, separation and reuse. The proposed assessment is intended to guide in the planning process and to point out challenges and potentials of the circular economy by making the complex interactions and requirements comprehensible in detail. The continuity of the assessment from the building material to the building component to the entire building allows users to track the impact of changes made at each level of aggregation. Based on extensive background research, end-of-life categories are assigned to building materials according to their reusability, taking into account assembly techniques and adjacent, associated materials. Example building components illustrate the method and show the impact of design changes. At the building level, the quantity determination of materials in the end-of-life condition allows transparent comparison of different design variants and documents in detail the material inventory for use in building material passports. Future developments envision the inclusion of building services in the circularity assessment, benchmarking of circularity at the building level, and integration of circular qualities into life cycle analysis calculations.

s.18
Urban Governance – Socio-Political Frames for Transition

s.18.84

Sustainable Building Arenas: Constructing a Governance Framework for a Sustainability Transition in Cambodia's Urban Built Environment

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Keywords: Urban Sustainability Transitions, Global South, Transdisciplinary Research, Transition Management, Cambodia

Transition governance approaches for the building sector have been discussed for more than a decade. Very little work has however moved beyond the socio-political contexts of the global north to scrutinize the spatial-institutional challenges of sustainability transitions in the global south, or more illiberal contexts. Consequently, this paper introduces a transition governance framework, a Sustainable Building Arena (SBA), that addresses the contextual particularities of the urban building regime and its de/stabilizing factors in the case of Cambodia to inform transformational change. The design of the SBA draws on the literature on urban transition management, transition management in the Global South, as well as transdisciplinary transition management arenas, and extends these concepts to Cambodia's urban built environment. It furthermore builds upon the results of an extensive analysis of the socio-technical system and an evaluation of residential buildings in Phnom Penh, including indoor environmental conditions. The SBA is conceptualized as an informal institution and as a protected and co-creative space at the science-policy-business-civil society interface. It allows sustainability-minded but often marginalized actors to co-produce and pluralize knowledge – including the co-development of problem framings, visions and transition strategies – and facilitates cooperation, as well as the creation of alternative discourse coalitions and networks of social capital. Overall, the paper argues that such scientifically grounded and participatory processes, that are attentive to and designed for the particular spatial-institutional context, can indeed support the development of actionable knowledge, the empowerment of marginalized actors and support collective action for transformative change in the built environment sectors in contexts outside the Western liberal norm of transition studies.

s.18.85

Critical Indigenism as Approach for Sustainable Urbanization

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Keywords: Urbanization, Sustainability, Africa, Indigenous, Structures, Materials

Within the next 30 years, cities will grow dramatically. Rural areas will become new urban centers, and open spaces will transform into urban cityscapes. Population growth, demolition of natural landscapes, and urbanization are fueling the already imminent threat of climate change. Indigenous structures with their own »critical regionalism« touch on a wide range of cultural, economic, and societal aspects. The authors of this paper examine the possible influence of indigenous vernacular structures and the important regional dependencies in African communities. Paradigm would be the use of materials, typologies, building layouts, urban planning, and ecological concepts as well as the question of the importance of a defined urban image. The paper is based on results derived from interdisciplinary and intercultural collaboration within the framework of the Female Academic Leadership Network for Conscious Engineering and Science towards Sustainable Urbanisation FALCONESS.

s.18.86

Urban Qualities for Dense Mixed-Use Spaces: Theses, Case Studies and a Toolbox for Integrated Tangible Urban Planning

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Keywords: Urbanism, Densification, Urban Development, Urban Zoning, Hybrid Use, Quality Discourse, Integrated Planning Approach, Tangible Urban Design Elements

The built environment is under pressure. Climate change, migration and social inequalities challenge previous urban planning concepts and will change our cities. The task is to transform the sustainable city of the future into a climate-friendly and socially just living space. Solving these challenges requires an integrated quality discourse with all actors based on tangible structural-spatial situations. In the BBSR research project »Qualities of Urban Zones«, contributions for an early in-depth quality discourse were developed based on the new building zone category »urban zones«. Urban zones are regarded as a future-oriented concept for sustainable densified districts and a diverse, ever-changing mix of uses.

This paper presents the specific context and main findings as »theses of urban quality« as well as potential applications for MU. The authors propose guidelines to improve process quality and illustrate exemplary tangible structural-spatial as well as process-related »design elements«. A toolbox with instructions and templates to design and implement scenario-based workshops supports an integrated quality discourse in urban development.

s.18.88

Matching Energy Targets, Stakeholders' Needs and Modeling Choices in Developing Urban Energy Scenarios

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Keywords: Building Stock, Scenario Method, Stakeholders Engagement, Energy Demand, Urban Building Energy Model

In order to meet greenhouse gas reduction goals, cities need to develop robust energy transition strategies relying both on the local capacity of combining social, economic and environmental perspectives in the decision-making process and on the collaboration between different actors to achieve knowledge and data integration. Scenarios are well-established methodological instruments to guide decisions in energy and spatial planning and have been employed to compare possible future pathways and envision the consequences of implementing decarbonization measures. However, qualitative and quantitative scenarios approaches are often disconnected. With the primary goal of supporting the implementation of the energy plan, this study develops for the City of Gothenburg a participatory method to support the alignment of qualitative and quantitative scenarios approaches. Decarbonization actions and drivers of change were discussed and prioritized in workshop sessions with representatives from the energy supplier(s), municipal administrations (city planners, environmental department), and researchers to develop relevant qualitative scenarios descriptions. Based on this, a list of requirements for quantitative scenarios analysis is developed to be, in a next step, translated and integrated into urban building energy models. Findings indicate the importance of early knowledge integration from different fields and highlight the lines of advancement in urban energy modeling to facilitate decision-making towards successful implementation of decarbonization targets.

s.18.89

Effects of Sustainability Policy: Evaluating Social Consequences of Carbon Targets Using Trip Completion Rates

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Keywords: Neighborhood, Social Sustainability, Trip Completion Rate, Scenario Analyzes, Personal Carbon Allowance, Social Equity, Travel Survey

Sustainability is widely recognized as having social, economic, and environmental dimensions. Strategies to combat global climate change inherently have an environmental focus. However, in line with the sustainability agenda, the social and economic dimensions must also be addressed. Evaluating the social consequences of decisions is often challenging due to a lack of relevant tools and indicators to measure and track them. This paper presents the Trip Completion Rate (TCR) as an indicator currently under development to evaluate the social consequences of climate change policies such as Personal Carbon Allowances (PCA). TCR is an accessibility indicator that evaluates the proportion of a population that can perform their daily activities against a performance metric. Two examples demonstrate the sensitivity of social impacts based on the geographic and demographic variations in different locations, one at the region level and another at the municipal level, through a national household travel survey (NHTS). The Västra Götaland region of Sweden is taken as a test case to illustrate how the indicator may be used, comparing TCR on the entire region and then comparing it to TCRs calculated at the municipal level. The greenhouse gas emissions of the trips are calculated based on assumptions for different modes of transport. Finally, the results are evaluated against a hypothetical PCA based on the climate goals for the city of Gothenburg, Sweden. The results show that the ability to satisfy one's daily travel needs depends on individual characteristics such as behaviour patterns of travel, travel mode choices and access to local amenities.
We find that PCAs may disproportionately affect certain groups more than others. Policymakers must understand who is most affected by sustainability targets to ensure that disproportionately affected groups have an equal opportunity to achieve their daily needs and that adequate measures are taken to mitigate the local policy effects on social equity.

s.19 Life Cycle Assessment I

s.19.90

Integration of Life-Cycle Assessment in a Multimodal Building Design Approach

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Keywords: Building Project, LCA, Building Performance, Parametric Design

Decades of rapid and widespread digitization of our living and working environments have not yet brought about a comprehensive qualitative improvement of our built environment in terms of sustainability and functional and aesthetic performance. The designs of the future must be much more consistently concerned with optimizing the multimodal performance of human spaces. This paper presents a design approach to implement and combine life-cycle assessment with different simulation methods such as energy efficiency, daylight analysis, acoustics, noise insulation, structural analysis and fire protection in order to provide the designer with tools to evaluate how architectural decisions affect the building performance and its environmental impacts. This approach was applied by the architecture students of a master course at the Universität der Künste Berlin. They were given the program of a building to be constructed in the Siemensstadt in Berlin and they implemented this methodology to come up with different sustainable designs. This paper also discusses the results of this course and empathizes how the implementation of simulation tools does not constrain the possibilities of the design process, but it enriches it and leads to a more sustainable built environment.

s.19.91

Tool Characterization Framework for Parametric Building LCA

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Keywords: Early-Stage Design, Life Cycle Assessment, Tool Characterization, Parametric Design, Sustainable Architecture

Connecting Life Cycle Assessment (LCA) to parametric design has been suggested as a way of facilitating performing environmental assessments in early design stages. However, no overviews of potential approaches and tools are available within recent research. Also, no characterization frameworks adapted for parametric LCA tools are present. In order to guide the development of workflows for environmental analysis aimed at the early design stage of buildings, the goal of this paper is to provide such a framework, and to demonstrate its use by characterizing a number of available LCA plug-ins for the commonly used parametric design framework Grasshopper® (GH). First, a framework for classification and characterization of tools based on workflow, adaptability, and required user knowledge was developed. Second, a tool inventory was performed, identifying 13 parametric LCA plug-ins for GH. Finally, four of these plug-ins were further investigated using the developed evaluation framework, a user persona approach, and a simplified test case. It was found that the characterization framework was able to differentiate tools based on the level of LCA expertise integrated in the tools, and the allocation of responsibility for data entry and interpretation. A contrast was found between streamlined tools, and tools which provide more versatility. The characterization framework, and the resulting overview of approaches can be used to guide the future development of parametric environmental analysis frameworks.

s.19.92

Consequential Impacts of a Net-Zero Carbon Design: Life Cycle Assessment of an Active Building

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Keywords: Building, Life Cycle Assessment, Consequential LCA, Case Study

Life Cycle Assessment (LCA) is becoming the predominant means for determining if a building design meets a carbon emission target. These target values are set to help building designers meet aspirational net-zero carbon targets. Within LCA, there are two modeling frameworks. Attributional LCA (ALCA) assigns a portion of global emissions to a specific product or process. Consequential LCA (CLCA) assesses the impacts from a market's response to a change in demand for a product or process. A case study building, located in Swansea, UK, has been assessed to investigate the differences between ALCA and CLCA. The case study building employs: a modular off-site construction building fabric; on-site energy generation; and, on-site energy storage – all strategies that may be adopted at large scale to decarbonize the built environment. Based on global warming potential assessed over a 100-year time horizon (GWP100), the total upfront embodied impacts from CLCA are 19 % higher than that from ALCA. Three differences exist within the rank order of building elements. The Frame presented the highest contribution to the GWP100 within the CLCA results, whereas External Walls contributed the most within the ALCA results. The differences arise mostly from how electricity production is modelled within attributional and consequential datasets and whether substitution or cut-off are used within the background processes. CLCA can capture the environmental impacts of decisions taken to create a net-zero built environment. However, CLCA should not be directly compared to ALCA without appreciating and recognizing how the methods and scopes differ.

s.19.93

Buildings LCA and Digitalization: Designers' Toolbox Based on a Survey

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Keywords: Building, Digitalization, Life Cycle Assessment, LCA Tools

In a context of digitalization and increasing quality requirements, the building sector is facing an increasing level of complexity regarding its design process. This results in a growing number of involved actors from different domains, a multitude of tasks to be completed and a higher degree of needed expertise. New buildings are also required to reach higher performances in terms of environmental quality. To that regard, the exploitation of the full potential of digital tools can facilitate the integration of environmental aspects in the planning process, limit productivity shortcomings and reduce environmental impacts, which can result from an unaware decision making. Building environmental assessment can be performed through several Life Cycle Assessment (LCA)-based tools. »Pure calculation« tools quantify final buildings' environmental potential, while »complex tools« additionally support decision making during the planning process. It is often difficult to choose the best suitable tool, which strongly depends on the user's needs. Within the IEA EBC Annex 72, a survey was realized with the main objective of creating a comprehensive overview of the existing tools dedicated to buildings LCA. The questionnaire included the usability, functionality, compliance, data reliability and interoperability of the analyzed tools. Lastly, based on the survey outcomes and their critical assessment, a procedure for the identification and selection of a tool has been proposed based on user's needs. As a result, this work outlines main features of currently available building LCA tools, for which there is a harmonized status in terms of usability and overall applied LCA methodology. Despite the need for more automatized workflows, tools' embedding is mostly not yet applicable in system chains or limited to a restricted number of tools.

s.19.94

To Weigh or Not to Weigh? Recommendations for Communicating Aggregated Results of Buildings LCA

