SBE19 Graz

SUSTAINABLE BUILT ENVIRONMENT D-A-CH CONFERENCE 2019

Graz University of Technology, Austria

BOOK OF ABSTRACTS

Transition Towards a Net Zero Carbon Built Environment

SBE19
Graz

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SUSTAINABLE BUILT ENVIRONMENT
D-A-CH CONFERENCE 2019

11 - 14 September 2019
Graz University of Technology, Austria

▶ www.sbe19.tugraz.at

TU Graz   KIT Karlsruhe Institute of Technology   ETH zürich   BOKU University of Natural Resources and Applied Life Sciences, Vienna

BOOK OF ABSTRACTS

Transition Towards a Net Zero Carbon Built Environment

IMPRINT

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WELCOME TO SBE19 GRAZ

Dear ladies and gentlemen,
Dear colleagues,

we would like to welcome you to the Sustainable Built Environment D-A-CH Conference 2019 (SBE19 Graz) - Transition Towards a Net Zero Carbon Built Environment. Together with other events in the SBE-series, the goal is to prepare for the World Conference in 2020 in Gothenburg (WSBE2020 - Beyond 2020).
The aim of SBE19 Graz is to enable an exchange between scientists, practitioners, politicians and the interested public on matters regarding innovative construction products, sustainable buildings, modern design methods and tools, sustainable urban neighborhoods and future-proof urban development. This includes new business models and instruments on green financing as well as national and regional strategies to implement sustainable development principles in the construction and real estate sector. For the first time, this regional conference has been jointly organized by institutions from Germany, Austria and Switzerland following the “D-A-CH” format.
The 145 international scientific committee members put a lot of effort into the double-blind peer review process of the scientific contributions and selected the best contributions for presentations, which are available as open source, indexed publications. 188 scientific presentations from more than 30 countries highlight the wide scope and complexity of international research activities that address sustainability issues for the built environment. The program is structured accordingly including the following topics organized in six parallel sessions: Buildings, Building Design, Processes, Products, Education & Economy and National Issues.
The matter of climate change has been stated clearly by the IPCC: Every degree of warming counts, every year of delay counts and every decision counts. It is now being increasingly discussed how the demands for climate protection can be translated into concrete design requirements, e.g. in terms of environmental budgets or environmental target values. Swift action is required and the advice of our colleagues in climate and environmental research is becoming ever more urgent. What is needed are general sustainability guidelines as well as practical solutions such as planning and assessment methods, innovative construction products and building solutions.
The role of the construction and real estate industry in developing answers to the current problems is crucial. The construction, maintenance and adaptation of the built environment is a basic prerequisite for social and economic development. On the one hand, these activities require significant amounts of energy and initiate material flows and green house gas emissions that impact the global and local environment not only during construction, but for a long time thereafter – typical lock-in factors. On the other hand buildings, cities and infrastructure are not only affected by climate change but are also expected to protect people from the undesirable effects of climate change. Therefore, the sector has multiple tasks, the most pressing one

being to exploit the savings potential of the sector with appropriate support through setting suitable framework conditions and policies. Greenhouse gas emissions must be reduced to 50% by 2030 and industrialized nations must achieve net zero emissions by 2050. That is an enormous challenge, but the stakes are high and the building and related industry sector must and will contribute to the effort.

From a complex analysis perspective, topics other than mitigation should not be neglected - examples are health protection, comfort, durability, adaptability, resilience, decommissioning and recyclability (circular economy) or affordability. Frequently, this not only results in synergies but also in trade-offs, sometimes conflicting goals, which only become recognizable and solvable in an integrated, systemic approach. Methodological approaches such as technology assessment or comprehensive sustainability assessment therefore remain indispensable.

The SBE19 Graz addresses questions with additional complementary formats to the regular scientific presentations. Aspects of climate change (SDG 13) and the role of sustainable cities and municipalities (SDG 11) will be discussed in roundtable events at the pre-conference. In the special fora specific topics will be discussed in a workshop character, for example regarding LEVEL(s), CRP special requirement 7, the further development of EPDs, sustainability performance of construction products (steel, concrete, wood and plastics). Last but not least, a focus will be put on how universities and research institutes can contribute to sustainable development with their own responsibility and their own building stock – where your valuable contribution would be highly appreciated.

The days of exchange and discussion at this conference at Graz University of Technology are also an important signal: inspiring cooperation and scientific exchange across all borders is not only possible but necessary - limiting global change within planetary boundaries.

Our organizing team made a special effort to make this event itself a more sustainable one following Green Events Austria suggestions.

SBE19 Graz provides a special setting to refresh existing contacts and create new partnerships and friendships. We hope that your stay in Styria, the green heart of Austria, will stir active discussion and we are looking forward to hear your thoughts and views to progress the Transition Towards a Net Zero Carbon Built Environment.

With kind regards,
SBE19 Graz Chairs

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Transition Towards
a Net Zero Carbon
Built Environment

INTERNATIONAL SCIENTIFIC COMMITTEE

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PROGRAM OVERVIEW

Transition Towards
a Net Zero Carbon
Built Environment

Wednesday 11 September

Pre-Conference

	Aula
09.30	Welcome Coffee
10.30	**SDGs & Universities**
13.00	Lunch & Registration
14.00	**SDG 13 Roundtable**
15.30	Coffee Break
16.00	**SDG 11 Roundtable**
17.45	
18.30	**Welcome Evening** Mayor's Reception Town Hall

Thursday 12 September

Conference

	Aula	HS I	HS VI	HS XII	HS V	ATEG-152	AT01-036	AT01-104	AT01-098
08.00	**Registration** | Conference Office								
09.00	**Opening Ceremony** | Aula								
09.30	**Keynotes** Aula								
11.00	Coffee Break								
11.30	SF Level(s)	1 Buildings	1 Building Design	SF Die 3 Schwestern Aspern Bauplatz D22	1 Processes	1 Products	1 Education & Economy	SF CONDEREF	
13.00	Lunch								
14.15	SF BWR7	2 Buildings	2 Building Design	1 Cities	2 Processes	2 Products	2 Education & Economy	SF ecoinvent	SF vinylplus
15.45	Coffee Break								
16.15		3 Buildings	3 Building Design	2 Cities	3 Processes	3 Products	3 Education & Economy	SF EPD	
17.45									
18.00	**Guided City Tour** From the conference venue to the Schlossberg								
19.30	**Conference Dinner** | Schlossberg Restaurant								

Friday 13 September

Conference

	Aula	HS I	HS VI	HS XII	HS V	ATEG-152	AT01-104	AT01-098	
08.00	**Registration** | Conference Office								
09.00	ADOPTION OF THE "GRAZ 2019 DECLARATION" | Aula								
09.20									
09.30	1 National Issues	4 Buildings	4 Building Design	3 Cities	4 Processes	4 Products	SF Beton	SF Plastics	
11.00	Coffee Break								
11.30	2 National Issues	5 Buildings	5 Building Design	4 Cities	5 Processes	5 Products			
12.00									SF green.LAB Wagner-Biro-Straße
13.00	Lunch								
13.30							SF Holz-system-bau		
14.15	3 National Issues	6 Buildings	6 Building Design	5 Cities	6 Processes			SF Smart City Graz	
15.45	**Closing Event** including ***Best Paper Award*** | Aula								
17.15	**Farewell Coffee**								

Saturday 14 September

Side Event

09.30	**Technical Tour**
12.00	
15.00	
15.30	

Thursday
12 September

Conference

	Aula	HS I	HS VI	HS XII	HS V	ATEG-152	AT01-036	AT01-104	AT01-098
08.00	**Registration** | Conference Office								
09.00	**Opening Ceremony** | Aula								
09.30	**Keynotes** Aula								
11.00	Coffee Break								
11.30	SF Level(s)	1 Buildings	1 Building Design	SF Die 3 Schwestern Aspern Bauplatz D22	1 Processes	1 Products	1 Education & Economy	SF CONDEREF	
13.00	Lunch								
14.15	SF BWR7	2 Buildings	2 Building Design	1 Cities	2 Processes	2 Products	2 Education & Economy	SF ecoinvent	SF vinylplus
15.45	Coffee Break								
16.15		3 Buildings	3 Building Design	2 Cities	3 Processes	3 Products	3 Education & Economy	SF EPD	
17.45									
18.00	**Guided City Tour** From the conference venue to the Schlossberg								
19.30	**Conference Dinner** | Schlossberg Restaurant								

SF Special Fora

SF SF in German language

Conference Sessions

Special Sessions

Friday
13 September

Conference

	Aula	HS I	HS VI	HS XII	HS V	ATEG-152	AT01-104	AT01-098	
08.00	**Registration** | Conference Office								
09.00	**ADOPTION OF THE "GRAZ 2019 DECLARATION"** | Aula								
09.20									
09.30	**1** National Issues	**4** Buildings	**4** Building Design	**3** Cities	**4** Processes	**4** Products	**SF** Beton	**SF** Plastics	
11.00	Coffee Break								
11.30	**2** National Issues	**5** Buildings	**5** Building Design	**4** Cities	**5** Processes	**5** Products			**SF** green.LAB Waagner-Biro-Straße
13.00	Lunch						13.30		
14.15	**3** National Issues	**6** Buildings	**6** Building Design	**5** Cities	**6** Processes		**SF** Holz-system-bau	**SF** Smart City Graz	
15.45	**Closing Event** including ***Best Paper Award*** | Aula								
17.15	**Farewell Coffee**								

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PREFACE

Transition Towards
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Built Environment

Dear SBE19 Graz participants,

sustainability is one of our most eminent topics. It is a necessity for our dealings with nature and scarce or even infinite resources. A responsibility of pressing urgency for all mankind, it is an obligation we owe to future generations. One of the most important contributions we can make for this so very urgent task is to achieve sustainable construction.

The development of sustainable solutions is not an effort limited to single scientific disciplines as we strive for sustainability. Interdisciplinary approaches are key to effectiveness and success through a broad front and are on high demand. TU Graz fosters multiple concepts and focusses on interlinking them. Our Field of Expertise Sustainable Systems – one out of five internationally outstanding research areas – involves researchers from all our seven faculties and half of our around 100 institutes. Its research topics range from future-oriented urban planning, innovative building technologies and energy systems to the use of renewable energy sources, intelligent energy networks and green mobility.

The topic is well represented in our graduate and continuing education. Furthermore, our students organize sustainability events on a regular basis. Our internationally successful student teams work on projects ranging from lightweight concrete to energy-efficient vehicles.

The initiative UniNEtZ unites Austrian universities and relevant official institutions in contributing to the goals defined and pursued by the United Nations Sustainable Development Agenda. Under the leadership of the TU Graz Sustainability Advisory Board, our university and the University of Graz co-ordinate our universities contributions make to the UN sustainable development goal (SDG) 11 of ensuring sustainable cities and communities. Furthermore, contributions are made to work on quality education (SDG 4), clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), industry, innovation and infrastructure (SDG 9), responsible production and consumption (12) and climate action (13).

This conference will bring valuable contributions and yield practical results for the diverse facets and the assignments of sustainable construction. Experience an inspiring visit to Graz University of Technology while participating in fruitful discussions and gaining new insights.

Yours,

Univ.-Prof. Dipl.-Ing. Dr.techn. Dr.h.c.mult. **Harald Kainz**
Rector of Graz University of Technology, Austria

Dear SBE19 Graz participants,


credit: ETH Zurich

the construction industry accounts for over 40% of all raw materials extraction, as well as 40% of total energy supplied and 16% of annual water consumption worldwide. During the last century, overall global material consumption multiplied approximately tenfold, while consumption of construction minerals multiplied by a factor of 42, showing a positive feedback-loop between socio-technical system evolution and its construction material requirement. Following business-as-usual practices will drive building and infrastructure activities along a dramatic and unsustainable path. But these future challenges can also be turned into opportunities.

Selected building technologies can reduce or even store carbon emissions during construction and in the longer term. They can also be used as depositories of materials to be mined at a later stage. Building renovation can also be a catalyst to re-activate social and economic networks in a neighbourhood. To harness these opportunities, the Swiss Federal Institute of Technology (ETH Zurich) is engaged in research and innovation towards a post carbon environment.