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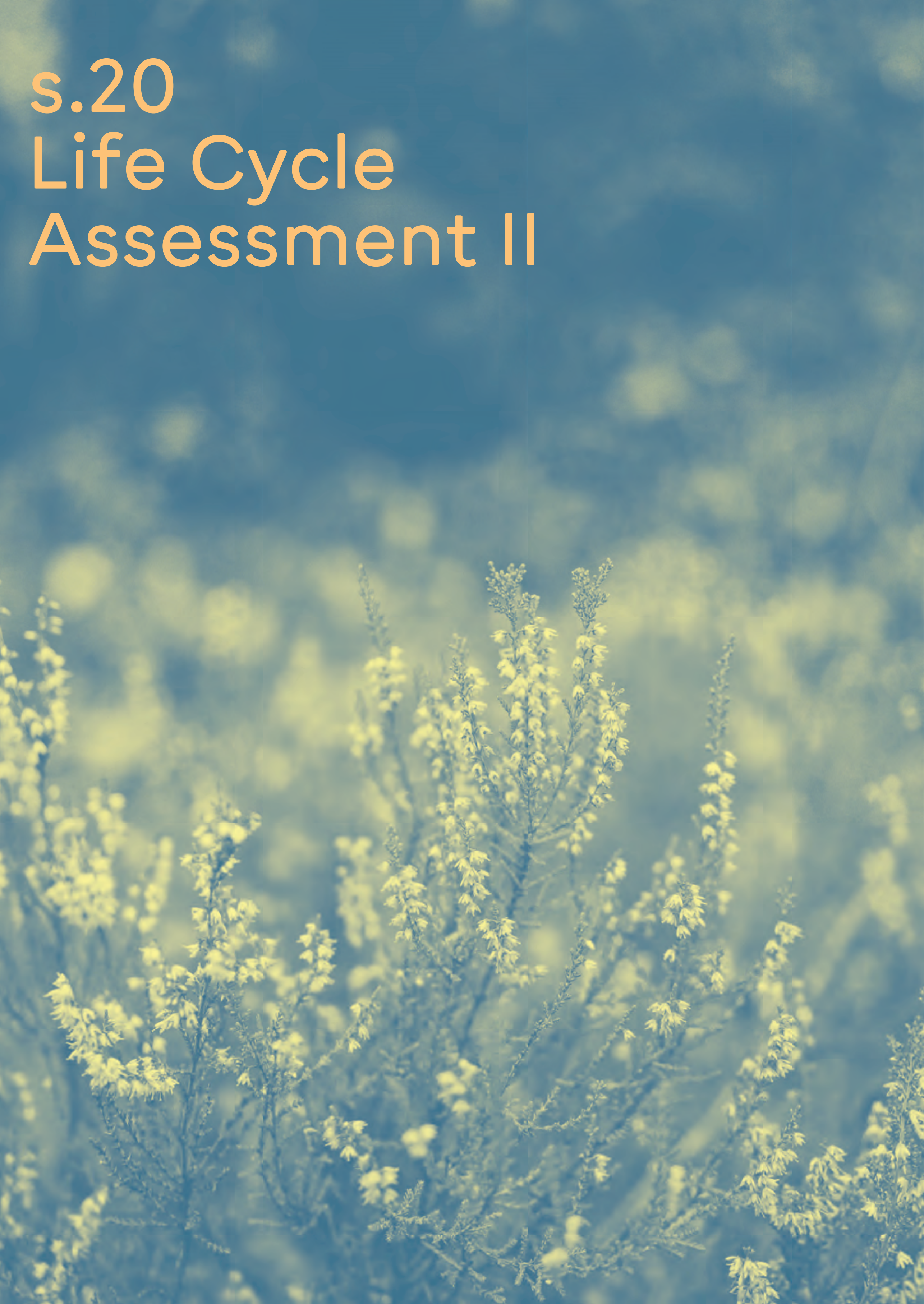
Keywords: Buildings LCA, Weighting, Distance to Target, Panel, Monetization

Interpreting contradictory results of multiple midpoint environmental indicators is challenging task. Hence, partial or full aggregation into building single scores has gained ground for the clear message they convey. This paper helps to improve understanding of the possibilities and limitations of such practice. Partial aggregated scores of five buildings were explored, limited to the environmental indicators shared by the methods examined and inventoried for the case studies. In general, the buildings' single score ranking was maintained regardless of the aggregation approach, but rank reversal is possible if, e.g., ecotoxicity impact indicators are considered. Such indicators are directly influenced by the mass of metals used in a building. Furthermore, uncertainties on their results, in LCI data and in impact and damage assessment are high, and experience with them is still limited. No single best aggregation stands out per se. All of them can play their part if officially supported to ensure that coherent weights/factors are built upon solid, up-to-date data and fair intergenerational and income equity valuation procedures. In such cases, LCA practitioners are encouraged to use single scores in addition to environmental profiles or selected indicators. Overall aggregation procedures shall be transparently described, and zero pure time preference rate and equity weighting applied and explicitly declared. Sensitivity/uncertainty analysis shall be performed to assess results robustness, potential ranking reversal risks, and the effect of different discount rates. When partial aggregation is alternatively pursued, it shall be based on endpoint categories.

s.20
Life Cycle Assessment II



s.20.95

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Keywords: LCA, Residential Buildings, Basement, Functional Unit, GWP

What Is the Impact of a Basement on a Building LCA and What Role Does the Functional Unit Play?

The goal of reaching nearly zero emissions in the construction sector by 2045 is important and at the same time ambitious. Therefore, emissions from operation and structural design of a building play an important role. Life cycle assessment is an established method for determining the environmental impact of a building throughout its life cycle. The implementation of an LCA follows in general the standards ISO 14040/14044, and on building level the standard EN 15978. It requires, among other things, the definition of the goal, the system boundaries and the functional unit.

For buildings with basements, there are certain discrepancies in the definitions of goals, system boundaries, and functional units.

When the production, construction and maintenance phases of a building are included in the system boundaries of the LCA, the whole building is considered and is for example related to the functional unit gross external area or others as net external area or heated area. The set goal, system boundaries and selection of the functional unit has a direct influence to the LCA results.

In this paper, the effects of a basement on the LCA results of the operational and structural design of a building are presented as a function of different functional units. Therefore, a comparative LCA on residential buildings in two different energy standards (level 40, level 55) and additionally for conventional and future-oriented construction were calculated.

s.20.96

Reviewing Allocation Approaches and Modeling in LCA for Building Refurbishment

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Keywords: Building, Refurbishment, Life Cycle Assessment, Allocation, Renovation

With a growing building stock and initiatives such as the European »renovation wave« which aims to double the annual energy renovation rates in the next ten years, environmental assessment of building refurbishment becomes still more important. Using standardized environmental assessment methods such as life cycle assessment (LCA) on renovation projects is important to keep impacts low, and avoid burden shifting. However, a specific methodological challenge in refurbishment projects is how to include the existing building materials in the assessment. The aim of this study is therefore to present and characterize different existing allocation approaches for LCA in refurbishments. Furthermore, the study highlights advantages and disadvantages of the analyzed approaches from an LCA practitioner's view. A literature review was conducted to find studies that illustrate the different allocation approaches and modeling of the existing materials in refurbishment projects. The approaches characterized in the study include allocation using 50:50, avoided burden, product environmental footprint (PEF), burden-free (and semi-burden-free), residual value or depreciation, and adjusting for past production of existing materials. The implications for LCA-practitioners were evaluated based on the work burden required for application. Here, the main cons relate to the large workload connected to modeling the existing building.

s.20.97

How the Modeling of Transport Affects the Building Life Cycle Assessment (LCA) Results: A Case Study Analysis

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The building Life Cycle Assessment (LCA) involves the use of different types of information about the building, including products, processes, and services related to the building and along its life cycle. The modeling of the transports process can be complex and performed using different approaches and assumptions. Considering the existing approaches, the most accurate results, close to the real scenario, must be calculated once the building has already been built. While others are based on estimations used at design stages and based on generic scenarios and data sources. But what can be the variation of the LCA results when using different modeling options for transport modules? To answer these questions and to identify the possible errors or dispersion of the LCA results related to the different transport modeling options, the transport impacts using a case study and compared five different modeling options are calculated. The results obtained provide evidence that the transport impact difference between the lowest values (the real scenario) and the highest values (normalized detailed scenario) is around 30 %. To conclude, efforts should be invested in defining the default scenarios especially for transport distances and volumetric capacity of the transport vessels correction, adapted to the real scenario.

s.20.98

Automated Life Cycle Inventories for Existing Buildings: A Parametric Reference Model Approach

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Keywords: Renovation, LCA, Whole-Life Carbon Assessment, Early Design, Parametric Model Generator

Buildings account for 40 % of global Greenhouse gas (GHG) emissions. In heating-dominated climates, most building-related emissions originate from building stock operational energy, especially from buildings constructed before energy requirements were introduced. Renovation can mitigate operational emissions, however, materials should be included to increase the mitigation potential. Life-cycle assessment (LCA) includes emissions from materials and energy but are time-consuming in renovations because BIM-aided approaches for automating inventories are inaccessible for existing building fabric. This paper proposes a parametric inventory-generator for existing buildings, which defines material quantities through few key variables, which are accessible in early design stages, and which relate to a reference model for a specific building type. The generated model includes LCA inventory data such as service life, replacements, and End of Life from a generic impacts database. The model is adjustable and can be supplied with predefined renovation interventions and new components. The proposed simplification has potential to facilitate modeling of LCA inventories for every existing building, and makes LCA feasible for more than deep renovations, offering a base for the proposed renovation pass by the EU commission. Future research will add building types and explore implementing default inventories based on cadastre data as public resource.

s.20.99

Energy – Comfort – Environment: What Matters Most? A Multi-Criteria Assessment of a Residential Apartment

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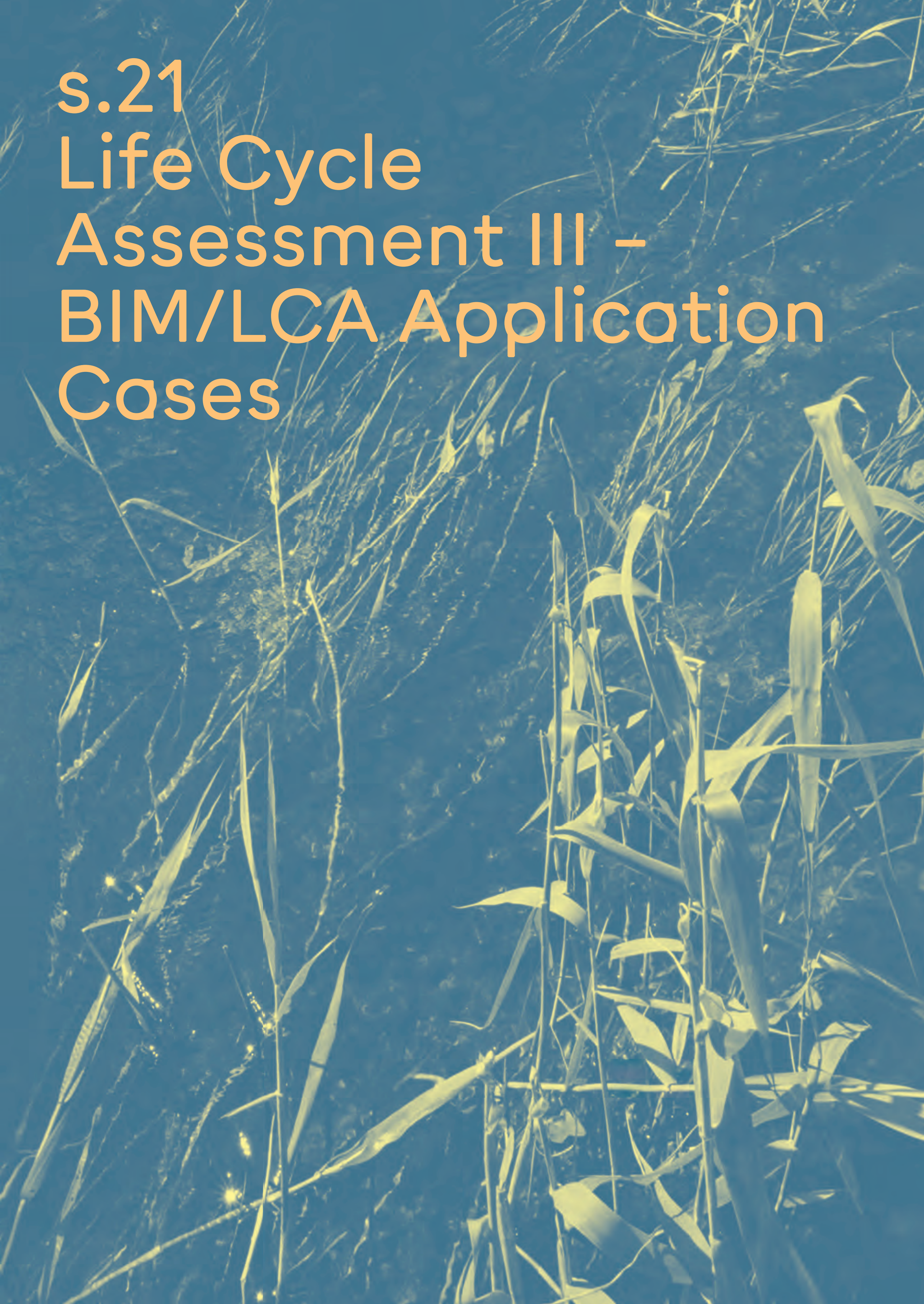
Keywords: Residential Building Apartment, Primary Energy Consumption, Thermal Comfort, Visual Comfort, Carbon Emissions, EnergyPlus Software, Analytic Hierarchy Process, Multi-Criteria Decision Making.

In this study, a multi-criteria assessment approach is performed for a residential apartment located in Athens, for a combination of different energy systems, building envelope and shading systems. 24 alternative cases in total are fully simulated via EnergyPlus software aiming to the calculation Key Performance Indicators (KPIs) in terms of energy consumption for heating and cooling, thermal comfort, visual comfort and environmental impact. The results of KPIs are fed to a decision-making process that takes into consideration the preferences of stakeholders. The optimum solution is selected by the use of the Analytic Hierarchy Process (AHP). In the most optimum scenario, the potential of primary energy savings and CO_2 emissions are approximately 35 % while the discomfort hours for thermal and visual comfort are respectively 17 % and 67 % less than the cases with the worst comfort conditions. The results suggest that such a multi-criteria assessment approach can be useful at an early stage of building design or renovation in order to better inform decisions and avoid sub optimizations.



s.21 Life Cycle Assessment III - BIM/LCA Application Cases

s.21.100

Bridging the Gap: A Database Tool for BIM-Based Circularity Assessment

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Keywords: Buildings, Database, BIM, LCA, Circularity

The concept of circular economy attracts attention across sectors. Since construction materials are the single largest material stock and flow, there is a particular interest from research and policy to apply the circularity concept to buildings. Large quantities of construction and demolition waste end up in landfill, despite new EU legislation that requires a 70 % recovery rate. There is a gap between this ambitious goal and the reality of the construction industry. Building Information Modeling (BIM) has the potential to improve building design and construction processes for an increased recovery of materials. However, insufficient data, inconsistent methods and interoperability issues inhibit BIM application to unfold its full potential in circularity assessments. This paper introduces the CirBIM database framework. It provides BIM users with the required robust data to improve the circularity throughout the building's life cycle: from the design phase throughout renovation activities to the end-of-life stage. The paper proposes a new workflow of building circularity assessment, describe the architecture of the new database tool, and recommends relevant data sources and information models to streamline data mining processes. The new database tool is exemplified through application to a case study building in Portugal, emphasizing the need for different metrics and the need of integration of the end-of-life scenarios in the building design stage.

s.21.101

Developing an Integrated BIM/LCA Framework to Assess the Sustainability of Using Earthen Architecture

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Keywords: Earthen Architecture, Life Cycle Assessment, Building Information Modeling, Framework, Viability

The construction industry is responsible for one-quarter of the solid waste generated globally, much of which is excavated soil. Repurposing this soil for the use of earthen architecture (EA) will reduce a considerable amount of this waste. However, little research has been conducted on how to assess the use of EA within the architectural, engineering, environmental and economic context, and in comparison with other construction system solutions. This paper presents the development of an integrated building information modeling (BIM) and life cycle assessment (LCA) framework to explore what advantages EA may have, based on the client's needs and the building's requirements. The decision-making conditions and criteria for the use of EA are firstly identified in an extensive literature review supported by interviews with decision-makers. A workflow is secondly proposed to apply a LCA evaluating the decision criteria in a BIM tool at the early-design stages. This method allows for the evaluation and comparison of choice criteria as functional requirements of the building and objectives set by the decision-makers. The flexibility of setting input parameters in this tool increases the visibility of the potential benefits of EA over other construction systems. Along with this approach, upcoming applications on case studies will aim to be replicable by designers, based on their practices and design tools, to support clients in their choice of using EA.

s.21.102

Concept for Combining LCA and Hazardous Building Material Assessment for Decision Support Using BIM

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Keywords: Open BIM, IFC, LCA, Hazardous Building Materials

The construction and building sector is responsible for a large part of the world's re-source and energy consumption and is considered the largest global emitter of greenhouse gas (GHG) emissions. Hazardous and toxic substances in building materials affect indoor air quality as well as the environment and thus have a high impact on human health, as we spend around 90 percent of our lives in buildings. Life cycle assessment (LCA) and hazardous building material requirements of green building certification systems allow to reduce the environmental and health impacts of building products and materials. However, they are usually very complex and time-consuming to perform and require expert knowledge to use the results for decision support. Digital approaches to support the simplified application of these methods and intuitive visuali-zation of results are becoming increasingly important. Especially Building Information Modeling (BIM) offers a high potential for this purpose, as the integration and linking of geometric and semantic information in 3D-models for LCA and hazardous building material assessment can be done much more efficiently and intuitively.