ETH Zurich also wants to play a key role in training a new generation of scientists, engineers and architects. We want them to have the fundamental knowledge to tackle these challenges but also, and most importantly, to exercise critical thinking in order that they can engage in society by developing and designing the appropriate answer to the real needs of future generations.

The conference on the Sustainable Built Environment, SBE 19 in Graz, is part of a major international series of conferences supported by the International Council for Research and Innovation in Building and Construction (CIB), the International Initiative for a Sustainable Built Environment (iiSBE), the Sustainable Building and Climate Initiative (SBCI) of the UN Environment, the International Federation of Consulting Engineers (FIDIC) and the Global Alliance for Buildings and Construction (GABC). The series, now on a three-year cycle, is recognised as the world's preeminent conference series in this important field.

I am delighted to learn about the common initiative from Austrian, German and Swiss universities to co-organise this conference. It is hosted at the Graz University of Technology in collaboration with the University of Natural Resources and Life Sciences in Vienna, Karlsruhe Institute of Technology and ETH Zurich.

I wish you all success for the conference and hope that under this common roof you, as researchers and industry partners, will have exciting and fruitful discussions that will trigger the necessary dynamics for transformation towards a net zero emission built environment.

Yours sincerely,

Prof. Dr. Dr.h.c.mult. **Sarah M. Springman** CBE FREng
Rector of Swiss Federal Institute of Technology Zurich, Switzerland

Dear participants of the SBE19 Graz,

credit: andrea fabry

as the President of Karlsruhe Institute of Technology, KIT – The Research University in the Helmholtz Association – it is my great pleasure to send you greetings from the executive board as well as the employees and students.

In an era of intense struggle to achieve the internationally recognized sustainable development goals, it is particularly important to put scientific knowledge at the service of society and to strengthen international cooperation. This also applies to the subject areas of design, construction, renovation and use of buildings, sustainable urban development and sustainable energy supply. After participating in the preparation of the SB13 in Munich and the SBE16 in Hamburg, KIT is now involved in the implementation of the SBE19 in Graz – for the first time as partners with institutions from Austria and Switzerland in a transnational format. KIT staff have directly participated in the Advisory Board and the immediate organization, as well as making scientific contributions to the conference.

At KIT, around 9,300 employees are working together on a broad disciplinary basis in natural sciences, engineering, economics, humanities and social sciences. KIT offers research-oriented studies to prepare its 25, 000 students for responsible tasks in society, economy and science. Our aim is to make significant contributions to global challenges in the fields of energy, mobility and information.

Innovations at KIT bridge the gap between knowledge and application for the benefit of society, economic prosperity and the preservation of our natural resources. According to this mission, knowledge for society and the environment is developed and taught at the research university. Due to its broad profile, KIT's divisions and institutes are able to almost completely map the value added chains of the construction, real estate and energy industries. This approach allows us to develop products, technologies, assessment methods and business models that contribute to sustainable development. Thus, KIT has successfully dealt with these key issues: (1) development and testing of sustainability assessment systems for buildings and neighborhoods; (2) analysis of building-related energy and material flows in regions; (3) development of indicators for assessing energy supply systems.

The organization of scientific disciplines of KIT is purposely structured in five divisions: I: Biology, Chemistry and Process Engineering, II: Informatics, Economics and Society, III: Mechanical and Electrical Engineering and V: Physics and Mathematics, deal with research issues with direct relevance to the topics of construction and energy industry. Division IV provides a center for all topics of the natural and built environment. The creation of three overarching strategic fields: „Energy“, „Mobility“ and „Information“, ensures that targeted research contributions can be expected in the coming years to address current megatrends.

Foundations, principles and solutions for the implementation of sustainable development are an integral part of the education of students and young scientists. An extra-curricular course of studies called „Sustainable Development“ organized by the Centre for Cultural and General Studies (ZAK) is just one example. In 2018, UNESCO designated KIT as a “learning location for sustainable development”. The “Future Campus” department coordinates and promotes sustainable development at our own campus.

I am convinced that the SBE19 in Graz will not only be a showcase of past results and achievements, but also the starting point for an even more intensive cooperation in all relevant fields of research. I wish all participants every success in this regard. Finally, I would like to thank the institutions in Austria and Switzerland for their cooperative spirit and in particular TU Graz for their initiative in connection with the host's role.

Yours faithfully,

Professor Dr.-Ing. **Holger Hanselka**
President of Karlsruhe Institute of Technology, Germany

Dear SBE19 Graz participants,

credit: BOKU Wien

a continuous increase in the population over the last centuries along with the industrialization and its increasing demand for fossil energy led to a record high CO2 concentration in the atmosphere and further ecological and social challenges. The 17 SDGs (Sustainable Development Goals) proposed by the United Nations give a vision for 2030 and are based on the planetary boundary concept with the goal to avoid further damage to our planet. One of the SGDs, the SDG 11, focusses on **“Making cities and human settlements inclusive, safe, resilient and sustainable”** and directly links to the topic of this conference, a sustainable built environment. Issues like land consumption and its related consequences, the use of construction materials, energy efficiency and production are as well addressed as social implications on how we as human beings want or should live together.

BOKU University of Natural Resources and Life Sciences, Vienna is the University of Sustainability. We do research and offer study programs since 1872 based on the integration of technical, ecological and socio-economic fields. This interdisciplinary approach perfectly addresses the research and educational needs of the sustainable development goals. Not surprisingly that BOKU takes a leading role in the Austrian UniNEtZ-Project, which promotes the implementation of the SDG in Austria.

With this background we are proud to contribute to this conference. We expect new findings and we do hope that you have a successful stay in Graz.

Yours sincerely,

Univ. Prof. Dipl.-Ing.Dr. DDr.h.c. **Hubert Hasenauer**
Rector of University of Natural Resources and Applied Life Sciences, Austria

Dear SBE19 Graz participants,

credit: paul gruber

with the Austrian Climate and Energy Strategy, #mission2030, we heralded the end of the fossil fuel age in our country. We want to reduce greenhouse gas emissions by 36 percent compared to 2005 and aim to produce 100 % of Austria's power consumption from renewables by the year 2030. Presently, we are working to prepare the law on the development of energy from renewable sources; we advance electromobility, ensure new funding options by means of the Green Initiative, and promote the Bioeconomy Strategy.

High-quality refurbishment and renovation of existing buildings and energy-efficient new construction are effective strategies in the fight against climate change. With the help of Austria's Heat Strategy the goals for the building and thermal sector laid down in #mission2030 are to be achieved by 2030. Promoting energy efficiency and renewable energy in buildings also creates important impulses for Austria's economy and offers substantial opportunities on international markets.

In addition to the thermal rehabilitation campaign, the subsidies offered within the framework of domestic environmental subsidisation and the Climate and Energy Fund, my climate protection initiative "klimaaktiv" is setting trailblazing impulses with the building standard, the complex evaluation system in the field of climate protection and energy efficiency.

The fight against climate change is anything but easy, but it also represents a great opportunity. Bearing this in mind, I wish the "Sustainable Built Environment Conference 2019" every success. It is a pleasure for us to offer support to this important event.

Kind regards,

Maria Patek
Federal Minister for Sustainability and Tourism, Austria

Dear SBE19 Graz participants,

credit: johannes zinner

cities and buildings of the future have to provide a major contribution to the national and European climate and energy targets. Therefore, energy driven and sustainable city planning, digitalization in the construction sector as well as renewable energy and building technologies are key to support stakeholders, especially under the requirements of building quality and affordability.

Research can significantly contribute to generate innovative solutions for the future by questioning known patterns. If they succeed, they will be put into practice, and the creation of suitable framework conditions are essential to enable a broad and successful implementation.

As an example, the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) is committed to the implementation of plus energy districts as a mission of “City of Tomorrow”. It will do so by funding research and development on urban technologies, technological systems and services, and taking the growing importance of digitalization into account.

The focus lies on innovative technologies and systems for energy generation, distribution, transformation and storage as well as the optimization of the energy consumption in buildings and urban neighbourhoods, in addition to energy efficiency and new building technologies for new constructions and renovations.

For many years, Austria is internationally recognized as a pioneer in the field of building and urban technologies. This role is to be further strengthened by the current initiatives, an objective that can only be achieved with the involvement and cooperation of research, industry, public administration and commercial enterprises.

With this in mind I wish those attending the Sustainable Building Conference 2019 stimulant and exciting discussions!

Yours sincerely,

Andreas Reichhardt
Federal Minister of Transport, Innovation and Technology, Austria

„Architecture is a manifestation of freedom“


credit: lebensressort

Scientific evidence for a global warming and change of the climate system is unequivocal. Climate change impacts thousands of citizens‘ lives around the globe every day in countless ways. One way in which we are impacted is in our weather patterns: we face periods of enormous heat and extreme thunderstorms followed by particularly frosty winters. As we gradually move from a state of normality to a state of extremes, the call on our nation’s leaders has become louder and louder. The call? One for sustainability.

Although it is a fact that climate change does not know any borders, Styria wants to procede as a role model. We know that climate change and its effects do not have touchpoints with just one or two thematic areas. Therefore, the Styrian government has decided not to pass just one single law, but to consider these problems in all of its political activities, ranging from tasks such as spatial planning, funding guidelines and general legislation. For Styria, sustainability is not merely one project or something that gets passed in a couple of laws by Parliament. Rather, sustainability is one lens through which all decisions will pass through.

A major area in which sustainability plays a special role is housing and its funding guidelines. Therefore, we pay particular attention to which building materials are used for construction. Another important criteria for obtaining public funding is the issue of energy efficiency when it comes to constructing or renovating houses. Land Steiermark’s course of actions clearly favours buildings that protect the climate by using materials that help the buildings achieve energy efficiency, in accordance with European Union directives.

The issues related to climate change and global warming cannot be solved by a single country, yet it is our duty to make our modest contribution to preserve our liveable environment.

Yours faithfully,

Johann Seitinger

State Councilor for Agriculture and Forestry, Water and Waste Management, Housing and Sustainability, Styria, Austria

Dear SBE19 Graz participants,

credit: freisinger

the topic of sustainability affects a variety of areas in our lives; be it the production and consumption of goods, the volume of traffic or our built environment, which seals large areas of land.

All this presents future generations with ever-increasing challenges. However, it is up to us to keep this negative legacy to a minimum.

The economic efficiency, when it comes to using resources as economically as possible, the developments in economic terms as well as the social aspects of responsibility for the future and global distributive justice should guide our actions.

In the Climate and Energy Strategy Steiermark 2030, an important chapter for sustainable construction methods was opened with a focus on „buildings and settlement structures“ from a holistic perspective. It ranges from energy-optimized settlement structures as an element of energy planning to energy-efficient building technologies and climate-friendly and therefore sustainable building envelopes.

In addition, the Climate and Energy Strategy Steiermark 2030 also addresses the aspects of ecology (such as open spaces and urban climate, water and soil, resource cycles and emissions). For example, the sustainability criteria in the waste and resource industry, the energy supply and distribution and the reduction of the personal carbon footprint of each and everyone of us are essential issues.

Now it is important to suit the action to the word and take concrete measures. The fight against climate change does no longer tolerate a delay.

With this in mind, I wish all involved parties a successful participation. May you be the initiator and driving force for processes for a livable future for our children and grandchildren.

Yours faithfully,

Anton Lang

State Councilor for Finance, Transport, Environmental and Renewable Energies / Climate Protection, Sport and Animal Welfare, Styria, Austria

Ladies and Gentlemen,

as the Mayor of Graz, I am particularly pleased that the „Sustainable Built Environment D-A-CH Conference 2019“ is taking place in Graz once again. Graz is growing: about 60,000 more inhabitants since 2003. That also means, we are forecasting another 40,000 new citizens by 2035. In view of this development, urban sustainability strategies, especially in the residential sector, are not „nice to have“, but indispensable.

Since this internationally renowned conference enables encounters between young researchers and established scientists, not only the content but especially the format can be described as particularly sustainable.