Within the scope of this work, the following three objectives were pursued (1) development of a method for combining LCA and hazardous building material assessment, (2) simplification of the results by converting them into comprehensible indicators for decision support, and (3) implementation of the method in a BIM-based digital assistant for intuitive visualization and communication. The preliminary results show a concept for combined use of LCA and hazardous building material assessment in Germany with differentiation in six use cases. A prototypical implementation as BIM-integrated digital assistant was developed for one of these use cases. For the first time, this prototype provides understandable feedback in real time of LCA and hazardous building material requirements. This research project contributes to the awareness in the context of embodied impacts and low emitting materials in buildings and advances the current digitalization potentials.

s.21.103

A Carbon-Focus Parametric Study on Building Insulation Materials and Thicknesses for Different Heating Systems: A Swiss Case Study

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Keywords: Building Insulation Material, Building LCA, Embodied Impacts, Parametric Analysis

To tackle the problem of climate change, Swiss energy strategies aim to reach the carbon neutrality by 2050. However, this challenge cannot simply be solved by focusing on the operational energy performance and instead, on a lifecycle evaluation. Thus, in order to reduce the sector's carbon footprint, building stakeholders need to consider embodied GHG emissions of construction materials. In this study, a parametric method was developed to balance operational and embodied impacts of insulation strategies on GHG emissions according to the material and heating system choices. The methodology is split into two for the computation of the overall carbon emissions of the heating plus insulation system. Firstly, the calculation of the embodied emissions, which relies on Environmental Product Declarations of different construction materials. Secondly, the calculation of the operational emissions, which is the product between the thermal energy needs and the energy carbon content of the respective heating system. Thereafter, the methodology was applied to two case studies: an existing building and a brand-new building. The first main finding was that, for high-carbon insulation materials, there was clearly an optimal thickness after which, adding insulation would only increase the lifecycle impact of the system. For instance, in the heat-pump equipped case study, installing 35 cm of extruded polystyrene insulation (XPS) is more harmful towards global warming than installing 17 cm of XPS. This trend was not present for low-carbon materials whatsoever. The building's carbon emissions benefited from their addition of insulation up to the maximum thicknesses studied. To conclude, it is also important to highlight that aimlessly targeting energy efficiency can be a step back towards the goal of carbon neutrality. Indeed, it is possible to claim that for energy efficient buildings, fossil fuel-based insulation should be carefully used. This study allowed the development and application of a method that identifies optimal insulation thickness and material for a given heating system and hopefully, highlight the importance of considering both embodied and operational emissions of construction materials and systems.

s.21.104

Development of an Advanced Methodology for Assessing the Environmental Impacts of Refurbishments

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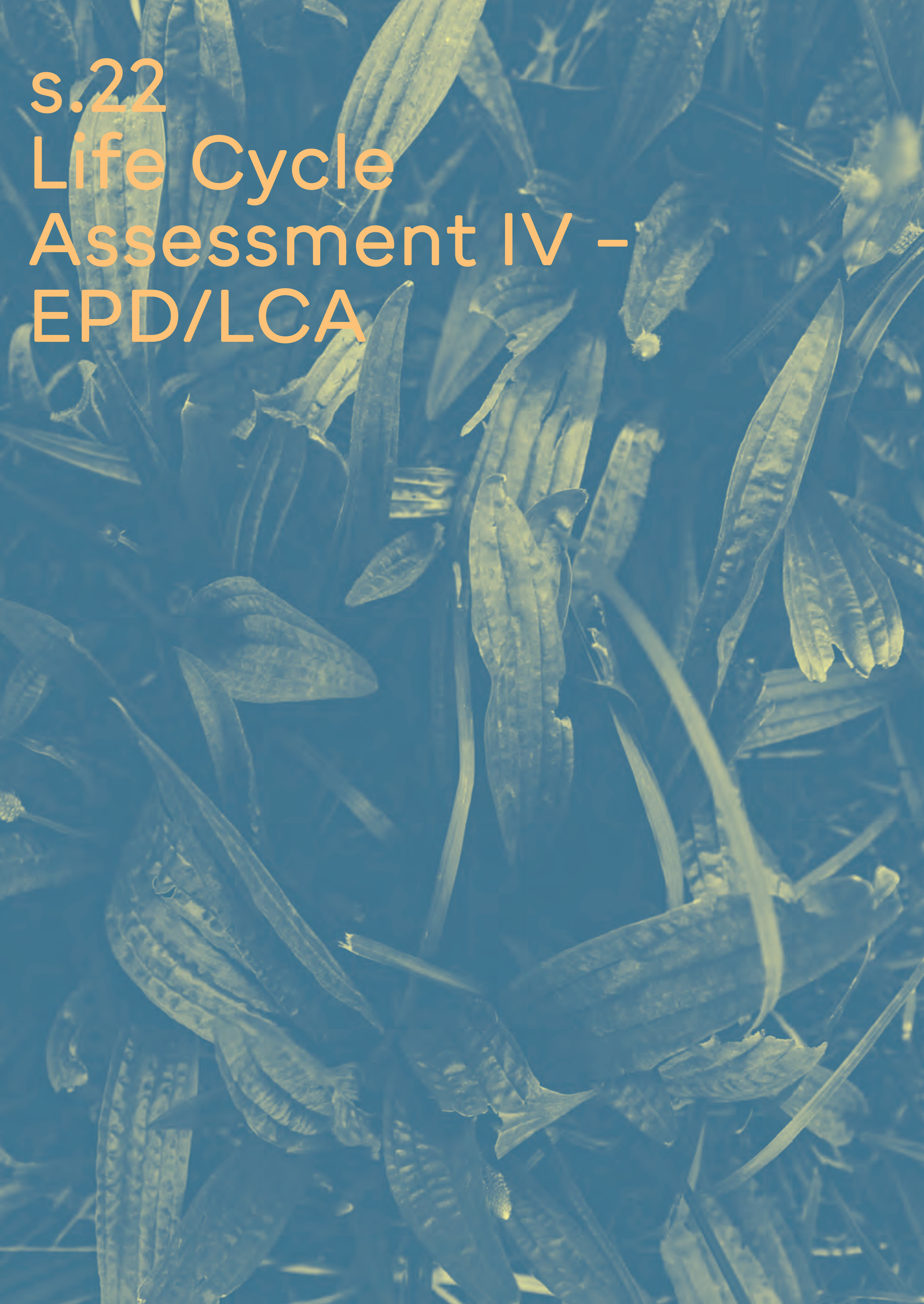
Keywords: LCA, Refurbishment, Allocation, Module D, Dynamic LCA

The refurbishment of the building stock is one of the key tasks for reducing the future environmental emissions in building sector. The assessment of the environmental impacts (EI) of refurbishments with LCA methodology remains a challenge. In the current practice, the refurbishment is threated as the beginning of the new lifecycle and all the impacts associated with the previous life cycle are generally neglected. The exclusion of materials and components used prior to the refurbishment produces a data gap at the end-of-life since information about materials that remained in the building after the refurbishment are missing. Furthermore, no information about what impacts have already been considered in the past bears the risk that some of the impacts are double-counted. In order to overcome these problems, an advanced methodology for the assessment of the embodied impacts in the case of refurbishment was developed that combines two sub-methodologies that can also be used separately. The first sub-methodology is used for remodeling the input data in order to make them time corresponding. The second sub-methodology is used for the assessment of the EI in the residual value of building materials and components and is including the allocation of EI between the life cycle before and after the refurbishment. The combination of the two sub-methodologies enables a more realistic and accurate assessment of the environmental impacts.

The methodology is presented on the case study of a façade refurbishment. Five different allocation approaches were included and the residual value is calculated after a selected time period before and after the refurbishment. For all the inputs time-corresponding data is modeled and used. The study showed that for the life cycle before the refurbishment the EI and the residual value are generally higher if time-corresponding data is used since the EI of the electricity mix are higher. It turned out that the use of different allocation approaches is favoring either the use of recycled or reused materials or the recycling of the materials at the end. The PEF and the cut-off approach with module D are both enhancing the circular economy. It can be assumed that they are likely to prevail in the future.

s.22 Life Cycle Assessment IV - EPD/LCA



s.22.105

Management and Communication of HVAC-Specific Life Cycle-Related Information: Filling the Gaps for Sustainability Assessment of Buildings

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Keywords: HVAC-Systems, Information Management, Information System, EPD, DoP

Assessing the contribution of buildings to sustainable development is no longer just a matter of scientific investigation. Increasingly, such considerations are becoming a prerequisite for the award of subsidies or the fulfillment of legal requirements. One aspect is the evaluation of the environmental performance, based on a life cycle assessment of the complete building in its life cycle. This requires corresponding data on all installed products (materials, components, systems) on a consistent methodological basis and suitable communication forms. To that, in-formation is required on technical characteristics and the life cycle assessment results of con-struction products. Thereby the following problems are occurring: (1) there are not enough en-vironmental product declarations according to EN 15804 A2 available in the field of building services systems (e.g., HVAC) and (2) the data contained in EPDs do not fully cover the infor-mation needs of designers and decision-makers. This complicates the work of involved actors and endangers the competitiveness of product suppliers. In response, a proposal for a product information system for building services is presented. It is adapted to the specifics of HVAC systems and the information needs of related actors. The background is the situation in Germany, but results can be transferred to other countries / markets.

s.22.106

The Influence of EPD Data on LCA Results

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Keywords: Construction Materials, Life Cycle Assessment, Global Warming Potential, Environmental Product Declaration (EPD), Data

The built environment is responsible for reaching global climate targets such as the Paris agreement and carbon neutrality in 2050. It is a well-known fact that buildings stand for 37 % of global greenhouse gas (GHG) emissions, where 10 % is due to emissions from the production of building materials, while the remaining 27 % comes from energy consumption [1]. The awareness of the major contribution to global GHG emissions from the built environment has enabled a great interest in developing more sustainable buildings, reducing the contribution to GHG emissions, and conducting life cycle assessments (LCA) of buildings in Denmark. In March 2021 a national strategy towards more sustainable buildings was introduced, which requires an LCA of new buildings, and compliance with the limit value of 12 kg CO_2e/m²/year for new buildings with > 1000 m². The strategy underlines the urgency of educating the Danish construction sector in conducting LCAs of new buildings and gaining knowledge in environmental product declarations (EPD) available for the Danish sector to apply. Eventually, this will enable more specific and transparent LCA results of Danish buildings. We investigate the availability and applicability of EPDs from a Danish perspective in the first part of the study, and in the second part, we investigate the influence on LCA results when applying industry- or product-specific data instead of generic data (Ökobau 2020 II). Three exterior wall types A, B and C are outlined based on the same U-value, and generic data are replaced with EPD data. The results show the various combinations possible with applying the EPD data. Secondly, the LCA results are highly dependent on the chosen materials and their corresponding EPD data.

s.22.107

Mission accomplished? – 6 Years of InData – International open Database Network Structure for Sustainable Construction

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Keywords: Life Cycle Assessment Data, Digitalization, Environmental Product Declaration, Sustainable Construction, International Network

InData (International open data network for sustainable construction) started in 2015 as a voluntary initiative with the goal to establish an International open Database Network Structure for construction products based on EPD (environmental product declaration) information. In 2022 InData can proof its results by its release of the InData network with international participating databases. A key precondition was offering and giving support for producing machine readable EPD/LCA (life cycle assessment) data in a harmonized data format. All participants of the InData Network have committed to the format, including compliance rules. Beyond that, the works of InData have international significant relevance, as InData could implement its works in Standardization. And also, further key stakeholders have adopted the concept of an open database network structure. In this paper, the goals, results, and their relevance, as possible future key issues are presented.

s.22.108

The Construction Material Pyramid: Integrating Health and Toxicity Parameters

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Keywords: Building Products, Hazardous Chemicals, LCA, Building Declarations, Transparency

This article investigates how hazardous substances and toxicity information can be integrated into the Construction Material Pyramid [Pyramid] in order to showcase the potential health impacts of material choices in architecture. The current Pyramid indicates different materials' upfront environmental impacts in the initial life phase of a building product, specifically in the Life Cycle Assessment phases A1–A3. The success of the Pyramid hinges on its communicative strength of conveying complex data in a simple format, easily understood by architects and planners. Can other aspects of material impacts be conveyed with a similar graphic ease to provide a more complete material assessment? Material health and toxicity is notoriously difficult to assess, as data is insufficient and hard to acquire due to proprietary concerns from manufacturers and lack of proper legislation to ensure transparency. The Pyramid has not yet dealt with health and toxicity as a parameter and there exists no predefined method as to how these problems can be included in a comparative model such as the Pyramid. This article's first line of inquiry is to discuss a suitable methodology to disclose the potential health impacts of construction materials and their associated, often invisible, chemical products applied for mounting, finishing, mold or fire resistance. The Swedish Chemicals Agency's and the European Chemicals Agency's evaluation of substances will inform the framework for a comparative system. Secondly, the article will address how the model can graphically convey the potential health and environmental impacts from the production and construction phases of prime and associated materials. This augmentation of the Pyramid would enable architects and designers to more easily obtain information regarding potential health impacts resulting from hazardous chemical content and could provide incentives for selecting less-toxic alternatives. By drawing on H-phases and SundaHus's product assessment, a stop-sign method is used to indicate hazard levels of construction materials.

s.22.109

Environmental Product Declarations – an extensive collection of availability, EN15804 revision and the ILCD+EPD format

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Keywords: Environmental Product Declarations (EPDs), EN15804, Digitalization, EPD Program Operator (EPD-PO), Data Availability, ILCD+EPD, ECO Platform, InData

The increasing awareness on climate issues in the built environment places a greater responsibility on the different actors to map the building emissions, reduce and optimize the use of materials, and thereby lower the environmental footprint. With several countries enforcing legally binding CO_2 limits to assess and benchmark the negative environmental side effects from buildings using the LCA method, it is presumable that practitioners from the industry will look for higher availability of data found from Environmental Product Declarations (EPDs). As the availability of data more than likely will increase drastically over the years, the study provides an extensive look into the world of digitalized EPDs, and how to use the format to extract a comprehensive number of EPD data. The extraction of data from the ECO Platform leads to a total of 1478 entities, and when adding EPDs from EPD Denmark, this study scrutinizes 1644 EPDs in total, from 4 EPD Program Operators (EPD-POs). The extraction process highlights the need for transparency and more mutual agreements in the documentation methods. Further, the study scratches the surface of the revised European EPD Standard EN15804, and what the changes and the transition will mean for the applicability and transparency in the building sector and for LCA models when the majority of emissions from GWP will increase.

s.23 Innovation & Economy I - Transformative Projects

s.23.110

Real-World Laboratories in the Building Sector: Strategies for Transformation and Leap Innovations

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Keywords: Real-Word Laboratories, Building Sector, Leap Innovation, Transformation Strategies

The German Federal Environment Agency's (UBA) goal is a climate-neutral and resource-conserving building sector by latest 2050. To reach these targets, radical innovation is needed in all areas from material and construction development to the life-cycle-compatible design and adaptability of entire buildings. To accelerate this kind of radical innovation in various areas of the economy, real-world laboratories or regulatory sandboxes are already employed. These are physical or theoretical spaces where legislative frameworks in targeted areas can be lowered or abolished – allowing researchers and businesses to operate in less restrictive regulatory environments. Real-world laboratories have the potential to function as what Schaepke and Steltzer call transformative research – research that drives societal change processes by transforming knowledge. In the building sector, this approach can facilitate the necessary rapid development of new material and construction techniques, while simultaneously valuing the communicative exchange and transfer processes through which these advances can be societally co-produced, validated and legitimized. Planning culture is plagued by outdated and often counter-intuitive norms and regulations, making it extremely difficult and economically unviable to apply experimental techniques, materials, and approaches in real-world projects. In this context, the Real-world Laboratories model has great potential to drive innovation in the planning disciplines through new inter- and transdisciplinary approaches that can integrate actors from civil society at an early stage, thus anchoring newly produced knowledge and innovation in society. Universities are well placed to initiate and drive such processes. Especially in architecture training, projects with a strong link to real contexts, actors, and materials allow learners to access new understandings of how planning processes can function. By working on eye level with clients, administrators, lawmakers and those from other disciplines, a new blueprint for real practice can be developed. This paper analyzes the characteristics of the Real-world Laboratory method specifically for the building sector. Principles to successfully implement the method in practice are derived from a series of transdisciplinary projects undertaken as part of the research, practice and teaching at Natural Building Lab, TU Berlin.

s.23.111

Model Projects as Tools for Cooperative Urban Development: The Case of Haus Der Statistik in Berlin

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Keywords: Haus der Statistik, Model Project, Real World Laboratory, Cooperative Urban Development, Public-Civic Partnership

According to the New Leipzig Charter, urban development processes should be a matter of all – the common good, climate protection and environmental justice, to name but a few aspects. Currently, new forms of innovation seeking models emerge within this context of sustainable urban planning practice – for example, real-world field laboratories and model projects. Haus der Statistik in Berlin is one such model project for cooperative and common-good-oriented urban development. It is widely recognized for its demand- and process-driven approach, as well as its project development being based on public-civic partnership. As anthropological and urbanist researchers and practitioners involved in the project, we give a situated account on the socio-political elements of the Haus der Statistik's public-civic partnership and investigate the potentials of this model for a more sustainable urban development. The structure of the paper is threefold: Firstly, we introduce the so-called model project Haus der Statistik and its common good orientated agenda and relate it to sustainability goals of the New Leipzig Charter. Secondly, we introduce the specific public-civic-framework in regard to its methodological framing within the context of model projects and comparable approaches that focus on collaborative, transdisciplinary and innovative methods, such as real-world field laboratories. Thirdly, we reflect on the elements of the public-civic-partnership framework that have been explored and developed at the »model project« Haus der Statistik since 2015 and its implications for a more sustainable urban development.

s.23.112

Social Innovations for Supporting Regenerative Lifestyles: Exploration of Three Pioneering Co-Housing Projects in Austria

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Keywords: Social Innovation, Housing, Lifestyle Changes, Demand-Side Action, Sharing Economy, Co-Housing, Sociocracy, Buildings, Construction, Whole Life Carbon, GHG Emissions, Reduction Pathway, Decarbonization

Limiting global temperature increase needs demand-side actions and lifestyle changes«, stated the IPCC in their Special Report on Global Warming of 1.5. Social innovation in the form of alternative models for spatial production and ownership can support such regenerative lifestyles and emission reductions in the emissions-heavy building sector. However, today's real estate market hardly supports the development and realization of alternative housing models. In response, practice shows that innovative models of housing are often driven by the initiative of the (future) inhabitants.
In this study, we investigate and analyze different models of social innovation in housing based on three recently completed building case studies in Austria. The case studies are situated in a broad range of spatial contexts: re-activating the countryside, vitalizing a newly developed neighborhood, or bringing new life to abandoned, existing buildings. They are showcasing strategies such as: innovative models of (co-)financing and (co-)ownership to provide affordable housing; the shared use of spaces, functions and resources for reducing environmental footprints. We provide insights as to how alternative housing projects are being established successfully, what models groups are exploring for governance, financing and ownership, and which other social innovation practices may support or enable the implementation of regenerative lifestyles.

s.23.113

Assessing the Multi-layered Value of Urban Development Policy: The Case of Developing a Creative and Circular District in the City of Utrecht

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Keywords: Urban Development Policy, Case Study, City Model Canvas, Multi-Layered Value

In recent years, circular economy has become more important for the development of many places, including cities. Traditionally, urban development policies have mainly been aiming to improve the socioeconomic wellbeing of neighborhoods. However, technical and ecologic aspects have their effects too and need to go hand in hand. This paper is based on an urban area experiment in the Dutch city of Utrecht. In order to assess urban area developments, typically rather straight-forward quantitative indicators have been used. However, it has proved more complicated to assess multifaceted developments of the area studied in this paper. With the City Model Canvas a multi-layered model is being used to better assess the impact of the urban development being studied. Key findings include that the project studied resulted in more space for companies from the creative industry and the settlement of local »circular« entrepreneurs and start-ups, although it remains unclear to what extent these benefit from each other's presence. The increase in business activity resulted in more jobs, but it is again unclear whether this led to more social inclusion. From an environmental point of view the project activities resulted in less raw materials being used, although activities and public events bring nuisance to the surrounding neighborhoods.

s.23.114

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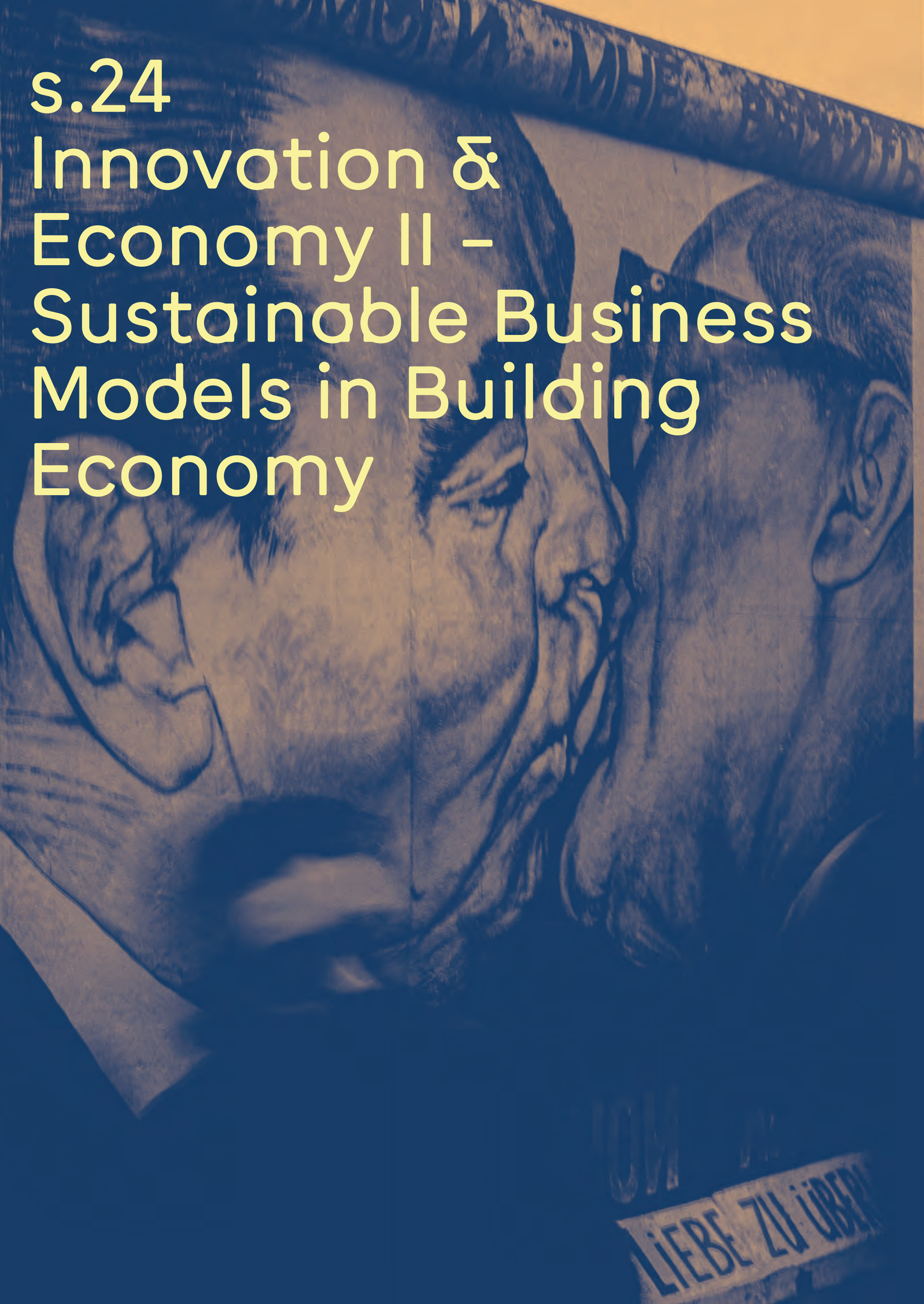
Keywords: Sustainable Neighborhood Development, Case Study, Sharing, Adaptive Governance, Design Thinking

Planning for Sharing Neighborhoods: Negotiating Sustainable Transition With Adaptive Governance Models

Thorough sharing is discussed as a promise concept to reduce emissions and enable sustainable development, little is known about how the diverse approaches of sharing ranging from Collective Commons to the Sharing Economy can be incorporated in the development of the built environment. In this study, we set the spotlight on sharing and how it could be implemented as a guiding principle in neighborhood development. We build our study on an empirical case study within the new planned zero emission neighborhood development of Ydalir within the city of Elverum, Norway. Building on document analysis, accompanying research and a one-day workshop with diverse stakeholders, we identified respective sharing solutions to create social value for future Ydalir residents. The findings let us draw the picture of an adaptive governance model to initiate and facilitate sharing within a multi-stakeholder setting of a new planned neighborhood development.

s.24
Innovation & Economy II – Sustainable Business Models in Building Economy



s.24.115

Future Proof Real Estate Companies Through Sustainable Development of Institutional Building Stocks: Basics and Tools

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Keywords: Institutional Building Stocks, Portfolio Analyzes, Risk Assessment, Real Estate Companies, Sustainability

The stakeholders and companies in the real estate industry are facing new challenges. They must react to mega trends such as climate change, resource depletion, shift in social values, demographic change and digitalization and at the same time comply with their responsibility to society and environment. In order to contribute to sustainable development and thereby ensure the future viability of the company, it is necessary to consider the social, environmental and economic impact of any business activities and decisions. Referring to the German market, a discussion will be based on the example of housing companies to show how sustainability aspects can be integrated into the instrument of portfolio analysis. The interactions between sus-tainability aspects resulting of the external business environment, the respective location characteristics, the building performance and the rentability and marketability as a success factor will be discussed. In this context, it will be explained how to react dynamically to a changing envi-ronment by using adaptable weighting factors and to local location and market requirements. As a conclusion, it will be discussed how the concerns of society, the cities (housing districts) and the tenants can be taken into account in addition to the economic interests of the housing companies.

s.24.117

The Paris Climate Agreement as Benchmark for Buildings and Companies

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Keywords: Benchmark, Real Estate, Sustainability, Paris Agreement, Climate Change

The real estate market has a high obligation, but also many opportunities, to tackle climate change. The real estate sector is responsible for 40 % of energy consumption and 36 % of CO_2 emissions in the EU. The global temperature must not rise by more than 1.5° Celsius compared to pre-industrial times in order to avert serious consequences of climate change. 195 countries agreed on this target by signing the Paris Climate Agreement in 2015 and thus also set the legislative framework and the desired direction of development for societies, companies and buildings. The Paris Climate Agreement can be used to establish a benchmark by showing which development routes are necessary to be compliant with the Agreement. It can be examined which adjustments are necessary to limit maximum global warming to 1.5° Celsius. By matching specific properties against such a benchmark, it can be worked out which properties are at risk of no longer being usable/rentable because they cannot meet the expected increases in environmental regulations, CO_2 pricing, building standards and market expectations. This can be used to address transitory climate change risks.