I hereby thank all those who have contributed to the preparation and implementation of the conference, as well as all speakers and wish you all informative and enjoyable days in Graz!

Yours faithfully,

Mag. **Siegfried Nagl**
Mayor of the City of Graz, Austria

Dear SBE19 participants,

it is a great pleasure for me to welcome you to Graz as the capital of the province of Styria and with nearly 300,000 inhabitants the second largest city of Austria. Graz is very proud to host four universities and two universities of applied sciences with about 50,000 students. This is one main reason to support such important scientific events like SBE19.

Another reason is that knowledge exchange and capacity building – with such a holistic approach – are essential for the public sector to keep pace with rapid technological development and changing societal and environmental framework conditions. The SBE19 Graz conference where internationally renowned experts will present important aspects of sustainable building and construction in numerous talks and lectures is a perfect possibility for practitioners, scientists and administration to learn from each other.

As a strong growing city, Graz is continuously looking for sustainable urban development solutions to preserve and even expand its high quality of life under growing framework conditions.

In this regard the City of Graz has already achieved national and international recognition for its innovative efforts to implement such sustainable solutions under its local umbrella strategy for a Smart City. This can only be achieved through a strong PPP-cooperation with numerous experienced scientific partners such as the University of Technology in Graz, the Provincial Government of Styria and with many other innovative institutions and companies.

Curbing climate change today is one of the biggest challenges facing politics, the economy and society. Sustainable building and renovation concepts are essential instruments of climate protection and important steps towards local energy autonomy. More than one third of our energy consumption results from the private, public and service sector. Hence comprehensive thermal retrofitting of building stock, greater energy efficiency in new buildings and a significant increase in the share of renewable energy can - in addition to more efficient energy use in the transport and producing sector - slow down climate change for the long term. Other important topics for urban areas, which will be addressed during the SBE19-conference, are inter alia cities as temporal carbon and energy storage or circular economy concepts for the built environment.

I wish the Sustainable Built Environment Conference 2019 every success and all participants lots of inspiring discussions, insights and findings for future practical implementation.

Kind regards,

Bertram Werle
Director for urban planning, development and construction
City of Graz, Austria

Dear Participants of the “Sustainable Built Environment D-A-CH Conference 2019”,
Dear Ladies and Gentlemen,


credit: wienerberger

in an increasingly interconnected society, companies worldwide face severe challenges. Consequently, Wienerberger is continuously working to improve and further develop its products as well as system solutions for all fields of application, including the recycling and reuse of our products. The foremost goal of our entrepreneurial activities is to achieve a sustainable growth of the company in accordance with ecological, social and economic principles. To achieve this goal, we have defined a clear strategy focused on organic growth, operational excellence, investments and portfolio optimization. We do our utmost to supply future oriented sustainable building material solutions in the building sector. By providing long-lasting and resource-conserving building materials and energy efficient building and infrastructure concepts we confirm that we are taking our role as a responsible member of society very seriously. All stages of the value chain of the Wienerberger Group are covered by a voluntary commitment to sustainability.

At the SBE19, internationally renowned experts will emphasize all aspects of sustainable construction. We especially welcome the fact that many young people and students in the field of sustainable building solutions will participate in the conference. Wienerberger makes every effort to contribute to the promotion of sustainable buildings which is demonstrated by the certification of the residential construction project “D22” in the Seestadt Aspern (Vienna, Austria). The building achieved 769 of 1000 points in the ÖGNB building certification and was awarded “klimaaktiv GOLD”. Fascinating is the fact that the team opted for Wienerberger Porotherm 50 W.i bricks for the building envelope. For the first time in a long while a subsidized residential building was constructed with monolithic, loadbearing clay blocks without additional external thermal insulation. In our opinion, the project can be seen as a real lighthouse project due to its contribution to the energy efficiency of buildings and to climate protection.

Having this in mind, I wish all attendees of the SBE19 stimulating discussions and very promising results!

Yours,

Heimo Scheuch, Chief Executive Officer
Wienerberger AG, Austria

Dear SBE19 Graz participants,


credit: FV Steine-Keramik/Lukas Lorenz

in recent years new construction methods have been developed (e.g. building component activation) in order to reduce the energy consumption of the building sector. Massive research has been carried out on material components in order to minimise the use of raw materials, optimise designs and at the same time improve quality - and thus longevity. The development has also progressed in terms of circular economy. In the mineral sector, for example, almost all construction waste is recycled. A lot of things have been automated and thus undoubtedly optimized. The goal of reducing energy consumption and emissions during the use and dismantling phases of buildings as well as during the production of the building materials was also achieved.

In this context, conferences such as the SBE19 Graz contribute to discussing forward-looking methods, technologies and processes on the levels of building products, buildings, neighbourhoods and existing buildings. They contribute to pointing out solutions in the sense of resource conservation and environmental protection, taking into account social and economic questions.

For this reason the Austrian Association of Building Materials and Ceramic Industries makes special efforts to support various national and European research projects, e.g. in cooperation with Graz University of Technology, and thus makes a contribution to sustainable construction research.

With kind regards,

Dipl.Ing. Dr. **Andreas Pfeiler**
CEO Austrian Association of Building Materials and Ceramic Industries

Dear SBE19 Graz participants,


credit: klimafonds/ ringhofer

the significant reduction of greenhouse gas emissions by 80 to 95 percent by 2050 compared to the reference year 1990 is the primary objective of the Paris Agreement. The building sector, responsible for around a third of the local energy consumption, must therefore be completely free of CO2 emissions in the medium to long term.

It is important to exploit the great potential in the building sector. Energy savings and the use of energy-efficient technologies help to reduce greenhouse gas emissions. From building materials and the supply with space heating, cooling and hot water to the lighting of buildings and technical equipment, there are numerous starting points for forward-looking technologies and solutions. However not only the individual-building-level shows a great untapped potential, but also the interplay in the urban network.

The Climate and Energy Fund focuses on both areas and has for years been promoting model-rehabilitations, research and technology development in the area of sustainable building. With 84 model-renovations already implemented, we show that our vision of designing the building sector free of emissions is already feasible: The energy requirement of 65 of the 84 flagship projects is 100 percent covered by renewable energies. Ten buildings are even classified as plus-energy houses. These objects act as independent power plants and generate more energy than they consume.
Entire cities are taking actions towards greater efficiency and climate compatibility too, which is an important step towards energy independence. More than 50 Smart Cities throughout Austria are already striking this path.

Austria has a pioneering role in the field of sustainable building in Europe, not least because of our funding programs. As part of this funding programs, we initiate numerous R & D activities in this field of research, focusing on the topics of building insulation, multifunctional façade systems, solar thermal and solar cooling, decentralized power supply with photovoltaics, storage technologies, highly efficient lighting technologies, demand-side management, smart home solutions as well as waste and water saving technologies. Numerous technologies and products have already been brought to industrial production and are marketed internationally.

Yours sincerely,

Theresia Vogel and **Ingmar Höbarth**
Management Austrian Climate and Energy Fund, Austria

Ladies and Gentlemen,
Dear participants of the Sustainable Built Environment D-A-CH Conference 2019,

acting sustainably is a law of our time. The Fridays For Future movement shows impressively how vehemently especially young people demand to take determined action for climate protection in all societal, political and economic areas. Sustainable building as part of the national climate and environmental strategies in Germany as well promotes climate protection. Sustainability in the construction sector, on the one hand, means environmentally suitable and energy-efficient building to minimise negative impacts on the climate. On the other hand, we have to adapt our buildings to the climate change to keep damages to the built infrastructure as low as possible.

As a research institution of the German Federal Government, the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) advises and supports the German Federal Ministry of the Interior, Building and Community in a wide spectrum of construction-related issues, including climate protection, energy and resource efficiency, planning quality, cost-effective housing construction and demographic change. A special focus is on interdisciplinary research and development projects. The projects create a bridge between research and construction practice. All measures have the aim to promote a sustainable development in the construction sector as a whole.

With the Guideline for Sustainable Building and the Assessment System for Sustainable Building (BNB), the Federal Building Ministry has developed instruments to put its ambitious climate goals into practice. The goal behind was to realise the Federal Government's construction projects sustainably thus acting as an example to other public owner-builders. The Guideline for Sustainable Building and the BNB pursue an approach combining climate protection and climate change-adapted building in terms of sustainable building. In the context of their „Future Building" research initiative, the Federal Building Ministry and the BBSR have developed many action guidelines for planners and architects or builders.

With an exhibition and various lectures during the Sustainable Built Environment D-A-CH Conference 2019, the BBSR will provide an overview of the Guideline for Sustainable Building and the Assessment System for Sustainable Building (BNB), its supporting instruments as well as of model projects of the Federal Government's construction activities. Our Special Forum "Level(s) and its place in the tool box for sustainable construction" shall enable the discussion about how a division of labour between Level(s) as the European Union's voluntary reporting context and other national assessment systems for sustainable building like the BNB might be realised.

The Conference serves to inform and exchange about sustainable developments in the construction sector. It offers an excellent basis for presenting and discussing research results. I wish the Conference all the best, a lasting success and many interesting conversations and findings.

Yours,

Dr. **Robert Kaltenbrunner**

Deputy Director of the Federal Institute for Research on Building, Urban Affairs and
Spatial Development, Germany

KEYNOTE SPEAKERS

Transition Towards
a Net Zero Carbon
Built Environment

KEYNOTE SPEAKERS

OPENING

1.5°C Climate Change - What are the Implications for the Built Environment?

Prof. Dr. **Diana ÜRGE-VORSATZ**
Department of Environmental Sciences and Policy at the Central European University, Budapest;
Vice Chair of Working Group III of the Intergovernmental Panel on Climate Change (IPCC)

Supporting, Challenging, Advising:
Building Policy in the Light of Climate Change

MinDirig Dipl.-Ing. Arch. **Lothar FEHN KRESTAS**
Head of the Department of Building, Construction Industry and Federal Buildings at
the Federal Ministry of the Interior, Building and Community

Sustainability Assessment of Buildings in the Focus of EU-Taxonomy for Sustainable Finance

Ursula HARTENBERGER
Global Head of Sustainability, RICS, Member of the Technical Expert Group on
Sustainable Finance, Chair of Buildings Sector Group

Building Related Environmental Impacts - the Hidden Aspects

Dipl.-Ing. Dr.techn. **Peter HOLZER**
Institute of Building Research & Innovation ZT GmbH


credit: Nepszava


credit: Roland Horn


credit: RICS


credit: P. Holzer

CLOSING

SBE19 Graz Highlights

Richard LORCH
Editor in Chief, Journal Buildings & Cities

From Challenge to Mission - Make Sustainable Cities a Reality

Prof. Dr.-Ing. **Holger WALLBAUM**
Full Professor in Sustainable building, Dep. of Architecture & Civil Engineering, Chalmers University of Technology, Gothenburg, Sweden and host of the World Sustainable Built Environment (WSBE2020) conference in June 2020 entitled BEYOND 2020


credit: Clare Park


credit: Holger Wallbaum

1.5°C Climate Change - What are the Implications for the Built Environment?

Prof. Dr. **Diana ÜRGE-VORSATZ**
Department of Environmental Sciences and Policy at the Central European University, Budapest; Vice Chair of Working Group III of the Intergovernmental Panel on Climate Change (IPCC)

The first keynote speech will guide us from the broad topic of climate change to our specific topic „Transition Towards a Net Zero Carbon Built Environment“.

Diana Ürge-Vorsatz will present recent developments from IPPC (especially from Working Group III Mitigation of Climate Change) and will inform us about the implications for the built environment.

Supporting, Challenging, Advising: Building Policy in the Light of Climate Change

MinDirig Dipl.-Ing. Arch. **Lothar FEHN KRESTAS**
Head of the Department of Building, Construction Industry and Federal Buildings at the Federal Ministry of the Interior, Building and Community

Megatrends such as climate change, resource scarcity, demographic change and a shift in values towards a greater sense of responsibility to society and the environment are currently presenting additional challenges to politics at federal and regional level. Taking as an example the need and opportunities for German federal politics to act and support sustainable development in the construction, housing and real estate industries, I will in the following consider how governmental tasks and roles can be generally defined in this context.