s.24.118

Does Energy Retrofitting Pay Off? An Analysis of German Multifamily Building Data

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Keywords: Energy Performance Certificates, Hedonic Pricing Model, Generalized Additive Model, Economic Viability, Marginal Cost

Several studies have investigated the relationship between the energy performance of buildings and housing prices. First, this paper identifies a price premium for energy efficiency within the German rental market. Then, the generated price differences and associated marginal benefits are compared to the marginal costs of energy retrofits. An extensive database of Germany's largest online platform for housing over a time span from 2016 to 2020 is used in a hedonic regression approach. Additionally, to extract the marginal costs of energy consumption abatement, a dataset of 1.048 rental units regarding green-retrofit measures is utilized. While a significant green premium is identified in the rental market, the findings suggest that it is not high enough to compensate landlords for the money they have to spend to retrofit. The marginal costs exceed the marginal benefits by far. Furthermore, it is found that the German government's recent plans to split the CO_2 tax between landlords and tenants does not change this because the price per metric ton of carbon is insufficiently high. The findings can help both tenants and landlords in their decision-making, as well as policy makers in the implementation of decarbonization efforts.

s.24.119

Tailoring Transformation: A Framework of Transformation Potentials of the German Craft Sector

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Keywords: Craft, Grounded Theory, Transformation Research, SME, Sustainability Transition

The risk of approaching planetary tipping points requires a fundamental and concerted transformation of global societies towards sustainability along climate resilient development pathways which integrate mitigation of and adaptation to environmental change. While the urgency to act calls to draw on the totality of available options to accelerate transformation, research and policy-making has focused on industrial mass production, technological innovation, and upscaling one-size-fits-all solutions. Yet, lacunae remain regarding SMEs, craft production, and tailor-made solutions. Taking a Grounded Theory approach, this study explores and conceptualizes transformation potentials of the German craft sector Handwerk and proposes a novel interdisciplinary framework of its role in transformation. It draws from a diverse set of data including official documents, expert interviews (N=30), and workshops. We understand Handwerk as consisting of three elements: craft enterprises, craftspeople, and craft institutions. These show craft-specific constituents distinguishing craft from industry: small owner-managed enterprises, local operation, contextual problem-solving in self-responsibility, low division of labor, production on demand, formal dual education system, strong group identity, and high institutionalization. These constituents determine Handwerk's distinctive role in transformation, i.e., providing tailored, context-dependent solutions on the spot under conditions of uncertainty for existing problems. Handwerk facilitates transformation twofoldly: through internal actions (e.g., enterprises' mobility) and by assuming external functions that cannot (easily) be assumed by other entities (e.g., offering renovation-service). Current conditions limit fulfillment of these functions. Internal impediments include skill shortage, enterprise size, and institutional path-dependencies. Bureaucracy, short-lived funding and project structures, economic incentives, and consumer-demand constitute main external impediments. The study provides insights in Handwerk's roles in several transition arenas, highlights its importance as indispensable provider of resilience, and concludes by analyzing how current adverse trends and conditions may threaten the feasibility of transformation if decision-makers do not explicitly and timely attend to craft-specific impediments. Finally, we make recommendations for (political) action.

s.25
Infrastructure – Civil Engineering and Transport Infrastructure

s.25.120

Life Cycle Assessment of Tunnel Structures: Assessment of the New Austrian Tunnelling Method Using a Case Study

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Keywords: Tunnel Construction, LCA, Scenario Analyzes, Case Study, GWP, New Austrian Tunnelling Method, NATM

One important measure to combat progressing climate change is compliance with the decreasing greenhouse gas budget and to under no circumstances exceed it. Every economic sector must strive to make its ecological contribution to achieve this objective. The construction sector is largely responsible for these negative environmental burdens. Although tunnels are considered to have extensive energy and material consumptions, the literature has failed to present their environmental impacts. Aimed at this knowledge gap, the objective of this study is to present the life cycle assessment (LCA) of a tunnel construction project situated in Bulgaria. The study analyzes the impacts of the New Austrian Tunnelling Method (NATM) using the case study »Modernization of Railway Section Elin Pelin-Kostenets – Lot 3«. Moreover, by applying dominance and sensitivity analyzes, the environmental drivers and optimization potential for reducing greenhouse gas emissions are identified. The results show that steel, shotcrete, and concrete, contribute the most to the global warming potential indicator and are responsible for 85 % of this. Furthermore, the life cycle stages for the production of materials and components have a share close to 85 % of the total global warming potential. These findings may help future tuneling construction projects to improve the environmental performance and thus to combat the alarming development of climate change.

s.25.121

Influence of Traffic Load on the Environmental Impacts of Roads: A1 and A2 Highways in Austria

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Keywords: Flexible and Rigid Pavement, Sustainable Road Construction, Bituminous Pavement, Performance Related Approach

Professionals should aim to significantly reduce greenhouse gas (GHG) emissions by implementing the best road construction technologies to develop low-carbon projects. Although the traffic loads vary over the road length, the environmental impacts are assessed based on the average values of the traffic loads. Consequently, there is a gap between reality and the impacts calculated with fixed traffic load. This paper aims to assess the gap in terms of the environmental impacts of two roads by considering both a constant and a variable traffic load. With the help of a life cycle assessment (LCA), the environmental impacts of the A1 and A2 highways in Austria are calculated. We have calculated the impacts in the first scenario by considering an average traffic load. In the second scenario, based on real measurements, the environmental impacts of both highways are calculated for a variable traffic load. In the end, the results show a gap in the range of 25 %. This difference was because some parts of the roads required frequent repair. Besides, we figured out the optimal thickness of the wearing course, which improves the impact calculation and makes it less likely that the results will be different along the length of the road.

s.25.122

Aligning Actors in a Road Renovation Project by a Co-Design Process: The Road to Circularity?

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Keywords: Road Renovation, Co-Design Process, Circularity, Experiment, Actors

In a circular economy, the aim is to close material loops that retain the highest utility, quality, and value of products, components, and materials. The environmental impact of the material used in constructing, maintaining, and renovating roads is severe. Within the European H2020 project CityLoops, the municipality of Apeldoorn prepares a circular road renovation project, one important measure to combat progressing climate change is compliance with the decreasing greenhouse gas budget and to under no circumstances exceed it. A literature study and experiment were conducted. The experiment consisted of a co-design process aiming for the renovation of a residential road constructed in the late seventies. When conducting road renovation, multiple departments within the municipal organization and different external organizations need to collaborate. To them, circular material usage was introduced as a new specific sustainable objective, while traditional constraints, like time and costs, remained. It was visualized in a process journey, showing who is expected to meet which collaborative milestones and when. The insights from this experiment might help other municipalities, principals, and contractors to come to circular design processes in the road construction industry.

s.25.123

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Reducing the Carbon Footprint of Municipal Infrastructures

Keywords: Infrastructure Management, Climate Change Mitigation, Carbon Footprint, Management Cycle

Developers of municipal infrastructures have focused so far mainly on the operation of infrastructure networks (e.g., roads) or facilities (e.g., district heating facilities) and their impacts on climate change. Only recently, the focus shifts to optimizing CO_2 emissions embodied in building materials and caused by processes and transports related to construction, maintenance, overhaul and renewal of civil engineering works. The European standard EN 15643-5:2017 provides specific principles and requirements for the assessment of their environmental performance and a new standard for calculation methods will be published in 2022 including an assessment of embodied C02 emissions. But, how can this information be used to systematically reduce the carbon footprint for municipal infrastructures?
In an ongoing research project, we want to answer this question and develop a management cycle for optimizing the carbon footprint of municipal infrastructures. In a first step, we used expert interviews with infrastructure operators, planers and builders focusing on roads to define use cases where information on embodied CO_2 emissions is needed. In a second step, we studied construction projects (completed in the past) to analyze data availability at different stages of the planning process. Based on our preliminary results, a management cycle should include the following four use cases for using information on embodied CO_2 emissions for decision support. First, it should be used for monitoring of infrastructure networks (as part of scope 3 accounting for operators). Second, it supports priority setting for renewal and overhaul planning when used to analyse representative project portfolios. And, it will help developing project specific benchmarks for optimization at early design stages as well as before public tender. In the next step of our project, we will adapt existing calculation methods in collaboration with operators of municipal road networks to meet information requirements in the identified use cases.

ps.26
Poster Session A

ps.26.124

Circular Economy Digital Market Solutions for Reuse in the Construction Sector of Europe

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Keywords: Reuse, Market Analysis, Marketplace, Circular Economy, Buildings

Focusing on the cross-matching of supply and demand for reused building components and related services, the paper analyzes existing Digital Reuse Market Solutions (DRMS) in the European construction sector. A collection of 746 DRMS is built from major online circular economy platforms and custom online search queries. A taxonomy of 9 categories and 28 types is then extracted based on the activities of collected DRMS. Nearly half (46 %) of collected DRMS are proper dealers of reused building components. Traditional building component dealers and demolition companies account for another third (32.8 %). The rest is made of marketplaces, craftmanship, and providers of related services and knowledge. Only 13.4 % of all collected DRMS allow online payment for goods or services.

ps.26.125

A Pathway to Climate Neutral Buildings: Definitions, Policy and Stakeholder Understanding in Sweden and China

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Keywords: Climate Neutral Building, Comparative Study

In recent years, »climate neutral buildings« has become one of the most popular emerging terms in the context of global warming and the built environment. However, due to a vague definition, the term still lacks real-world uptake in practice. While initial research focuses on »climate neutral buildings«, few have discussed this term from the perspective of different countries or stakeholders. To address this gap, this paper explores the current understanding and future development of the term »climate neutral buildings« in Sweden and China. Through a literature review of related definitions, an investigation of current regulations, and stakeholder interviews in both countries, we find that Sweden and China are in different stages of development towards climate neutral buildings. Sweden seems to surpass China in terms of theoretical research, regulation development and stakeholder understanding. Despite this, the two countries share similar issues regarding the future development of climate neutral buildings. Both countries lack an official interpretation of »climate neutral buildings«, sufficient regulations, and collaborations among different stakeholders. This paper suggests a foundation for the future development of climate neutral buildings.

ps.26.126

Ecological Performance of Reusable Load-Bearing Constructions

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Keywords: Sustainable Architecture, Reuse, Recycling, Reusable Construction, Deconstruction, Reduce, Resource Efficiency, Structural Components

This study provides an overview of sustainable reusable load-bearing constructions as a contribution to the debate over whether building construction provides the building industry with the best and most environmentally friendly qualities. By contrasting their building-specific features, it demonstrates the benefits and drawbacks of particular structural elements and envelope solutions and ecological aspects using various system boundaries of life-cycle assessment (LCA). Following a careful consideration of ecological factors and sustainable circular economy criteria, a structural component that is sustainably optimized is defined. This component should be chosen based on external conditions. By selecting environmentally friendly building materials and proper connecting procedures that enable separability, resource-efficient and sustainable buildings can be achieved. Both the selection of load-bearing elements and the necessary insulating material have a significant impact on the ecological performance and reusability options of the components. The elements of homogeneity, separability, and pollutant-freeness play a significant influence in the reuse process, namely in terms of details and construction type in general, as well as the ways of reusing and recycling them. Sustainable solutions for load-bearing building components can be created by simultaneously investigating environmentally friendly building materials and the structure of the components. This paper illustrates how the natural resources can be used both optimally and sustainably. It presents a conceptual framework for scenario development of the LCA of load-bearing structures, their effect on the design and decision-making process. There is a potential of increasing total resource efficiency at the building level with a suitable combination of the material components employed at the component level. Because of this, the overall energy efficiency and its consequent ecological impacts are the main topics of this study.

ps.26.127

AESA Approach Applied to Mineral and Metal Resources Use Sustainability in the Building Sector: The MiMOSA Method

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Keywords: Building's Absolute Sustainability Assessment, Circular Economy, Mineral and Metal Resources, LCA, MFA

Considering the increase of natural resource use, humanity is facing the problem of resource depletion. The building sector is a major consumer of resources. The most consumed resources are mineral and metal resources. Thereby, the identification, and then Optimization, of mineral and metal resource use in the building sector appears as a necessity. One tool to quantify the use of those resources is LCA. Currently, several authors develop absolute environmental sustainability assessment (AESA) methods, combined with LCA, to compare the pressures of the studied project with the global carrying capacity of the planet. However, most of the AESA approaches do not actually include normalization factors about the use of resources, and in particular mineral and metal resources. Besides, the mainly used LCIA characterization methods of mineral and metal resources present several limits when applied to Circular Economy projects within the building sector. Thereby, the goal of this research project is to answer the following question: Can the consumption of mineral and metal resources for a given building project be considered sustainable? To answer this question, a methodology was developed. This methodology is inspired by the AESA approach by proposing a sustainable resource budget for each mineral or metal substance and will combine the MFA methods to the LCA method to calculate sustainability indicators for each mineral and metal resource. The Mineral and Metal absOlute Sustainability Assessment (MiMOSA) method integrates the circular economy actions and considers an appropriate spatial scale for each resource and will be presented in this paper.

ps.26.128

Circularity of Building Materials: A Nondiscriminating Calculation Methodology

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Keywords: Resources, Renewable, Circular

The energy transition has shifted impacts to materials, their energy use and potential depletion. Especially affected is the building and construction sector, since it is the sector which has the largest consumption of materials. Therefore, it is of utmost importance that materials cycles be closed as well, that they stay within system boundaries, and that we use objective calculation and evaluation methods. If we look at organic or biobased resources, the basic impacts in their flow are obvious and can be characterized fairly simply: they grow on the basis of solar energy at a certain speed and volume per unit of land. It's a constantly renewing flow, with use maximized to what naturally (re-)grows.

In-depth analyzes have created growing awareness that non-organic materials are also in fact renewable, even without human intervention but in different scales of time and volume, in time frames way beyond the normal planning horizons of humans. They are renewed by volcanic and tectonic movements of the Earth's crust.

The paper explores how non organic materials will renew, that is, become re-concentrated in the Earth's crust. In fact it is the concentration that is crucial for effective use, without additional energy input that would deplete other sources. From this analysis it follows that all resources can be characterised by the speed and volume in which they concentrate—either by the soil and solar route, or by the Earth movement route. Resources can thus be grouped into four categories: regrowable, streaming, slow and synthetic. The characterization shows a similar pattern in other indicators for these resources: the slower the resources are regenerated, the more (embodied) energy is required to obtain the resources, for instance.

This is an attempt, a pre-study, to set up a methodology, and the first estimations for the global flows of resources in different categories. In the end, it turns out that all resources have a natural renewal basis, and that there are no sustainable or non-sustainable (or non-renewable) resources: it is their use, within maximized flows, that determines their sustainability. Therefore, it is nessecary to redefine the notion of »circular«.

ps.26.129

Sensitivity Analysis of Building Energy Models Due to the Shading Effect of Surrounding Buildings to Support Building Renovation

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Keywords: Shading Effect, Building Renovation, Surrounding Buildings, Building Energy Performance, Building Energy Simulation

Building energy simulation is an analytical process to help building owners and designers evaluate the energy performance of the building. Uncertainty in the building energy modeling influences the building renovation from two perspectives: 1) calculating as-built energy consumption, 2) analyzing the energy performance of renovation alternatives. Energy models can enhance by incorporating contextual and surrounding data. To this aim, we conducted a systematic study to investigate the effect of surrounding buildings in different distances, heights, and orientations in studying the as-built energy consumption of an example building. The research also investigates the impact of a specific surrounding building on the energy performance of three different renovation alternatives, namely the modification of windows, external walls, and roofs. The results demonstrate that a higher height to distance ratio of the surrounding buildings influences the energy consumption more dramatically. In addition, a surrounding building located in the south direction causes more effect on the energy result than buidings in other directions when the building is located in the nothern hemisphere. For renovation scenarios, if there is a specific building in the south of the building under renovation, the window modification leads to less energy consumption than other renovation scenarios. The paper discusses that for renovation projects, an initial examination of surrounding buildings before selecting the renovation alternative is crucial; since different placements of surrounding buildings can affect the performance of renovation scenarios differently, which can cause a variation in the cost of renovation.

ps.26.130

Towards Climate Neutral Buildings: Case Study of Positive Building in Brussels: Gare Maritime Project

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Keywords: Building Asset, Case Study, Energy-Positive, Sustainability, Climate-change

The Gare Maritime is a former freight station in Brussels that has been vacant for quite some time. The exceptional architectural features of the building have encouraged the owner to maintain and restore the building and create commercial and office spaces. To this end, the large hall is renovated into a well-insulated envelope in which the office volumes are placed independently. These spaces are climatized by using a geothermal loop with ATES to which individual heat pumps are connected: Cooling is provided in a passive way and heating is done through the heat pumps. A 3MW of PV-panels installations is on the existing roof structure. By means of the insulation package and an intelligent control system for openable parts of the building envelope, a comfortable indoor climate is created within the hall itself in which activities can take place for most of the year. The moderate temperature in the hall leads to a low energy consumption of the built-in volumes and losses to the outside environment are drastically limited. The ventilation is supplied in all spaces using a mechanical system. Inside the office-volumes, a perfect flexible climate is guaranteed by means of chilled ceilings, which also act as acoustic absorption material. Large window-openings maximize the benefit of daylight penetrating the building. By using variable frequency pumps, variable air volumes and daylight controlled light fixtures and sensors; the energy use of the building is minimized. Besides the 100 % refurbishment of the existing structure, the design team developed a structural strategy of prefabricated, wooden constructions for the built-in office spaces, making it a perfect example of the reduction of the use of natural resources and maximizing the amount of absorbed CO_2. To come to the overall strategy of this renovation, numerous simulations, brainstorms and gathering of references were conducted from the early-stages. The start design parameters of the project were determined through simulations before the elaboration of an architectural design. This process allowed the client to take decisions based on robust data relating to attainable comfort, investment costs and environmental considerations. Overall, the project is energy positive building.

ps.26.131

Environmental Product Declarations (EPDs) of Construction Product in Spain: Current Status and Future Challenges

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The current decarbonization scenario demands decreasing embodied and operational environmental impacts of buildings. There, the use of the Life Cycle Assessment (LCA) method and the Environmental Product Declaration (EPD) play a crucial role. There, the main objective of the EPDs is to provide validated and geographically representative data to conduct the LCA, having a relevant role in the application of the LCA into practice. However, the development of EPDs in the European context is still irregular. Several countries such as Germany or France have a great number of EPDs of construction products. On the contrary, other countries such as Spain have a lower number. This study aims to analyse the existing EPDs of construction products developed in Spain, identifying the EPD programs, type of products (building system and element associated), the LCA information modules included, and the accuracy of the declared impact values. The results obtained show that ceramic claddings, gypsum plasterboard, cement, and clay products are the product with the highest number of EPDs. On the other hand, building services products have a scare number of EPDs. Finally, some recommendations and challenges to address towards improving its development are proposed.

ps.26.132

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Keywords: Construction Product, LCA, Sustainability Assessment

Development of a new environmental scoring methodology for building products, a French case study

The building sector consumes about one-third of total final energy and contributes to 38 % of greenhouse gas (GHG) emissions around the world. Thus, the EU has established a set of directives that includes the EPBD and the EED to achieve carbon neutrality by 2050. Hence, France adopted more challenging legislation by introducing the new environmental regulation RE2020. Among other measures, the RE2020 allocates a carbon budget to new housings starting from 2022. As a consequence, it promotes the use of materials and products that have a lower environmental impact. In this low carbon material competition, one of the challenges is related to the comparability of environmental product declarations (EPDs) and the lack of harmonization in terms of functional units and lifespan. Also, EPDs have multiple impact categories that make the decision-making process complex. In this context, the objective of this research is to develop a new environmental scoring methodology for building products based on their life cycle assessment. The methodology has been applied to the two product families of windows and insulation as case studies thanks to the French EPD database called INIES.

ps.27
Poster Session B

ps.26.133

Energy Assessment of a Residential Building Renovated with a Novel Prefabricated Envelope Integrating HVAC Components

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Keywords: NZEB, Deep Renovation Solution, Prefabricated All-In-One Envelope Kit, TRNSYS Building Simulation

Off-site prefabrication systems continuously gain attention in the building industry as they combine fast construction with fewer and more sustainable resources as well as minimize disturbance for occupants. In this direction, adaptable off-site prefabricated envelope components with embodied HVAC systems have been developed as an effective renovation solution. They can minimize thermal losses through the envelope while at the same time integrated HVAC systems efficiently maintain indoor thermal comfort conditions. In this study, a »Plug-and-Play« prefabricated envelope component incorporating HVAC systems is examined as a solution for the deep renovation of a typical single-family residence in Berlin, aiming to reach NZEB state. This versatile modular system, called SmartWall, can be installed either to the exterior or the interior side of the external wall, incorporating timber-based frame, boards and insulation, high-performance windows and a slim-type fan coil. The evaluation of this prefabricated system is investigated with respect to its energy performance both at component and building level, as well as its calculated embodied energy. The results indicate a reduction of 89 % total primary energy highlighting that NZEB state can be ensured if the SmartWall application is combined with sufficient photovoltaic modules. The climate change potential contribution of such retrofit indicates a significant amount of embodied energy, which is nevertheless counterbalanced by the operational energy savings within the first few years after the implementation.

ps.26.134

Ensuring Proper Management of Building Renovation Based on an Optimized Decision-Making Model: Application in Schools and Social Housing From Southern Europe

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Keywords: Building Stock, Decision Support System, Building Renovation, Schools, Social Housing

One of the main challenges for architects and technicians is the efficient management of the built environment, in response to the growing deterioration and obsolescence in the building stock. This research introduces the design, development and application of a novel decision support system that assesses the multidisciplinary advantages or disadvantages of different intervention strategies, mainly focused on schools and social housing. The concept of the model aims to gather, interrelate and weight different renovation factors and variables, according to technical, social, energy and economic parameters, quantifying results on the impacts, consequences and benefits of each renovation strategy and providing practical outcomes in the design, construction, management and maintenance stages. This study uses schools and multi-family buildings, located in southern Europe, to apply and test the system iteratively in both building typologies, serving to adjust the calculation model and demonstrate its operation and replicability. The results are classified according to different intensity levels with their corresponding design alternatives along with a graphical output of results for decision-making. This model is expected to contribute to policy-making by introducing new theoretical and practical renovation guidelines, with a rational adjustment of proposals and ensuring effective and feasible action strategies in the built environment.

ps.27.135

Green-Blue Infrastructure in the Built Environment: Sustainable and Resource-Saving Designs for Urban Structures and Open Spaces

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Keywords: Green-Blue Infrastructure, Case Study, Street Trees, Vertical Green Shading, Circular Soil

Urban grey infrastructure, as it generally consists of monofunctional, sealed, impervious, heating up and reflecting surfaces, has led to a series of serious challenges (urban heat stresses, loss of biodiversity, flood risks and natural hazards) decreasing urban resilience. Ongoing construction activities result in irreversible soil consumption and loss of its numerous and vital functions. However, a common understanding has been evolving that the establishment of green-blue infrastructure (GBI) supports compensating for functional losses, as they are integrative and provide pervious, absorbent, shading and non-heating up surfaces. We present a concept to holistically interconnect stand-alone approaches to improve and support constructional design for transforming green open spaces addressing specifically urban landscape construction and building greenery. The underlying state of knowledge emerges from currently four ongoing projects on advancing GBI for re-establishing ecosystem functions and diverse habitats: 1. The Circular Soil Concept targets the reuse of excavated soil materials from construction sites to produce engineered soils. These are applied as functional vegetation substrates for landscape construction and installing building greenery, saving scarce soil resources while generating large scale and vegetated areas with climate change adaptation performance. 2. The Street TREE Planter is designed to install urban trees in a given street infrastructure. The advanced planter systems will support extended tree lifespans, microclimatic benefits, flood protection and urban resilience. The design is based on targeted rainwater harvesting for irrigation management in alignment with water requirements and the desired microclimatic performance. 3. The GLASGrün projects generates plant-based shading designs for glass facades. As plants and their leaves do not heat up from solar radiation, vertical greenery is promising, however challenging, for green shading of glazed surfaces and for indoor and outdoor microclimatic regulation. 4. The INReS rainwater management tool was developed as a prototype web application to integrate sustainable, plant-based rainwater management systems into BIM-(Building Information Modeling)-based construction projects. It provides up-to-date design for the wider public and specific planning guidelines. In synthesis with the present and upcoming findings of these projects, a parameter-based and BIM-compatible GBI-design management tool is foreseen to better and sustainably integrate GBI systems into construction projects, and to consider the resource question.

ps.27.136

Analytical Framework for the Analysis of Co-Benefits, Conflicts and Trade-Offs of Urban Heat Mitigation Strategies

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Keywords: Urban Heat, Co-Benefits, Trade-off

Many cities are undergoing urban heat challenges because of heat waves and urban heat islands (UHIs). During urban planning and design, properly adding cooling interventions, namely urban heat mitigation strategies, into cities and communities are essential to address urban heat challenges. However, cities are required to provide a variety of functions (e.g., buildings, transportation, park) and meet the requirements convenience, safety, health, comfort and wellbeing. Such functions and requirements result in some co-benefits, conflicts and trade-offs, promoting and constraining the application of urban heat mitigation strategies. However, the possible co-benefits, conflicts and trade-offs have not been well documented, where the improper use of cooling strategies may lead to unintended consequences. Therefore, it is essential to understand the co-benefits, conflicts and trade-offs of different cooling interventions. In particular, this study aims to develop an analytical framework for the analysis of the co-benefits, conflicts and trade-offs of different mitigation techniques. Mitigation techniques considered includes four clusters such as green infrastructure, blue infrastructure, white/grey infrastructure and urban design. The scope of urban functions and requirements, related to urban lives and urban operation, in ten aspects including economy, policy, ecology, environment, technology, space, urban beauty, practicality, culture, and transportation. The analytical framework was further applied to analyze the co-benefits, conflicts and trade-offs of cooling strategies in ten aspects of urban functions. Furthermore, it was used in environmental functions (e.g., local temperature regulation, stormwater regulation, waste treatment, air quality regulation, pollination, and recreation & aesthetic appreciation) and space functions (e.g., activity venue/entertainment venue, neighborhood vitality, resident satisfaction, space utilization and city identity), respectively. The results reveal that green infrastructure can provide the most aspects of benefits in ten aspects, and also in environmental and space aspect. Green infrastructure was followed by blue infrastructure, urban design and then white/grey infrastructure. Overall, the analytical framework offers a new perspective of the feasibility analysis of urban heat mitigation strategy and provides a reference for urban planners and designers to select proper urban heat mitigation techniques, with possible additional benefits of addressing other urban challenges.

ps.27.137

Urban Pervious Concrete for Thermal Conditioning in Open Spaces: An Adaptation to the Climate Change and the Urban Heat Island Effect

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Keywords: Urban Environment, Adaptation to Climate Change, Heat Island Effect, Pavements, Evaporative Effect

UIA CartujaQanat project is part of a new vision of the urban environment, in which the way of thinking about cities and their spaces is changed, as well as in the interaction of its inhabitants with them. In this new concept of urban space, possible solutions to current and future needs, both social and climatic, must be found, since these environments have the responsibility to contribute to improving the lives of their inhabitants by minimizing the consumption of resources used in it. These solutions are the result of the knowledge gained from experience and tradition together with innovation and research.

The project incorporates passive techniques and bioclimatic solutions adapted to the hot and dry climate of the city of Seville, which is where it is located, trying to create semi-confined open spaces that provide a comfortable environment. The solutions adopted introduced water as a heat transfer fluid that allows these spaces to be tempered. Apart from other solutions such as bioclimatic lattices, we worked on draining pavements that, thanks to their permeability, allow the flow of water and the evaporation of air through their surface.