One matter which has been a subject of discussion for some time now is whether politics has a key role to play when it comes to environmental and health protection issues and securing the future viability of politics, or whether the task of developing and implementing adequate solutions for promoting sustainable development should be left to market forces. Experience gained in Germany and elsewhere shows that a combination of governmental measures and individual or institutional initiatives holds great potential. Politics is thus called to take responsibility for developing medium- to long-term strategies, for setting the framework and boundary conditions, defining socially justified standards and determining requirements to be made in respect of environmental and health compatibility. These are the guideposts along which market forces can seek and find solutions. It is thus especially important that these requirements be formulated so that they are performance-oriented and do not give preference to any specific technologies. Market players all acknowledge that politics has a particular responsibility when it comes to safeguarding social and economic developments while at the same time protecting the environment and conserving resources in such a way as to safeguard our natural resource base. Increasingly, politics is also coming up against growing expectations on the part of businesses and the general public. These expectations have conflicting underlying objectives, though. One example is the struggle to reconcile the goal of securing a quantitatively and qualitatively adequate supply of affordable housing while at the same time improving the energetic quality of the building stock through wide-ranging modernization measures as a means of contributing to climate protection.

Politics takes on various roles when it comes to the planning, construction and operation of real estate based on sustainable development principles as well as when it comes to improving the current housing stock. Given that it is policymakers who are responsible for legislation, it is they who thus first set the regulatory environment. Simultaneously, policymakers create incentive and support schemes which help get new products on the market or close efficiency gaps. At the same time, though, federal institutions are the builders, owners, operators and users of real property. That opens up the opportunity and the need for them to set an example on the one hand and to test new options themselves on the other. In the following these roles will be briefly outlined in connection with the resulting tasks and possible courses of action.

Federal legislation has for many years now included direct references to sustainable development in the construction sector – from the Building Code (sustainable land use) to the Regulations on Determining Real Estate Market Values (including energy quality when determining a building's value). Sustainability is a cross-cutting issue in the building and real estate industries and thus needs to form part of a whole-of-government strategy.

One aspect which Germany has still not addressed when it comes to developing energy quality standards for buildings is the need to add climate action requirements to resource conservation targets. For the first time the Federal Government's Climate Action Plan 2050 sets sectoral goals for reducing greenhouse gas emissions in the building sector, and these could be interpreted as the remaining CO2-eq. budget for real estate utilization. The task now is to achieve those goals by implementing suitable strategies and packages of measures. At the same time, the Federal Government has adapted its national reporting and statistics in order to be able to record and thus assess the level of achievement of select sustainable development targets. The options available for creating fiscal incentives to reduce greenhouse gas emissions have not yet been fully exhausted – a carbon tax is currently under discussion, for example.

It is up to politics to promote beneficial developments by way of providing financial support, where possible and sensible from a macroeconomic perspective. For many years such funding programmes have been available in the building sector to improve the energy quality of buildings, provide advice and support to clients, put products made from renewable resources on the market and construct accessible buildings. How funding programmes can be adapted and improved to contribute even more to climate action is a current matter of debate in Germany and many other countries. The KfW Development Bank, for instance, is reviewing options for funding various building measures, ranging from green roofs as a means of reducing heat island effects to climate-neutral building designs.

As is the case in Switzerland and Austria, research and development in the field of sustainable planning and building, sustainable neighbourhood and urban development, and the development of products, tools and methods is receiving publicly funded support on a massive scale in Germany. Here, these programmes are coordinated and pooled in the Zukunft Bau (The Future of Building) programme, the outcomes of which will be made available to the public.

Building on the traditions of energy-efficient, healthy, and cost- and space-saving planning and construction, the federal ministry responsible for building tasks began implementing the principles of sustainable development back in 2000. Since 2001, this work has been coordinated with representatives of business and science as part of the Sustainable Building Round Table. The aim is to set an example when it comes to sustainable public procurement. The Round Table has not only produced guidelines and a system for evaluating the sustainability of federal buildings (Bewertungssystem Nachhaltiges Bauen für Bundesbauten, or BNB) and made these an obligatory requirement for building projects, the required data and tools have also been made freely available. In the case of building projects funded by the Federal Government, sustainability requirements must be formulated in the early planning stages and then recorded in a target agreement. Projects have to achieve the "BNB Silver" certificate level, though they often do better. The focus is presently on expanding climate action targets, as well as passing on experience gained at the federal level to the federal states and local authorities. The Federal Government is also enhancing the planning, construction and operator skills of staff in regard to energy-saving, resource-friendly, healthy and cost-effective planning through special training programmes.

It will only be possible to successfully implement sustainable development principles in the building sector if the focus is not only placed on so-called lighthouse projects. That is why one approach which is being resolutely pursued is to provide clients and planners with the necessary methods (BNB), data (oekobau.dat, WECOBIS) and tools (eLCA) free of charge in

order to achieve a broad-based impact. These are based on European and international norms. Germany actively brings its positions to bear and puts forward ideas in this regard and – like Austria and Switzerland – is actively involved in improving and harmonizing these foundations. That makes it easier for planners, construction firms and product suppliers to cooperate across borders.
Information about sustainable building in Germany and about free-to-use data and tools is available on the www.nachhaltigesbauen.de platform, for example.

One good example of how common political goals can be pursued at regional level is the Alpine Climate Target System 2050 initiative (see https://www.bmu.de/pressemitteilung/alpenregion-soll-bis-2050-klimaneutral-werden/).

At a time when the real consequences of climate change are already being felt, it is important that policymakers step up the pace when it comes to translating scientific findings into policy action and adapting the framework and boundary conditions. Even though they recognize the particular relevance of this issue, the task remains to direct business and social development across the entire bandwidth of related issues so that a balance can be found. When defining and pursuing ecological, social and economic targets, conflicting goals can be identified and resolved, and the livelihoods of future generations safeguarded. In the truest sense of the word, politics itself must be sustainable, too.

Sustainability Assessment in the Focus of the EU-Taxonomy for Sustainable Finance

Ursula HARTENBERGER
Global Head of Sustainability, RICS, Member of the Technical Expert Group on Sustainable Finance, Chair of Buildings Sector Group

While initially the focus of legislative frameworks had been more on technical aspects of sustainable development, over the past few years, policy makers have been actively reaching out to and engaging with the finance community.

In this, COP21 in 2015, the signing of the Paris Agreement proved to be a decisive moment. As part of the agreement, signatories not only committed to climate targets, but also to aligning financial flows with a pathway towards low-carbon and climate-resilient development. No surprise then that sustainable finance has now also become a core element of EU policy initiatives, reflecting a growing awareness that this alignment is crucial for successfully addressing the complex challenges of climate change.

However, large-scale investment is needed for the EU to meet its 2030 climate targets, being clearly beyond the capacity of the public sector alone, especially in view of the short time-scale during which the changes need to be made.

The situation for energy efficiency investments in buildings is not dissimilar. According to the most recent Global Status Report[1] , annually published by the UN-led Global Alliance for Buildings and Construction Global Alliance[2] , the rate of investment flows towards more efficient buildings as a share of total investment when compared to previous growth rates is slowing down.

The financial sector thus has a central role to play in driving investments towards more sustainable businesses, technologies and products, including construction and real estate. But how to assess what is a sustainable business, technology or building?

This is where the EU Action Plan for Sustainable Finance[3] adopted in March 2018 which is setting out a comprehensive strategy to connect finance with sustainability comes into play.

One of the measures within the Sustainable Finance package is a proposal for a unified classification system or "Taxonomy". The aim behind creating this Taxonomy has been to define what can be considered an environmentally sustainable economic activity.

[1] UNEP and IEA, 2018, Towards a zero-emission, efficient and resilient buildings and construction sector, Global Status Report. Available at: https://www.unenvironment.org/resources/report/global-status-report-2018

[2] The Global Alliance for Buildings and Construction (GlobalABC), founded at COP21 in Paris in 2015, is a global platform for governments, the private sector, civil society and intergovernmental and international organizations to increase action towards a zero-emission, efficient and resilient buildings and construction sector. For more information: https://globalabc.org/about-gabc/introduction

[3] European Commission, 2018, Action Plan: Financing Sustainable Growth, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0097

Economic activities are screened for their contribution to six environmental objectives: (1) climate change mitigation, (2) climate change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to a circular economy, waste prevention and recycling, (5) pollution prevention and control and (6) protection of healthy ecosystems.

To be Taxonomy-eligible, an economic activity must contribute substantially to at least one of these environmental objectives and do no significant harm to the other five. It also has to meet minimum social safeguards in line with ILO[4] standards.
Climate change mitigation activities are categorised by their level of contribution: (1) activities that are already on a low-carbon trajectory, (2) transition activities and (2) enabling activities.
Within construction and real estate, four economic activities have been included in the Taxonomy: the construction of new energy and resource efficient buildings as a low-carbon activity; the renovation of existing buildings as a transition activity and individual measures, such as the installation of efficient building components, i.e. new boilers, windows, insulation, etc., renewable energy technologies and associated relevant professional services as enabling activities. Criteria for the fourth activity, acquisition and ownership, refer to the low-carbon and transitional activities. The appropriateness of the thresholds set will be periodically reviewed and tightened to ensure getting to net zero carbon by 2050.

Except for buildings used by companies engaged in the extraction, transport and manufacture of fossil fuels, the Taxonomy is very inclusive as it covers virtually all buildings and renovations and. To facilitate smooth market entry, it is closely aligned with EU policy instruments, such as Energy Performance Certificates (EPCs) and nZEBs (nearly Zero Energy Buildings) and corresponding thresholds. These obviously only work in an EU context which is why potential proxies have been identified for application by non-EU investors.

Given the complexity of the sector and the issues at hand, developing the Taxonomy for construction and real estate has not been without challenges. The most significant challenge has doubtless been having to find a compromise between ambition and the desire to avoid so-called “greenwashing” and the need to give consideration to different levels of market readiness across EU Member States in different climate zones. Furthermore, the aim was also to enable already operational or emerging financing tools, such as Green Bonds or the Energy Efficient Mortgage Initiative (EEMI)[5] to continue to flourish.

Workability and acceptance have also guided the thinking behind the transitional approach regarding the choice of metrics. Initially, these are going to be based on annual operational primary energy demand as at present only a small part of the market is working with GHG metrics. In future, this will be extended to include operational GHG emissions and eventually also whole life cycle emissions. While there is consensus about the impact and importance of embodied carbon, at present, the embodied carbon data gaps are making any kind of meaningful benchmarking in this area extremely difficult.

However, regardless of these challenges and the fact that there is still some work to be done until the Taxonomy becomes operational in 2021, for the construction and real estate sector the Taxonomy could represent a quantum leap forward by both rewarding buildings that are

[4] International Labour Organization
[5] Information on the EEMI is available at: https://energyefficientmortgages.eu/

already high-performing and by channelling investments to those needing upgrading to improve performance. With 97% of buildings in Europe stock requiring updating to achieve higher performance[6] , particularly in the case renovation, that investment is much needed.

What the EU Taxonomy has achieved is the creation of a common language around sustainable buildings, providing answers to questions that investors, their advisors and developers have been trying to come up with for years: what actually makes a building sustainable and how to assess this? This represents a major milestone for the sector and has a strong signalling function for the whole value chain.

Having a clearly defined set of criteria for sustainability performance characteristics will not only help investors to identify sustainable economic investments, it will also help professionals such as facility managers, valuers and brokers in their daily work and during conversations with investors and financing institutions.

[6] Buildings Performance Institute Europe (BPIE) Factsheet, available at: http://bpie.eu/wp-content/uploads/2017/12/State-of-the-building-stock-briefing_Dic6.pdf

Building Related Environmental Impacts - the Hidden Aspects

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SBE19 gathers an impressive number of most experienced, courageous and enthusiastic experts in the field of sustainable built environment. It does so in a series of international conferences which started back in the year of 2000. This year's conference' headline is nothing less programmatic than "Transition Towards a Net Zero Carbon Built Environment". [1]
Without any doubt this transition is a most urgent imperative on a desirable pathway to a generally sustainable development. It is in line with the Sustainable Development Goal (SDG) 11 – Sustainable Cities and Communities of the UN 2030 Agenda as well as with many other international and national targets. We may agree, that the target of a net zero carbon built environment is both crucial and ambitious. yet, encouraged by significant progress that have been made already, we may even agree that the target is realistically achievable. Still, parallel to consequently making this transition towards Net Zero Carbon happen, we have to be well aware of building related environmental impacts beyond carbon emission. I entitled them, somewhat mysteriously, the 'Hidden Aspects'.
Based on meta studies as well as own research activities I'd like to raise awareness to the impacts of buildings on two more alarming threats of sustainable development, beside climate change: Biodiversity Loss and Land Use Change.
Both trends – biodiversity loss and land use change – together with climate change, have basic qualities in common: They, without any doubt, predominantly result from human activities. They are severely threatening the chance of a civilized and desirable future of mankind. They are highly correlated to each other. Finally, they are significantly influenced by the way we design and operate our built environment.
The secured facts of biodiversity loss and land use change are alarming, the same as they are in case of climate change. There's no time left to address one challenge without and not even before the other. It is dangerous to address one aspect without considering consequences to the others.[2, 3, 4]
As a result of years and decades of collaborative and consistent effort, the assessment of carbon emissions of buildings, amongst many other environmental impact categories, has reached a mature and applicable methodological level, supported by databases, tools and coordinated by international standards. Quite different, biodiversity loss and land use change do not play an adequate, if any, role in the list of practically applied building related environmental impact categories.
This is a dangerous gap. Optimising one aspect (carbon emissions) without having the full picture nor an assessment methodology to consider aspects of equal importance (biodiversity loss and land use change) might lead to dangerously wrong decisions. I will take the chance of the keynote to draw your kind attention to these "Hidden Aspects", presenting learnings from

[1] As a consistent next step, WSBE2020 in Gothenburg, Sweden will address the full mission of "Make Sustainable Cities a Reality".

[2] https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/

[3] https://www.umweltbundesamt.at/umweltsituation/raumordnung/rp_flaecheninanspruchnahme/

[4] Österreichische Strategie Nachhaltige Entwicklung (ÖSTRAT) – ein Handlungsrahmen für Bund und Länder. Zl. BMLFUW–LE.1.4.5/0012-II/3/2010. Juni 2010

meta studies as well as preliminary results of own research, inviting for further discussion:
In case of biodiversity loss I will present ongoing research towards a methodology to develop a mass-related impact factor, which possibly could be integrated into the existing system of Environmental Product Declarations (EPDs). As an encouraging starting point, the impact category of biodiversity loss is already mentioned in relevant international standards.[5, 6, 7, 8]
In case of land use and land use change, to our assessment, the consideration of the environmental impact from building activities has to be done on political level in a process of responsible spatial planning, well before the process of responsible building design.[9] Still, one could think of integrating an impact factor such as a site-usage-density. But such a factor would only highlight the usage intensity of a site, without considering spatial or environmental qualities of the specific site.
Summing up: Integrating the qualities of biodiversity loss as well as land use change into environmental assessment of buildings and communities calls for new research efforts in development of methodology, derivation of databases and development of tools. It will necessarily raise complexity of environmental building assessment, but, to our understanding, it is definitely necessary to draw decisions of far-reaching consequences in a complex environment.

[5] Hammer, Renate; Holzer, Peter et al.: Biodiversity Impact Assessment. Entwicklung eines methodischen Ansatzes zur Einführung der Wirkungskategorien Biodiversitätsverlust in die Ökobilanzierung, laufende Forschung im Auftrag der WKO – Fachverband steine und Keramik

[6] EN 15643 – 2 (2011): Sustainability of construction works. Assessment of buildings. Framework for the assessment of environmental performance, appendix B.2

[7] ISO 21931 – 1 (2010): Sustainability in building construction -- Framework for methods of assessment of the environmental performance of construction works -- Part 1: Buildings, chapter 5.6.2

[8] ISO 14025 (2006): Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures, chapter 7.2.3

[9] Bundeskanzleramt Österreich (Hrsg.): Dritter Österreichischer Baukulturreport, https://www.baukulturpolitik.at/baukulturreport/dritter-baukulturreport/

SBE19 Graz Highlights

Richard LORCH
Editor in Chief Journal Buildings & Cities

This presentation draws together the key themes and ideas that emerged at SBE19 Graz conference. It comments on how the Graz conference may shape future research and policy agendas, particularly for the forthcoming WSBE Conference: Beyond 2020.

From Challenge to Mission - Make Sustainable Cities a Reality

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At the Earth Summit in Rio de Janeiro in 1992[1] , more than 178 countries adopted Agenda 21[2] as a plan of action to build a global partnership for sustainable development to improve human lives and protect the environment. At the Millennium Summit in September 2000, the UN Member States unanimously adopted the Millennium Declaration at UN Headquarters in New York. The Summit led to the elaboration of eight Millennium Development Goals (MDGs)[3] to reduce extreme poverty by 2015. The Johannesburg Declaration on Sustainable Development and the Plan of Implementation, adopted at the World Summit on Sustainable Development in South Africa in 2002, built on the Agenda 21 and the Millennium Declaration and put more emphasis on multilateral partnerships as well. At the United Nations Conference on Sustainable Development (Rio+20) in Rio de Janeiro in 2012, Member States decided to launch a process to develop a set of SDGs to build upon the MDGs. At the UN Sustainable Development Summit in September 2015, the subsequent adoption of the Agenda 2030 for Sustainable Development was decided. As we all know, the 2030 Agenda for Sustainable Development provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. The main contribution of Agenda 2030 has to be seen in the 17 Sustainable Development Goals (SDGs), *“which are an urgent call for action by all countries a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.”*[4] Although the SDGs build on decades of work by countries and the UN, including the UN Department of Economic and Social Affairs, the implementation of the SDGs to real actions remains a challenge. Today, the Division for Sustainable Development Goals (DSDG) in the United Nations Department of Economic and Social Affairs (UNDESA) provides substantive support and capacity-building for the SDGs and their related thematic issues, such as water, energy, climate, oceans, urbanization, transport and plays a key role in the evaluation of UN system-wide implementation of the 2030 Agenda. As stated by the UN, *“in order to make the 2030 Agenda a reality, broad ownership of the SDGs must translate into a strong commitment by all stakeholders to implement the global goals.”*

The built environment is – without any doubts – one of the most relevant sectors for the implementation of the Agenda 2030. With the globally ongoing trend of urbanisation, cities play a major role for more sustainable development. Projections suggest cities will swell at an astonishing pace and it needs to be seen whether that means our salvation or an eco-disaster.It is very obvious that the current trend of planning, constructing and maintaining our cities put even

[1] https://sustainabledevelopment.un.org/milestones/unced (accessed August 15, 2019)
[2] https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf (accessed August 15, 2019)
[3] https://www.un.org/millenniumgoals/ (accessed August 15, 2019)
[4] https://sustainabledevelopment.un.org/?menu=1300 (accessed August 15, 2019)

Fig. 1: SDGs that are strongly connected to SDG 11 Sustainable Cities and Communities selected by BEYOND 2020.

more pressure on the planetary boundaries[5]. Hence, what is needed is a transformational plan on how to achieve “Sustainable cities and communities” in terms of concrete actions.
The next version of the World Sustainable Built Environment conference that is entitled BEYOND 2020 will exactly focus on creating clear links between the most relevant UN SDGs and the built environment. Central to our discussion will be achieving UN SDG 11, Sustainable cities and communities by the 2030 deadline but from our perspective, the path towards SDG11 is only possible, if other relevant SDGs are fulfilled (Fig. 1).

Key points to achieve SDG 11 will, e.g.

- How can the building sector contribute towards the creation of Sustainable Cities and Communities (SDG11) of the future?
- What other UN SDGs (see below) should play a role in the pursuit of SDG11 from the built environment perspective?
- How does the role and importance of the UN SDGs (relevant for the built environment differ in various parts of the world?
- What challenges and opportunities result for the building sector from implementing the UN SDGs?

The next edition of the World Sustainable Built Environment conference will work on a transformational plan towards the Agenda 2030. Key elements will be addressed already at the SBE19 in Graz.

[5] Anders Wijkman & Johan Rockström. 2012. Bankrupting Nature - Denying Our Planetary Boundaries, Routledge, London, ISBN 9780203107980 and Rockstrom, J., et al. 2009. Planetary boundaries:exploring the safe operating space for humanity. Ecology and Society 14(2): 32.

BUILDINGS 1

Special Session nZEB I

Chair: Karl Höfler
AEE INTEC, Austria

Transition Towards
a Net Zero Carbon
Built Environment

Stakeholder related fields of action for process optimization of nearly zero energy and plus energy buildings

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In order to be able to guarantee a regulated process in the design of nearly zero and plus energy buildings, it is important that all relevant stakeholders are involved from the beginning of the project. This is particularly important because disagreements and lack of communication between the stakeholders often lead to problems, which delay planning and implementation and lead to additional costs. In order to prevent the resulting barriers, it is essential that the previous processes for such an implementation are analysed and the individual steps are optimized to such an extent that a goal-oriented and cost-efficient cooperation is possible. This is focused in the thesis "Stakeholder related fields of action for process optimization of nearly zero energy and plus energy buildings". In this way, an attempt is made to achieve process optimization with the aid of various methods from management consultancy. In order to achieve this, the focus of every construction project, especially nearly zero energy and plus energy buildings, must be on integral planning. The individual action steps must therefore be optimized in such a way that it is clearly defined for all stakeholders when and with which partner to interact.

NOTES

Life cycle cost reduction and market acceleration for new nearly zero-energy buildings

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Cost optimal and nearly zero-energy performance levels are principles initiated by the European Union's Energy Performance of Buildings Directive, which was recast in 2010. These will be significant drivers in the construction sector in the next few years because all new buildings in the EU from 2021 onwards have to be nearly zero energy buildings (nZEBs); public buildings need to achieve the standard already by 2019. While nZEBs realised so far have clearly shown that the nearly zero-energy target can be achieved using existing technologies and practices, most experts agree that a broad-scale shift towards nearly zero-energy buildings requires significant adjustments to current building market structures. Cost-effective integration of efficient solution sets and renewable energy systems are the major challenges. The EU Horizon project CRAVEzero focuses on proven and new approaches to reduce the costs of nZEBs at all stages of the life cycle. The primary goal is to identify and eliminate the extra costs for nZEBs related to processes, technologies, building operation and to promote innovative business models considering the cost-effectiveness for all stakeholders in the building's lifecycle. As a result, an international database for benchmarking actual nZEB life cycle costs (LCC) including urban and building planning, construction, commissioning, operation, maintenance, management, end-of-life, has been developed. Furthermore, an operative methodology to achieve the best conditions towards optimal cost nZEBs has been set-up.

NOTES

Life-Cycle Costs of a Minimally Invasive Refurbishment Approach in Comparison to a Standard Refurbishment

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The decision on constructing or renovating buildings is often based on construction costs; consequently, follow-up costs are not considered. *Life-cycle cost analysis* is a common method for assessing the economic viability of buildings over their entire life-cycle. In this project, life-cycle costs of a minimally invasive refurbishment with component activation are compared with those of a standard refurbishment approach with an external thermal insulation composite system (ETICS) and radiators. Although the follow-up costs approximate the life-cycle costs after a period of 50 years in this analysis, the additional erection costs of the minimally invasive refurbishment approach cannot be compensated. In order for the system to become economically competitive, the erection costs regarding the façade system and the associated building technology must be reduced by 36 %, assuming that the nominal follow-up costs remain the same. Since the current implementation is still a prototypical one, cost-saving potential is expected on basis of the experience of the executing companies. However, in addition to the economic efficiency, the non-monetary added value of the system in the form of a more homogeneous heat output, more ecological building materials, less stress for the inhabitants due to the minimally invasive approach, reduced use of floor space and increased sound insulation due to the sound insulation façade, should also be taken into account in the decision-making process.