In this work the study of the use of pervious concrete flooring solutions and their advantages over the use of other materials is developed. Analyzing its behaviour in its combination in hybrid pavements with vegetal soils or with fines such as silica sand, as well as other solutions that allow a constructive solution that reduces the temperature of the pavement using the evaporative effect, with minimal maintenance and cost.

ps.27.138

Indoor CO_2 Buffering Potential of Clay-Based Building Materials

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Keywords: Earth Plaster, Thermogravimetric Method, Indoor Air Quality, Adsorption/ Desorption, CO_2 retention

To mitigate the anthropogenic greenhouse gas emissions from the operational energy consumption in buildings, increasingly high-performance envelopes are developed. A reduction in indoor air renewal is observed that leads to a higher pollutant concentration in the built environment. Particular attention was given to CO_2, an anthropogenic gas that has consequences on the Indoor Air Quality (IAQ) and the health of occupants. Developing a passive regulation system appears to be a promising solution for improving IAQ and reducing the energy consumption of ventilation systems. For that purpose, earth-based materials present interesting characteristics through the presence of clay minerals and their microstructure. In this context, this paper aims at presenting a novel experimental method to assess the CO_2 retention potential of natural earth plasters. The method uses a thermogravimetric device (TGA/DSC) associated with a gas mixer and humid air generator. The mass variation resulting from the interaction of the increasing CO_2 content could thereby be measured and analyzed. Results show the important role of reversibility in the phenomenon: the majority of the captured CO_2 being released when the CO_2 concentration drops. It also highlights the role of the relative humidity on the retention capacity. As the retention of CO_2 is lower when the material is wet, the water molecules may occupy part of the adsorption sites and react themselves with the CO_2. This experiment provides the first values and thus evidence of the CO_2 retention capacity and passive regulation potential of this material.

ps.27.139

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Keywords: Sustainable Architecture, Vernacular Architecture, Deep Learning, Aerial Image, Big Data

The Methods of Deep Learning and Big Data Analysis in Promoting Sustainable Architecture

These days, sustainability in different aspects has been among the main discussions of architecture and building science. At the same time, historic architecture has evolved over centuries and has adapted to environmental conditions, it can be a great source of inspiration in using smart ways to achieve sustainable architecture. A good illustration of this adaptation can be found in using vernacular materials, the spatial configuration according to climate conditions, and different elements of historic architecture that have helped to improve the occupant's comfort. In response, one plausible solution for improving the sustainability of architecture is translating the concept of the sustainable elements and features of historic architecture to be used in contemporary architecture. Therefore, these elements need to be studied thoroughly to comprehend their features and characters. There are several studies, investigating sustainable historic architecture to find and measure sustainable solutions by using conventional methods. Although the accuracy of studying the sustainable historic elements has been fairly high, the number of features and variety of these elements in historic architecture have made this task highly challenging. It has been suggested to study and evaluate a considerable number of these elements in different types of architecture to reduce the errors and increase the reliability of results. Since the conventional methods are labor-intensive, time-consuming, and costly, this paper proposed a robust AI method to study the sustainable elements of historic architecture by using Deep Learning. In this study, by introducing and developing a new method for detecting sustainable elements in historic architecture, their features were comprehensively extracted by means of mining meaningful data from areal images of historic cities to produce big data. The proposed method has a sophisticated workflow starting from subdividing the high-resolution aerial images to detecting the sustainable elements and using data science to analyze the extracted features of the segmented objects. Results of a sample analysis of this method showed its high accuracy and its applicability in analyzing sustainable elements of historic architecture, by which designers are expected to design more sustainable buildings inspired by historic architecture.

ps.27.140

Machine Learning to Predict Building Energy Performance in Different Climates

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Keywords: Building Performance Simulation, Machine Learning, Artificial Neural Networks, Space Conditioning, Zero-Energy Buildings, Green Buildings

Digitalization is sweeping the world of buildings. Notably, the use of machine and deep learning techniques to develop buildings' digital twins is becoming crucial to foster the energy transition of the construction sector and a sustainable urban growth. Digital twins can ensure a user-friendly, fast and reliable prediction of building energy loads and demands, thereby enabling a comprehensive optimization of planning, design and operation. Accordingly, this study investigates machine learning techniques to predict heating loads of a building in Rome (Italy, Mediterranean conditions, »Csa« climate in the Köppen and Geiger classification) and in Berlin (Germany, European backcountry, »Cfb«). Firstly, the real building, located in Benevento, is used to develop the artificial neural networks (ANNs), then implemented in MATLAB® to achieve meta-models of building energy behavior. NARX (nonlinear autoregressive model with exogenous inputs) networks are used and trained based on simulated data, provided by the well-known building simulation tool EnergyPlus using the software DesignBuilder® as interface. The meta-model inputs are related to weather conditions, while the required outputs concern the thermal energy load for space heating. The analysis is performed with reference to annual forecasts of energy demands. In all cases, the ANNs architecture is optimized to achieve the best fitness with EnergyPlus outputs. The results show that machine learning can be a precious and reliable tool to support energy design and operation of different buildings in different climates. Nonetheless, the meta-modeling procedure needs to be properly conducted by experts to set suitable frameworks and hyperparameter values of the ANNs, as well as to achieve a right and comprehensive interpretation of the results.

ps.27.141

An Overview of the Impact of the COVID-19 Pandemic on Urban Heat Challenges

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Keywords: Urban Heat Challenges, COVID-19, Mitigation and Adaptation

This study aims to present an overview of the impact of COVID-19 on urban heat challenges. First, this study developed a framework for understanding the linkages between COVID-19 and urban heat challenges. In particular, the framework the COVID-19 pandemic in aspects of anti-pandemic measures (restriction, protection, individual consciousness) and anti-pandemic periods (lockdown and normalization), and analyzed urban heat challenges in the aspects of hazards, mitigation and apatation to hazards. Built upon this, this study collected the evidence of the impact of the COVID-19 pandemic on urban heat challenges in air quality, energy, economy, heat illnesses, and adaptation and mitigation strategies. This study will allow government authorities and experts in various fields to recognize the increasing vulnerability of entire cities to high temperatures as a result of current anti-epidemic strategies. Meanwhile, it provides a reference to the development of a robust, effective, and stable system for addressing urban heat challenges during public health events.

ps.27.142

Methods for In-Silico Environmental Resilience, 2018 to 2100

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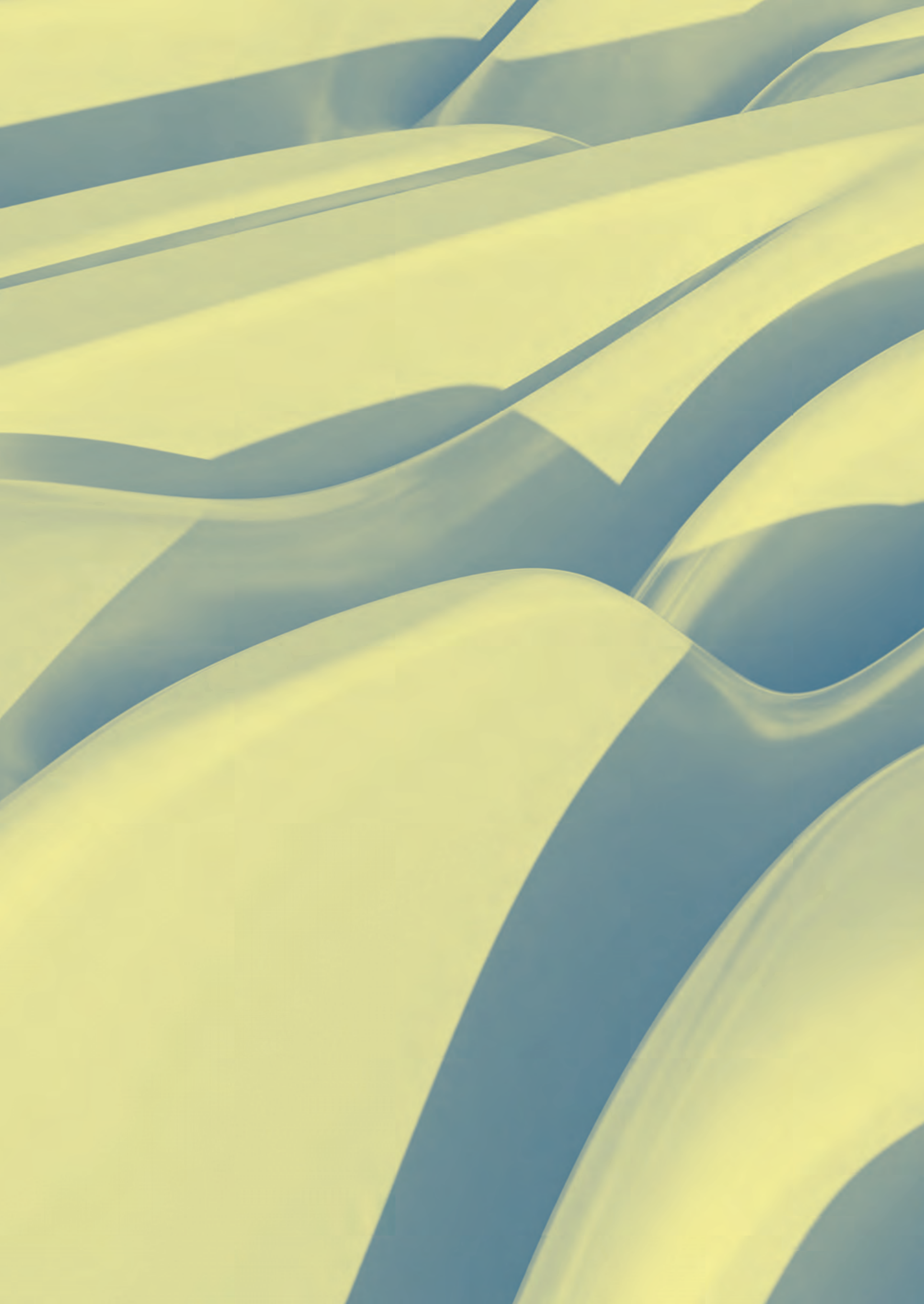
Keywords: Sea-level Rise, Artificial Intelligence, Carbon Positive Urban Simulation, Synthetic Biology, Bio-scripting

The research focuses on Genetic Water-Energy-Food Nexus Design Research Scenarios for Miami's Greater Islands. The Paris Agreement – 21st international Conference of Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) supports professional and municipal architecture and urban design practice emphasizing greenhouse gas reductions and carbon-neutral city planning and operations. In this respect, Miami benefits through multiple large-scale grants focusing on strategic solutions to combat and adapt to the effects of global warming, sea-level rise, flooding, hurricane impacts, and salt-water intrusion [1]. This paper presents research findings funded by a four-year transdisciplinary research project CRUNCH by EU agencies and the US-National Science Foundation in partnership with nineteen partners from six countries. It illuminates two transdisciplinary methods to produce bio-inspired infrastructural, architectural, and urban scale scenarios from 2018 to 2100. The silico-oriented research location is in Miami, proposing a trans-locational application envisaged in Berlin. The first method is based on parametric-algorithmic, generative design research workflows. The second utilizes synthetic biology through bio-scripting in collaboration with Autodesk. Both methods merge through the integration of cloud-based artificial intelligence and machine learning simulation engines. The research goals are to support international governments regarding sustainability master plans, and secondly, to raise and increase awareness towards urgent and societal relevant resilience topics for the future of human habitats. Scenario simulations are generated by the Florida International University (FIU) Miami research team at the Urban Living Lab (ULL), the GIS department, and two coastal cities in Miami Dade with low-lying areas. The ULL's research sectors include green-blue infrastructures to combat sea-level rise, synthetic biology scripting, robotic urban farming, local food production and hydroponics, mixed renewable energy design. In addition, and carbon-neutral power generation with adaptive infrastructure projects that support the local and regional Food-Energy-Water Nexus.



Special Fora

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Iea Ebc Annex 72 Assessing Life Cycle Related Environmental Impacts Caused By Buildings

The Annex 72 focuses on the assessment of the primary energy demand, greenhouse gas emissions and environmental impacts of buildings during production, construction, operation and dismantling, i.e., during the entire life cycle of buildings. The purpose of Annex 72 is:

- to reach consensus on the assessment methodology, which yet allows to respecting national or regional situations and rules regarding data and modeling.
- to better link methods for the environmental assessment with procedures and tools used during the design process (i.e., building information modeling, BIM)
- to work towards the definition of national and regional benchmarks and target values regarding primary energy demand, greenhouse gas emissions and environmental impacts of buildings during their full life cycle, including binding values for operational and embodied carbon.
- to support participating countries in need in the task of developing national or regional life cycle assessment databases tailored to the building and real estate sector
- to agree on recommendations for national and international standardization work related to life cycle thinking applied on buildings (e.g., draft for energy performance of buildings directive (European Commission 2021)

The scope of Annex 72 covers dwellings (single and multiple family housings), office buildings and possibly school buildings, both new and existing buildings. The life cycle covers the stages production (production of construction materials, building components and technical systems including resource extraction), construction process (erection of the building), use (operational energy and water use, maintenance, repair and replacement, planned refurbishment), as well as end of life (de-construction, recycling/waste processing and disposal). The indicators addressed comprise primary energy demand (non-renewable and renewable), greenhouse gas emissions (energy- and non-energy related) as well as environmental impacts.

The goals of this expert meeting are to:
- Present the outcomes of Annex 72, in particular regarding methodology, design tools, benchmarks, case studies and data management
- Launch dissemination and implementation of the recommendations to policy and scientific community
- Inviting larger community to follow the Monte Verità Declaration

We look forward to welcoming you to the Final Event at the Sustainable Built Environment conference 2022 in Berlin (SBE22 Berlin D-A-CH)!

In cooperation with: Federal Ministry for Housing, Urban Development and Building (BMWSB)

Wednesday, 21.09.2022

sf.2

New European Bauhaus (NEB): Federal Ministry for Housing, Urban Development and Building as National Contact Point for NEB in Germany in Dialogue

In September 2020 the European Commission launched an ambitious and wide-ranging process, the New European Bauhaus. The initiative is intended to be an environmental, economic and cultural project which aims to combine design, sustainability, participation and investment to kick-start a renovation wave which helps deliver the European Green Deal. The core values of the New European Bauhaus are sustainability, aesthetics and inclusiveness. The New European Bauhaus is a creative initiative breaking down boundaries between science and technology, art, culture and social inclusion and enabling interdisciplinary action to find new solutions to everyday problems.

Federal Ministry for Housing, Urban Development and Building as the National Contact Point for NEB in Germany has already established a dialogue platform. The priority fields of action are a focus on the housing stock, considering emissions and the use of valuable resources throughout the lifecycle, an action at the neighborhood level and the appliance of cultural knowledge and practices from other times and other places.

The special session will inform about the actual NEB-LAB as a co-creation space to develop enabling conditions for the green transition, such as new tools, frameworks, policy recommendations – and to trigger tangible transformation on the ground. Topics are »Regulatory analysis and experimentation«, »Nordic carbon neutral Bauhaus«, »Labeling Strategy« or »Transforming places of learning« and »NEB goes South« as a network to improve education through architecture.

Using examples, the discussion will explore how an NEB could emerge and present itself in Berlin and surrounding area as venue of the conference.

In cooperation with Natural Building Lab, TU Berlin

Wednesday, 21.09.2022

sf.3

Real World Laboratories in the Building Sector: Climate-Proof Transformation and Leap Innovation for Planning and Building Within Planetary Boundaries

The building sector in Europe is responsible for 30 % of waste generation, uses 40 % of non-renewable energy and is thus a major driver of climate change and resource scarcity. In order to achieve the Federal Environment Agency's goal of a climate-neutral and resource-efficient building sector by 2050 at the latest, radical innovation is required with the aim of climate-adapted and life-cycle-oriented planning and construction of buildings. The construction industry, especially in building construction, is not very inert and innovative; innovations take many years from basic research to market maturity. In order to achieve the climate and resource targets in the building sector, innovation thrusts are needed in all areas from material and construction development to the cycle-compatible design and adaptability of entire buildings. This requires the development of methods for cross-actor and cross-disciplinary experimental spaces in climate-friendly building construction, as well as new framework conditions and fields of action.

Real laboratories in the building sector can be used at the level of material and construction development, but also in the sense of linking change in the building sector to society (citizen science) and, in the context of necessary alternative approaches to sustainable new and existing building planning, methodically frame the realization and implementation of experimental (building) research in practice.

The Transformation Forum will bring together experts from science, building & planning practice and politics in order to define transformative potentials of Real world Laboratories as experimental fields in the building sector, and to define yet missing principles for the methodological framework of Real world Laboratories in the planning and building practice.

In cooperation with Einstein Center Climate Change and Public Policy of Human Settlement

Thursday, 22.09.2022

sf.4

CCC: Building with Boundaries

The Einstein Center Climate Change and Public Policy of Human Settlement (ECCC, in planning)* wants to use the unique potential of the metropolitan region Berlin-Brandenburg, its university landscape and the diversity of non-university institutes and actors for concrete climate protection projects.

During a two-year preparatory phase, the first transdisciplinary formats will be realized, such as this two-hour workshop under the motto »Building within Planetary Boundaries«. ECCC scientists and members of Berlin Partner interested in climate protection in the building sector want to explore together what the Berlin economy can contribute to climate protection in the building sector and how science can support them.

*The ECCC is closely linked to the climate research and transfer network Climate Change Center Berlin Brandenburg.

In cooperation with FNR –
Fachagentur für nachwachsende Rohstoffe (BMEL)

Thursday, 22.09.2022

sf.5

FNR: Calculating the National GHG Balance of Building With Wood

Building with wood has advanced to one of the key targets in combating climate change and to reduce greenhouse gas (GHG) emissions in the construction sector in various countries. But to consistently assess the environmental performance of buildings and quantify the overall GHG emissions associated with building with wood and also estimate the influence of a possible shift from conventional buildings to timber buildings on the national greenhouse gas budget, transparent calculations according to actual standards and rules are essential. This special session presents a consistent method for scaling from product level to building level and then to a national level. On the national scale, the potential GHG impact of wood consumption in the building sector is modeled based on an insinuated future increase of the market share of timber buildings. The deviation of future emissions and removals due to the biogenic carbon storage effects for changing scenarios is presented. The approach shows how increasing timber construction can contribute to achieving climate targets, where Germany serves as an example.

*This event is supported by the Federal Ministry of Food and Agriculture

In cooperation with InData (International Open Database Network Structure for Sustainable Construction) / BBSR

Thursday, 22.09.2022

sf.6

InData: Digital EPDs in a Unique Common Structure for All Stakeholders in the Value Chain

InData's mission is to support the digitalization of EPD data in order to assess and improve the environmental performance of buildings. EPD data shall be transported in a transparent, credible and useful way. Therefore, InData aims to provide internationally harmonized data structures, rules and guidelines that enable infrastructures for machine-readable data. This will make information in EPDs more understandable, transparent and useful, adding value to the entire data chain.

For this, InData has taken over the responsibility for the ILCD+EPD data format and corresponding compliance rules. ILCD+EPD data format is an open source data format for EPD data. In recent years, InData has succeeded in introducing ILCD+EPD data format as an open-source and harmonized data format across Europe. The ILCD+EPD data format is widely used by EPD program operators and has been adopted by ECO platform in the ECO portal.

The workshop will give a review what has been achieved so far and a preview on the next challenging steps.

More information: www.indata.network

Workshops

ws.1

Prototyping Material Cycles

with Haus der Statistik, Berlin-Mitte

The workshop at the Haus der Statistik as part of the sbe22 berlin conference entitled »Prototyping Material Cycles« focuses on circular principles in urban development and architecture. Based on the need for a structural and systemic transformation of the building sector, the focus is on global and regional material cycles, the reuse and recyclability of building materials and materials and their use in the planning and realization phases, as well as the necessary system interfaces in terms of processes and actors. The aim of the workshop is to discuss the overarching, structural and political issues against the background of concrete, prototypical project contexts and to interlink them with practical experience. The location is thus itself an actor – the Haus der Statistik stands as a Berlin model project for cooperative and commongood oriented urban development and has been a test laboratory for experimental and demand driven project development since 2015, for example with the« Reallabor für zirkuläres Wirtschaften – Haus der Materialisierung« (Real Laboratory for Circular Economy – House of Materialization) or with the construction project of three climate-friendly experimental houses for new forms of living and socio-cultural uses.


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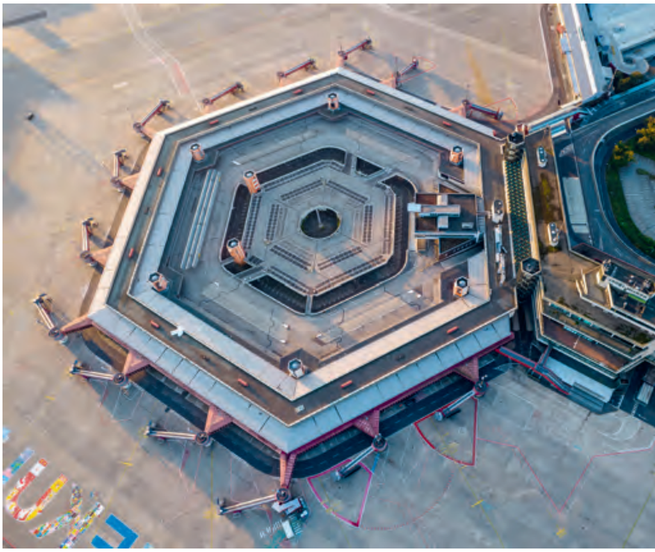
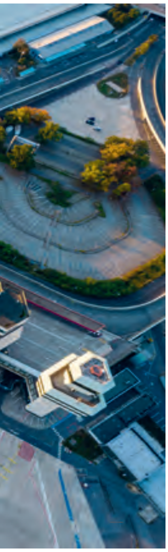
ws.2 Communal Climate Action Mayor:ess Forum

with Tegel Projekt GmbH

The aim of the workshop is to discuss in depth municipal requirements and concepts for a climate-friendly transformation of the neighborhood and building sector. As stated in the United Nations New Urban Agenda and the Leipzig Charter on Sustainable European Cities, the transformative power of municipalities is considered a driver for a livable and equitable future. City networks and alliances at the global and international level bring about a valuable exchange of knowledge and experience on how municipalities and cities can act as powerful and agile institutions, yet for a sustainable transformation, stronger networking of municipalities at the regional level needs to be politically shaped and embedded in the administration. The need for a more rigorous definition of the requirement and touchstones for a climate-compatible municipal neighborhood and building sector (Clean Construction Sector) exists, as does the question of inter- and intra-regional administrative units and tools such as real world labratories, test rooms or building exhibitions that can support and accelerate the transformation of an entire sector through experimentation and model character. Against the background of European best practice examples, the workshop will discuss municipal strategies for a clean construction sector in the morning with participants from politics, administration, business, science and civil society, and benchmarks and parameters for embodied carbon in a technical round table with EU representatives in the afternoon.


BERLIN-TEGEL
OTTO LILIENTHAL

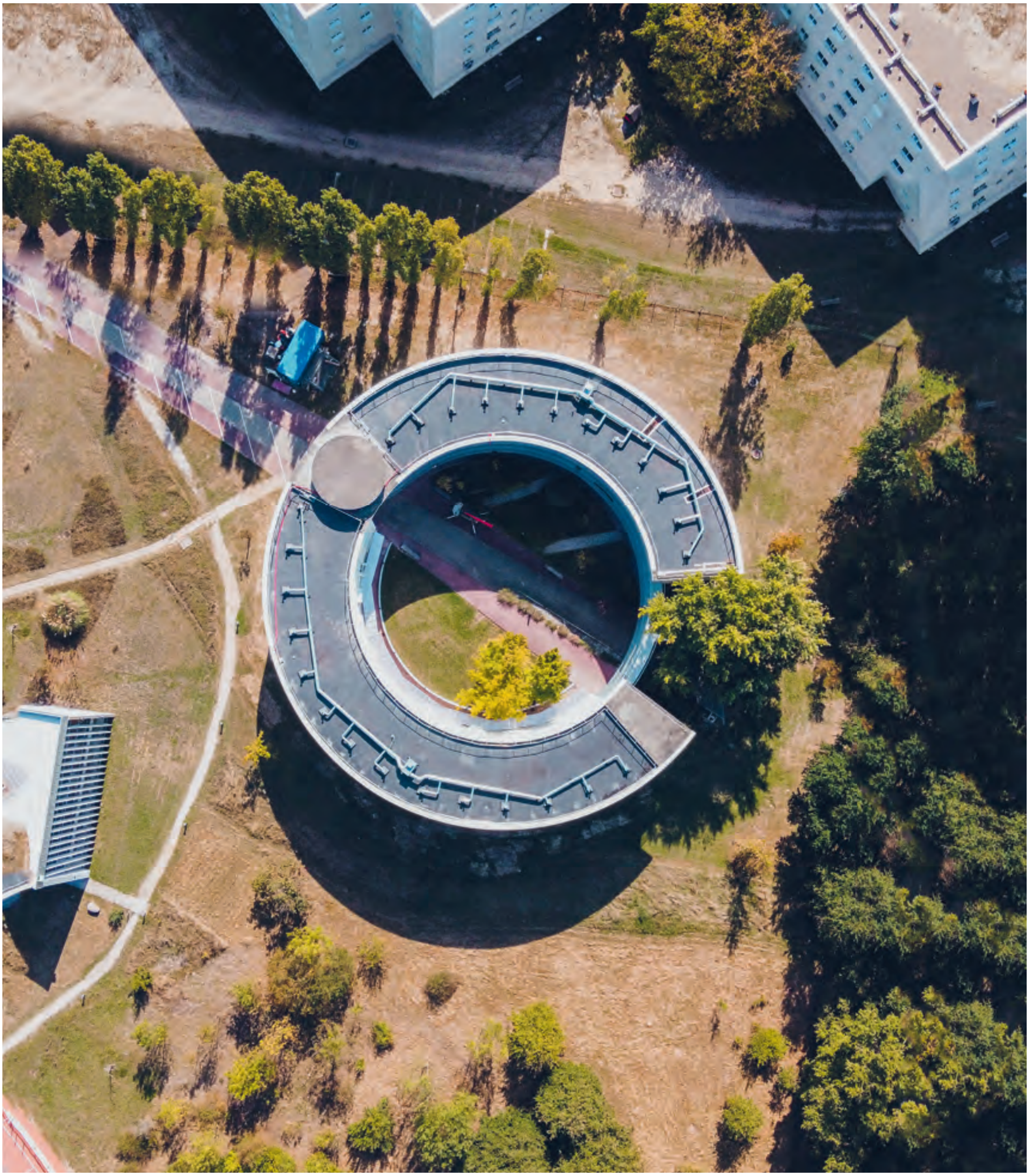





BERLIN-TEGEL

ws.3 Climate Protection in the Built Environment, EU Round Table

with Prof. Thomas Lützkendorf



Tuesday, 20.09.2022, 14–17 pm

Main Building, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin

*Participation in this event is by invitation

Climate protection in the construction and building sector as part of sustainable development is a complex task. A climate-neutral Europe presupposes a climate-neutral building stock, i.e., a building stock that does not cause or compensate for greenhouse gas emissions during maintenance, additions and operation. This climate-neutral building stock should and must be achieved by means of sustainable planning, construction and operation. The prerequisite is the interaction of basic methods, requirements, data and tools, as well as documentation and communication possibilities, funding programs, legal requirements and instruments for improving transparency in the real estate market in a cross-thematic and cross-departmental approach.

The workshop should discuss the possibilities of a division of labor approach of existing instruments as well as approaches to their further development. Participants are not only from the scientific community, but also represent individual DGs of the EC related to the construction and real estate sector as well as the federal ministries in Germany related to construction, climate and economy as well as environment. The planned exchange will last approximately three hours.

Excursions

e.1 Transformative Spaces: Socio-Ecological Perspective on Architecture

Places of bottom-up artistic, cultural, architectural and socio-cultural action are often the initiators for transformation and the development of new processes. In Berlin, pioneer projects on different scales and supported by their transdisciplinary networks of actors are promoted to open up spaces for democratic negotiation processes, exchange of knowledge and experience, development of new public spaces, architectural prototypes and design of new formats of work and cooperation. During this excursion, we will visit a selection of best practice projects that make urban transformation and set important impulses for the whole city.

*by bike

e.2

Urban Timber: Wood Construction on a City Scale

In order to pursue the city of Berlin's goal of transforming Berlin into a climate-neutral city by 2050, the state of Berlin and private owners are investing in timber construction as a future building technique. Building with wood was traditionally used in many ways in the city in the 19th century, and today it qualifies as a local, renewable material in urban multi-storey construction that conserves resources and binds emissions. In cooperation with the Holzbauatlas Berlin Brandenburg, we will visit innovative examples of contemporary timber construction in Berlin.

*by bus and bike

Postface

Acknowledgments

We would like to express our cordial thanks to all who helped make this conference a success. We have much pleasure in thanking our partners from ETH Zürich, KIT Karlsruhe, TU Berlin and TU Graz and our partner organizations iisbe, cib, UNEP and the Global Alliance for Buildings and Construction. In particular, we would like to thank all the reviewers from the Scientific Committee whose expertise and support helped to advance and ensure the scientific quality of the conference.

We especially would like to thank our cooperation partners – the Federal Office for Research on Building, Urban Affairs and Spatial Development, the Climate Change Center Berlin Brandenburg, the Senate Department for Environment, Mobility, Consumer- and Climate Protection and DFG German Research Foundation for their funding and support as well as our media partners Building and Cities, nbau and BauNetz for their partnership.

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sbe22 berlin Organisation Chair

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The global climate crisis requires us to develop new understandings of how we want to live, work, consume and build in the future.

sbe22 berlin –
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