NOTES

Towards the definition of a nZEB cost spreadsheet as a support tool for the design

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The 2010 Energy Performance of Buildings Directive (EPBD recast) established that all new buildings have to reach, by the end of 2020, the nearly-Zero Energy (nZEB) target as set by the Member States. In order to achieve the nZEB standards, while keeping investments sustainable, it is strategic to focus more on the operational phase and to guide the decision-support with a lifetime perspective. In this regard, a crucial step is to adopt a shared methodology for evaluating the Life-Cycle Cost (LCC), in order to minimize the effect of uncertainties, the impact of calculation approach and the variability of the boundaries at EU level. The H2020 CRAVEzero project developed a LCC spreadsheet, aimed at calculating a set of relevant indicators for assessing the cost during the investment phase (design, labour and material costs) as well as during the operational phase of a building (energy and maintenance costs). The LCC spreadsheet implements an approach for normalising the results according to the main relevant boundaries that can affect the comparability at EU level (e.g. energy prices, the national construction costs, the climatic conditions, etc.). Moreover, it introduces a sensitivity analysis that aims to provide the impact that the boundary conditions can have on the results, reducing the uncertainties in the LCC calculations due to a long-term perspective (http://www.cravezero.eu/lcc spreadsheet/). This paper presents the structure of the LCC calculation approach defined within the project, the structure of the spreadsheet and the main indicators as evaluated for a set of relevant nZEB case studies across Europe.

NOTES

BUILDING DESIGN 1

Design for Sustainability Calculation, Simulation, Evaluation

Chair: Diana Ürge-Vorsatz
Central European University, Hungary

Transition Towards
a Net Zero Carbon
Built Environment

Passive house-concept apartments: sustainability evaluation in a case study of Stockholm, Sweden

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The housing sector accounts for almost one-third of total energy use in Sweden; of this amount, the operation phase of a building is responsible for around 85% of its total energy use. The Swedish government aims to reduce the energy consumption in buildings by 50 % by the year 2050. One way to achieve this goal is the construction of the low-energy buildings. The purpose of the study has been to analyse the Blå Jungfrun passive house-concept, tenant occupied apartments in Stockholm, Sweden, through a blend of qualitative and quantitative research methodology. The Swedish energy-efficient buildings are considered as a platform for recommendations for improving the knowledge and practice of low-energy buildings grounded in sustainability science as the theoretical framework. The study has investigated the roles of the responsible architects and design features of the Blå Jungfrun. The economic viability of the apartments is calculated by the economic evaluation software OekoRat for a life span of 50 years. The annual energy requirements of the studied apartments are analysed in regard to their post-occupancy evaluations. The social inclusion of the Blå Jungfrun tenants is investigated considering the issue of their participation in planning stages of the apartments. The empirical findings of the study shows the inevitable correlations between the environmental, economic, and social dimensions of the passive house. The findings suggested that in order to achieve a successful sustainable system of the sustainable housing, a holistic approach in the low-energy buildings is necessary.

NOTES

The effect of insulation thickness on lifetime CO_2 emissions

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This paper assesses the total carbon emissions of a single-family home designed and built for Norwegian conditions, according to current standards (TEK 17), using an LCA approach. Various combinations of insulation thicknesses are assessed to identify which combination is most efficient in lowering the lifetime emissions as well as in which part of the building envelope additional insulation is most efficient in reducing the lifetime greenhouse gas emissions of the building. Overall, increased insulation resulted in lower lifetime emissions; the increased embodied emissions generally being outweighed by the energy savings resulting from the increased insulation thickness. The location of the insulation is the factor that was found to have the largest impact on the lifetime emissions. When increasing the insulation thickness from 100-500 mm, changing only one component at a time, the operational emissions were most sensitive to the insulation thickness in the walls, with a 26 % decrease compared to 7% and 3% for the roof and floor respectively. The most efficient cases tended to have little insulation in the floor (100 - 150 mm) and relatively high insulation thickness in the wall (350 mm). The most variable component was the roof, varying from 150 to 400 mm.

NOTES

Surface-to-volume ratio: How building geometry impacts solar energy production and heat gain through envelopes

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This paper explored the relationship between building geometry and renewable energy production of building-integrated photovoltaics (BIPV). Heat gain was incorporated as a conflicting constraint with respect to energy performance. The building facade was mathematically analyzed by taking into account heat transfer pertaining to site conditions along with different parameters that included shading, orientation, PV tilts (b) and surface-to-volume ratio (S=V) as a measure of building compactness. The study involved calculating the impact of each parameter on the convection, conduction and radiation components of the incoming solar energy. S=V was shown to be directly proportional to the amount of solar energy received by the facades and gained by the building in the form of heat. The positive correlation of heat gain with S=V was nearly linear with a slope of around 41.8 $kWh/m^2/m^{-1}$ and a mean of approximately 3.4 times more. With the most suitable geometry in terms of net energy gain, S=V of 0.14 m^{-1} yielded the highest difference between energy production and heat gain. In terms of b, the results demonstrated negative slope of energy production with respect to the tilt at about 2.12 times higher than that displayed by heat gain. Accounting for inter-building effects, a shading reduction equal to d percent can be estimated to an increase of 1.37d degrees in b at a building consumption of 60 kWh/m^2.

NOTES

Assessment System for Sustainable Buildings of the German Government (BNB): Calculation tool for the ventilation rate and the resulting carbon dioxide concentration in the ambient air

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An important criterion for Assessment of the sustainability of buildings owned and occupied by the Federal Government is the indoor air quality. The stated aim is to avoid pollutants from construction products and unacceptable carbon dioxide concentrations. Regarding the limitation of the carbon dioxide concentration especially in rooms with high occupancy the challenge is to find a suitable ventilation concept. That concerns natural ventilation as well as mechanical ventilation or the combination of both. Although there are normative rules for the required air change it is hardly verifiable during building planning whether the proportion of natural ventilation is sufficient in practice. Various evaluation reports in the past have shown that natural ventilation comparability mostly did not work, especially in rooms with high occupancy. In addition, it was also shown that comparability of the test results was usually not given and therefore no conclusions could be drawn on functioning ventilation concepts. To be able to determine and evaluate the air exchange (in case of natural ventilation) and the resulting development of the carbon dioxide concentration in a room, the development of a calculation tool is part of a recent research project. The tool is used to calculate the outdoor air volume flow with natural ventilation depending on multiple parameters (as examples: wind, temperature, window size, window opening). In the same step CO_2 concentration for a certain number of CO_2 sources in the room will be determined automatically. Thereby the tool will be very helpful in an early stage of planning to find a proper ventilation concept. In addition to its use as a planning aid, the tool offers two different applications for assessing carbon dioxide concentration in a room: The calculation under specified conditions provides the opportunity to classify the expected carbon dioxide emissions as part of the assessment of sustainable buildings. The tool is also suitable for checking the air exchange under extreme climatic or other individually selectable conditions. At the end the calculation results of each individual constellation are shown in graphical diagrams.

NOTES

Impact of dynamic CO_2 emission factors for the public electricity supply on the life-cycle assessment of energy efficient residential buildings

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Climate change and its effects are the reasons for the energy transition in Germany and lead to an increasing exploitation of renewable energy sources. At the same time, energy efficient buildings reduce the heat demand significantly and allow for the operation of electricity based heating systems. With the aid of dynamic CO_2 emission factors, the life-cycle assessment (LCA) for buildings can be adapted to reflect the fluctuating nature of renewable energy sources and the dynamics of heating power demand during the use phase more precisely. A case study using dynamic building simulation and static as well as dynamic emission factors for the year 2017 shows deviations of 3.4 % in the building's GHG emissions. Furthermore, two emission factors for 2030 and 2050, which reflect the national 80 % carbon dioxide reduction target, are developed and applied to the case study. For these emission factors, the overall building's GHG emissions decline drastically, whereas the deviation between the LCA using static or dynamic emission factors increases significantly. It can be seen that the application of a more dynamic approach for LCA adds substantial value to the investigation. However, further investigation on a broader set of dynamic input parameters for the LCA of energy efficient buildings seems to be reasonable.

NOTES

Implementing climate impacts in road infrastructure in the design phase by combining BIM with LCA

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Building information modelling (BIM) software is increasingly being used in as a visual road design tool and offers real-time information on material demands as designs change. Life cycle assessment (LCA) is a tool that is used to measure the lifetime environmental impacts of systems, materials and processes. LCA data sets are organized according to process or product, which is ideal for implementation as a parameter in BIM. This paper seeks to explore how BIM and LCA can be used together in road design by analysing existing literature, creating a Norwegian test case on a road designed in a BIM model and adding LCA data to the model before comparing to a standard LCA study of the same road. Challenges such as including machinery emissions, uncertainty, data availability, and other insights gained will be discussed. The goal of this paper is to present a path forward for road builders to combine LCA and BIM to promote simplified LCA calculations.

NOTES

PROCESSES 1

Special Session Management of Complexity in Sustainable Construction

Chair: Helmuth Kreiner
Graz University of Technology, Austria

Transition Towards
a Net Zero Carbon
Built Environment

Towards housing sustainability: a framework for the decision-making process of tenants

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The mismatch between the supply and demand of rental apartments in Switzerland represents an obstacle to the transition towards a more sustainable society. The difficulty for the housing providers to accommodate the fast societal change of the demand brings about an increase in vacancies and, to minimize investment risks, a resistance to innovation in the building sector. In this context, understanding the determinants of tenants' residential mobility and location choice becomes key to designing and promoting sustainable housing. In this paper we present a new interdisciplinary framework for the decision-making process of tenants. To do so, we elucidate the main parameters of the decisions to move and where to move, based on literature review and a group discussion in the Swiss canton of Vaud with the tenants of the two housing providers SCHL and Swiss Mobiliar. We find that the desired housing function determines the tenants' housing selection. We observe that this desired function changes according to the type of trigger that pushes tenants to move. Additionally, we elicit the potential sustainability implications of the housing functions in the Swiss context. We conclude that the framework can serve as a starting point for rethinking sustainable interventions in the housing sector.

NOTES

Sustainable cities and communities - Best practices on structuring a SDG model

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The UN's SDGs are powerful beacons to a better world yet some of their targets remain vague for the sake of special interest groups. They are sometimes synergetic and quite often ambivalent. On a concrete operative level it is therefore a challenge to plan for them fostering synergetic measures and minimizing trade-offs. Since many concrete projects that go for the SDGs are rather unique and need to consider many stakeholders, the systemic approach of a participatory explorative cause and effect modeling should be applied in order to tackle the underlying complexity of these projects. On the example of SDG 11 and with the use of the software iMODELER the approach is presented offering some best practice for structuring a SDG model, facilitating participatory stakeholder workshops, identifying levers for successful action, and establishing a culture of reflection. Although this approach has been applied successfully in Africa as well as in Germany it is also crucial to prevent typical hindrances. A kind of template for a model structure will be presented for both, a town in a developing country and a town in an industrialized country.

NOTES

Towards a sustainable district: a streamlined Life cycle assessment applied to an Italian urban district

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The literature shows a lack of environmental indicators able to support the transition from a sustainable to a smart city framework, since the priority area “built environment” is indeed more comprehensively addressed by urban sustainability assessment systems (13%), than by smart city frameworks (4%). As “smaller cities inside a larger agglomerate”, urban districts play a key role in defining effective and innovative paths toward a smarter city, but defining a sustainable urban district is not straightforward, and even less is capturing the induced impacts due to interactions between individual buildings and their surround urban setting. The adoption of a quantitative method for evaluation, such as Life Cycle Assessment (LCA), emerges as an essential step for this purpose. This article explores the application of a streamlined LCA on the urban district main issues (buildings, energy, water and waste), referring to an urban retrofitting intervention of Bolognina neighbourhood. A set of mitigation strategies developed by an interdisciplinary research group (joining researcher team from the Department of Architecture of the University of Bologna and Institute of Sustainability in Civil Engineering of the RWTH Aachen University) provides the reference framework for the application deepened within the article. This work is a first application of LCA to a case study but it not includes a comprehensive sustainability framework yet, further activities are planned to finalize the analysis, e.g. taking account of social dimension by applying Social Life Cycle Assessment.

NOTES

Considering the dynamics of electricity demand and production for the environmental benchmark of Swiss residential buildings that exclusively use electricity

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The environmental impacts of buildings can significantly vary with the dynamics of their energy demand and production. Significant variations have been modelled for buildings in the U.S., France, Denmark and Switzerland but the levels of variation are different between these countries. This difference can be explained by factors like the existing energy sources, the availability of renewable energy and the importation of electricity from nearby countries. With its high share of renewable energy and significant electricity exchanges with neighbouring countries, Switzerland presents a specific case where benchmark values from dynamic life cycle assessment should be well understood. The project's goal is to provide results from a dynamic life cycle assessment with a detailed study of the influence from temporal fluctuations in the national electricity production, electricity imports, decentralised generation and electricity demand from buildings. Additionally, consequences of changing the temporal precision (i.e. hourly, daily, monthly and annual) of energy dynamics are analysed. This assessment is conducted with demand and production estimations for the design of a residential building in Switzerland. Disparities of results are assessed for all temporal precision levels with a comparison to the values that are obtained with the current national methodology which operates with values based on average annual electricity production. Results thus suggest some methodological recommendations to develop the temporal aspects of the environmental impact assessment methodology for the Swiss building sector.

NOTES

Managing Construction Projects: Developing Complexity into Complicatedness

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Construction projects are understood as being complex and therefore in need of support through adequate tools to be successfully managed. Among others, the Building Information Model (BIM) is expected to provide a modern and powerful toolset allowing for reliable prediction of the respective development and behaviour. Based on Theory of Systems, the term of complexity in fact matches the principal capabilities of an object-oriented information system where e.g. the Building Information Modelling rests upon. However, any complex system tends to instable behaviour allowing principally for no reliable prediction, in particular in the single run required for unique projects with no possibility to rearrange processes without major losses. Correspondingly, experienced Construction Managers are judging the complexity of projects as a crucial obstacle to efficient execution but declare complexity as not measureable, thus as degree of unmanageability. Therefore, the inherent complexity of interdisciplinary projects needs to be reduced, i.e. transformed into complicatedness, not reducing the effort of elaboration but allowing for stable solutions. In order to achieve such a transfer, the inherent heterogeneity is utilized tracking down the strictness and linearity of the internal and external system borders, thus, investigating the separability of the adjacency matrices. These mainly topological considerations lead to criteria forming substructures finally allowing for predictable behaviour of the project structures with limited uncertainty. Therefrom, we expect some significantly improved understanding of the cybernetics of projects and consequently advanced possibilities in shaping and establishing activity-based risk management, which is crucial to nowadays construction and real estate projects.

NOTES

Multiple Criteria Decision Analysis under uncertainty in sustainable construction: a neutrosophic modified best-worst method

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Capturing uncertainty in multiple criteria decision analysis (MCDA) is not a new theme but a largely developing topic which is in close connection with uncertainty theories such as fuzzy set and grey systems theories. Due to growing complexity of construction processes mainly because of implementation of sustainability aspects it would be necessary to take advantage of a novel MCDA methodology as an efficient tool to handle the uncertainty in sustainable construction decision making. In this study, we utilise a novel neutrosophic modified best-worst method (NM-BWM) to deal with the uncertainty in decision making in the context of sustainable construction. The method is an integration of neutrosophic set theory (NST) and the modified best-worst method (M-BWM). The NST can provide insights on efficient uncertainty handling of decision makers (DMs) subjective judgements. The BWM is a MCDA method which utilises two vectors of pairwise comparisons (the best criterion to others and others to the worst criterion) to obtain the weights of evaluation criteria. Merits of the BWM include its capability in effectively remedying the inconsistency derived from pairwise comparisons as well as simplicity and less pairwise comparisons compared to other similar methods like analytic hierarchy process (AHP). We show the applicability of the method in a case study with focus on the implementation of sustainable construction.

NOTES

PRODUCTS 1

Innovation in Concrete

Chair: Lisa Wastiels
BBRI, Belgium

Transition Towards
a Net Zero Carbon
Built Environment

Reducing water footprint of building sector: concrete with seawater and marine aggregates

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Freshwater resources are currently under great pressure all over the world due to many factors, such as climate change and growing urbanization. Industrial products like concrete pauperize a significant share of available freshwater during their life cycle. Therefore, cutting down the amount of freshwater consumed by these products might be a solution to reduce the stress in regions affected by water scarcity. In this study, the potential freshwater savings linked to the adoption of innovative concrete mixtures were investigated via the Life Cycle Assessment (LCA) method. In particular, the use of marine aggregates instead of land-based ones and seawater rather than freshwater in the mixing process of concrete were examined. To improve the validity of the analysis, the applicability to the Italian context using geo-referenced data for the distance to the coastline and the availability of freshwater was explored. Results confirmed the positive effect that the use of seawater and marine aggregates might have in reducing the water footprint of the Italian construction sector, leaving freshwater available for human consumption. Mixing concrete with seawater would lead to a reduction of its water footprint up to 12%. Moreover, if land-won aggregates were replaced with marine ones, an 84% reduction of the water footprint could be achieved. In both cases, possible burden shifting (e.g. increase of greenhouse gases emissions) should be investigated.

NOTES

Sustainability assessment in Cuban cement sector-
a methodological approach

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The search of sustainability is a need for human activities in general. Particularly, cement sector as a significant contributor to climate change has to implement strategies to reduce its environmental impacts. But, effective strategies have to be complemented by adequate methodological techniques to assess, guide and certificate sustainability. Amongst all the techniques developed by the scientific community in recent years, life cycle techniques highlight as one of the most used one due to its integrated and holistic philosophy. In Cuba, a new cement based on a combination of calcined clay and limestone to reduce clinker to 50% (Low Carbon Cement, LC_3) is been developed as part of an international collaboration project. The main goal of this research is to assess sustainability of cement sector in Cuba using life cycle techniques such as: Life cycle assessment (environmental-LCA), Social Life Cycle Assessment (S-LCA), Life Cycle Costing (LCC), Economic Life Cycle Assessment (EcLCA). As part of the assessment LC_3 is compared with traditional produced cements in Cuba OPC and PPC. Results show that LC_3 introduction allows increasing sustainability in cement sector by reducing carbon emissions, energy consumption, costs and reporting positive effects on society.

NOTES

Eco-efficiency assessment of conventional OPC/PPC replacement by LC3 in Cuban residential buildings

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This paper aims at assessing the sustainability of replacing conventional OPC/PPC by Limestone Calcined Clay Cement (LC3) in Cuba. Authors conducted an eco-efficiency (E-E) analysis supported by E-E ratios, which in turn are rooted on the environmental assessment (Life Cycle Assessment, LCA) and the economic analysis (Economic Value Added, EVA). Taking case studies in Villa Clara province capital district, three construction methods were compared and further conclusions emerged with regard to economic and ecological criteria. A square meter of built area was employed as functional unit. According to main results, Grand panel technique appears to be the benchmarking method, followed by Forsa system and, finally, concrete block technique. LC3 blend outperforms OPC/PPC from both economic and environmental perspective. Furthermore, productive efficiency potentials were found on the field of material selection and raw material procurement. Authors provided decision-makers with some policy recommendations in order to contribute enhancing the sustainable use of LC3 in Cuban construction sector.

NOTES

Optimizing the economic, environmental and technical performance of concrete mixes with fly ash and recycled concrete aggregates

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This study answers an important question that may arise when selecting a sustainable concrete, namely “concrete mixes containing low cement and recycled aggregates are a sustainable solution?” To answer this question, this study shows how to optimize concrete mixes in terms of technical performance, and economic and environmental life cycle. Firstly, the weight to be considered for each of these dimensions of performance depends on the concrete application (e.g. residential house and high-rise building) and on the consumer’s requirements (e.g. business as usual, green, strength, service life and cost scenarios). In this study, concrete mixes containing recycled concrete aggregates (RCA) and/or fly ash (FA) are optimized to be used in sustainable residential houses. For that purpose, the CONCRETop methodology (developed by the same authors of this study) was applied to these concrete mixes by considering a “green scenario”. The results show that, for sustainable residential houses, the concrete mixes made with high incorporation ratios of FA and RCA are considered the best option.

NOTES

Sensitivity Analysis of Life Cycle Impacts Distribution Methods Choice Applied to Silica Fume Production

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The construction sector is known as an important consumer of natural resources. The use of by-products from different production chains in the sector is encouraged, promoting a reduction in the extraction of natural resources, reducing the need for residues disposal and enhancing circularity. Silica fume is a by-product from the smelting process in the silicon and ferrosilicon industry, commonly used as concrete supplementary cementitious material, which provides chemical and physical effects on concrete microstructure. When LCA evaluation is conducted, different impact distribution models may be applied to assess the potential impact of the by-products. Although their benefits are recognized, some studies still report them as burden free, having no allocated impacts. Thereby, the aim of this paper is to evaluate the differences in silica fume life cycle impacts by analyzing three scenarios from cradle to gate, considering the modeling procedures described by ISO 14040, the Cut-off model from Ecoinvent version 3.3 and the impact assessment method CML v.4.4, according to the CEN EN 15804 recommended categories. Results enhance the understanding regarding model selection and demonstrate that the selection of the proper distribution model is key, considering that this may lead to important differences in the results.

NOTES

Variability of environmental impact of ready-mix concrete: a case study for Brazil

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Life Cycle Assessment is a powerful tool towards sustainable construction, but it often relies on average impact results, failing to identify the dispersion of environmental impact among construction product manufacturers. This work presents cradle-to-gate impact results for ready-mix concrete production, based on primary data provided by several plants in Brazil, and the associated variability among plants and in the upstream processes of cement and sand production. Four compressive strength classes are considered. Concrete, cement and aggregates inventories are modeled with Brazilian information and other upstream processes are based on ecoinvent. EN 15804 impact categories are assessed. The ranges between minimum and maximum impact values can be as large as 7.2 times the average impact result of the analyzed sample, which shows that the variability among manufacturers is high and decisions based on average impacts may be highly misleading. For some impact categories, the differences among concrete plants (mix design, cement type and operational conditions) represent the highest contribution for variability, while for others the dominant variation comes from upstream processes, especially clinker production. These results indicate a high potential for process improvement and that manufacturer selection based on environmental performance can be an effective strategy for sustainable construction.

NOTES

EDUCATION & ECONOMY 1

Sustainability in Educational Campus Development

Chair: Chanjief Chandrakumar
Massey University, New Zealand

Transition Towards
a Net Zero Carbon
Built Environment

Austrian Universities and the Sustainable Development Goals

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In 2015, the United Nations released the 2030 Agenda for Sustainable Development, adopted by 193 countries, containing 17 Sustainable Development Goals (SDGs). The goals address social as well as economic and environmental challenges in a holistic approach. Participating university members of the Alliance of Sustainable Universities in Austria (ANU), a cooperative work platform that promotes sustainable development at universities in Austria, picked up on this impulse by developing approaches for universities to address SDGs in research and education. The article presents the cooperative process of developing a project with the aim of supporting political decisions for SDG achievement, establishing the SDGs in research and education and intensifying collaboration between universities. Besides interactive workshops and methods to develop the project, a mapping supported the team to find well-established and also underrepresented SDGs in research at universities in Austria.

NOTES

Architectural Education for a Post-Fossil Future

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The transformation to a post-fossil future will require us to radically rethink the way that we live, build, consume and educate. Currently in Europe the construction sector is responsible for nearly 40% of direct and indirect CO2 emissions and 30% of waste generated. With these numbers only increasing, young designers will carry a huge responsibility for reducing the sector's impact on the environment. Yet in many cases architectural education continues to place form-making in the centre of the curriculum at the expense of an understanding of the complexities of planning in a post-fossil future. Since its inception in 2017, the Natural Building Lab (NBL) at the Technische Universität Berlin has been exploring new methods of architectural education with the premise that new models and formats are needed in order to equip young designers with the tools they will need to affect change in a rapidly changing, globalised society. The projects undertaken by the Lab up till now have put an emphasis on self-determined learning as the vehicle to involve students proactively in urban-change processes. The first built projects from the Lab, while in diverse contexts, all combine circular, LowTech construction principles with the performance of natural building materials to produce a vision for a post-fossil architecture, often designed and realised by students in trans-disciplinary collaborations. The paper will look at the challenges facing architectural educators and how the Natural Building Lab is aiming to frame its pedagogic strategy based on the realities of resource scarcity and climate change.

NOTES

Affordance-based Design Method: A Case Study of University Campus

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Development of a built environment encompasses urban design, land use, transportation system, and accommodates patterns of human activity within the physical environment. Holistic development of built environment requires a multidisciplinary design team of urban planners, architects and sustainability advisors from an early design stage. Literature and industry-practices show growth of designer's techniques and competencies, sustainable development capabilities, and user-centric prospective in the early design. However, there is a lack of systematic method and all-inclusive approach to design a built environment. Thus, proposed research aims to develop a design method which is user-inspired, stakeholder conducive and environmentally conscious from an early design stage. To achieve this aim, an affordance-based design method is proposed and demonstrated through a case study of university campus. Affordance-based design method has been used for design of complex systems by capturing user needs, stakeholder ideas and generating design options. The proposed design method provides decision-making guidelines to designers, design space to incorporate stakeholders, and affordances to achieve sustainability. The proposed design method has potential to shift design and development of built environment from designer-controlled process to systematically organized process.

NOTES

Hoppet - the first fossil free preschool

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Residential and commercial buildings give rise to about one fifth of the greenhouse gas emissions in Sweden. One important goal of the City of Gothenburg is to be a climate neutral city with fair emission levels of greenhouse gases in 2030. In order to reach this goal, a demonstration project has been initiated with the aim to build a fossil free preschool - Hoppet. Hoppet will be built with a minimal climate impact and with no fossil resources. This includes everything from production and transport of materials to energy usage in the building. The fossil content and the climate impact of a standard preschool has been calculated, to be used as a benchmark for Hoppet. The result shows that all 250 building products in the reference preschool have a climate impact but finding fossil free and climate neutral alternative products has been found challenging. The climate impact of the building products in the reference preschool is calculated to more than 220 kg CO_2-eq. per m^2. Strategies to decrease climate impact for Hoppet preschool has been developed. For example, product development and innovation has been identified as key issues as well as increased collaboration between different actors in the construction industry. Communicating the project internationally is of high importance to find partners and innovations that don't exist in Sweden as well as to engage other stakeholders to help transform the building sector.

NOTES

Passive houses for active students – Providing knowledge about eco-efficient buildings

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The OeAD-Housing Office is a non-profit organisation in the area of international cooperation in education, science and research in Austria. We cooperate with our parent company OeAD-GmbH as well as various Austrian student residences and partner universities worldwide. The main responsibility is accommodating international and national students in Austria's university towns. Our success story started with the construction of the first halls of residence built according to the passive house standards world-wide in Vienna in 2005. Since its completion, the OeAD-Guesthouse Molkereistraße has accommodated 280 international students and guest professors per semester. We are successful in managing a total of 8 student guesthouses in the passive house design constructed in Vienna, Graz and Leoben. This paper describes the benefits of passive houses and raising awareness for eco-efficient buildings. We focus on two OeAD-Guesthouses in Austria and highlight their design, architecture and what it is like to live in both of them. Upon request we are also able to propose the OeAD-Guesthouse PopUp dorms. As we want to share our knowledge with the rest of the world we initiated 2 summer universities which pay attention to ecological buildings and the financial and economic system. We also draw attention to several awards we have won during the past years.

NOTES

BUILDINGS 2

Special Session nZEB I

Chair: Tobias Weiß
AEE INTEC, Austria

Transition Towards
a Net Zero Carbon
Built Environment

Contradictions of low-emission nZEB buildings

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Based on the EPBD 2010 directive and the mandated method of cost-optimum calculation the forthcoming national regulations require “nearly zero energy buildings” which have high energy performance, significant share of renewables in covering the low energy need and harmonizing the requirement system and the cost-optimum all over in Europe. Known intention of the EU Member States as well as some research reports create the impression that predominant use of biomass in the forthcoming years will be the right way to fulfil the above requirements of nearly zero energy buildings. Taking advantage of regulations in many Member States, the amount of yearly primary energy demand is favourably influenced by the low primary energy conversion factor determined by the very states; besides the delivered energy does not decrease. The CO_2 neutrality of biomass is not real. It is true that the emission of gas firing far exceeds that of wood firing, but emissions from the production of natural gas might be lower than that of the production of certain wood products. Overall, the lifecycle-based emission of biomass firing for the most converted fuels is already significant. In the case of wood combustion, the local pollutant emissions, which occur in cities, are significant, while the CO_2 constraint take place in the forests.

NOTES

Design transformation from standard conformity to Net Surplus Energy

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The energy performance of buildings directive requires all new buildings to be near zero by 2020. With that target year approaching, the lacking definition of what “near zero” actually means becomes increasingly prominent. While a weak definition threatens to undermine credibility of near zero claims, it is both environmentally profound, technically feasible and beneficial with regards to user qualities and indoor comfort aspects to plan and build net surplus energy and carbon neutral houses. One goal of the project was to demonstrate that established building developers can shift their building practice to deliver surplus energy homes – without leaving their range of experience. After analysing the base-line-design, incremental improvements focused on optimising the building envelope, including thermal bridges, air-tightness, fault-free insulation. The remaining energy demand is covered entirely from locally available renewable sources. Key elements are building integrated PV and power storage, geothermal heat pump for heating and warm water, ventilation system with heat recovery and LED lighting. The PV installation is designed to generate more than twice the energy needed by the building and the users, providing that surplus to electric mobility applications. Displacing electricity purchased from the grid and displacing fuel combusted in vehicles is key to life cycle carbon and cost optimisation. Energy efficiency is not in conflict with user comfort, especially not with daylight aspects or with architectural design. The successful merger of a wide range of sustainability aspects was highlighted by this building being category winner of the international active house awards 2018.

NOTES

Analysis and Cross-Comparison of Business Models for nearly Zero-Energy Buildings in Europe

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Nearly Zero-Energy Buildings (nZEBs) will be the standard for new constructions in Europe from 2019 (public buildings) and 2021 (private buildings). Even though several technologies for realizing nZEBs are already available, their market penetration in Europe is still low. This can be ascribed to both high initial investment for nZEBs and limited adequate business models for several stakeholders along the buildings' lifecycle. The aim of this paper is to present and analyse examples of existing business models for nZEBs in different European countries. A broad overview of these business models, accompanied by evidence of their key factors and strengths is essential for developing new business models that ensure a cost-optimal nZEB implementation and adequate profitability for all stakeholders involved. Therefore, at first business models of different European markets and nZEB lifecycle phases are searched for and described in a profile-like manner. Secondly, the key factors and strengths of each business model are pointed out. In the end, a cross-comparison of the business models is done according to some key parameters, such as involved stakeholders and covered life cycle phases. This knowledge serves as a basis for the development of innovative nZEB business models. The work presented in this paper is developed in the frame of EU funded project CRAVEzero – Cost Reduction and market Acceleration for Viable nearly zero-Energy buildings which is co-funded by the Intelligent Energy Europe Programme within the Horizon 2020 Framework Programme of the European Union.

NOTES

Energy and cost optimization in the life cycle of nearly zero energy buildings using parametric calculations

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Possible cost saving potentials in the planning and construction of future building standards are often not sufficiently assessed, as only a few possible variants are considered in the traditional planning process. Often planning and analysis are not carried out in parallel, and the various possibilities are discarded at an early stage. If, on the other hand, several variants are realistically compared in the planning phase, including life-cycle costs, a profound decision can be made. Therefore parameter studies were carried out as part of the national research project “KoPro LZK+” (cost and process optimization in the life cycle of nearly zero energy buildings) for seven buildings, five multi-family buildings, a school and an office building. For this purpose, a VBA macro was programmed in MS-Excel©, which automatically carries out energy demand calculations in the “Passive House Planning Package” (PHPP) and life-cycle cost calculations in the tool “econ calc”. A total of more than 216,000 variants were investigated in this way, whereby on the one hand a variety of technologies, such as insulation of the building envelope, ventilation or electricity and heat supply, and on the other hand a variation of the boundary conditions (such as observation period, user behaviour, energy price increases or CO_2 costs) were carried out. The results were analysed energetically and economically over the life cycle (separately from each other and combined) with the objectives of identifying coherences, deriving trends and optimizations over the life cycle.

NOTES

Energy Flexible Buildings - The impact of building design on energy flexibility

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Thermal load management has substantial theoretical potential for energy flexibility. To use the inherent flexibility in buildings, for example, district heating companies could temporarily control the heating system of buildings to switch-off or preheat dwellings in the morning to avoid using peak load gas boilers. The »thermal flexibility« in this study indicates the tolerance of buildings towards the changes of its heating system operation according to an external signal. The focus of this investigation is to give an overview of »thermal flexibility« of residential buildings in Austria from 1920 – 2020 with different envelope qualities, construction types and heating systems. Existing residential buildings in Austria usually have a high thermal mass within their massive brick or concrete primary structure, and therefore their indoor thermal conditions react slowly to operative changes in the supply of thermal energy. Depending on the buildings ability to retain or store heat **inside** the building envelope, space heating can be used to offer energy flexibility. Among other factors, especially the quality of the thermal envelope, the thermal capacity of the building, the sluggishness of the heat delivery system and passive solar gains are crucial for keeping indoor thermal comfort. Dynamic building simulation in IDA ICE is used to evaluate the potential of selected building typologies to shift heating loads away from peak demand periods. Potentials of various building archetypes according to the EU-Tabula building database to time-shift the operation of the heating system are pointed out respecting occupants' comfort.

NOTES

BUILDING DESIGN 2

Environmental Performance and Sustainability Assessment on Building Level

Chair: Dirk Alexander Schwede
Stuttgart University, Germany

Transition Towards
a Net Zero Carbon
Built Environment

Comparison of the environmental assessment of an identical office building with national methods

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The IEA EBC Annex 72 focuses on the assessment of the primary energy demand, greenhouse gas emissions and environmental impacts of buildings during production, construction, use (including repair and replacement) and end of life (dismantling), i.e. during the entire life cycle of buildings. In one of its activities, reference buildings (size, materialisation, operational energy demand, etc.) were defined on which the existing national assessment methods are applied using national (if available) databases and (national/regional) approaches. The “be2226” office building in Lustenau, Austria was selected as one of the reference buildings. TU Graz established a BIM model and quantified the amount of building elements as well as construction materials required and the operational energy demand. The building assessment was carried out using the same material and energy demand but applying the LCA approach used in the different countries represented by the participating Annex experts. The results of these assessments are compared in view of identifying major discrepancies. Preliminary findings show that the greenhouse gas emissions per kg of building material differ up to a factor of two and more. Major differences in the building assessments are observed in the transports to the construction site (imports) and the construction activities as well as in the greenhouse gas emissions of the operational energy demand (electricity). The experts document their practical difficulties and how they overcame them. The results of this activity are used to better target harmonisation efforts.

NOTES

New Portfolio-Rating-System based on LEVEL(S)

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In Switzerland, there are currently no instruments for the holistic and easily applicable assessment of the sustainability of existing buildings, which can also be applied to larger real estate portfolios and which are structurally based on Swiss or European sustainability standards. The instrument, developed as part of a ZHAW R&D project for the City of Zurich, Public Real Estate Management, is based on the already existing LEVEL(S) criteria structure. As distinguished from LEVEL(S), it can be applied to all types of buildings, including mixed buildings, and also scalable to larger portfolios of cities, banks, insurances or real estate investment funds. LEVEL(S) is a voluntary reporting framework to improve the sustainability of buildings. Using existing standards, LEVEL(S) provides a common EU approach to the assessment of environmental performance in the built environment. In the current Version LEVEL(S) is suitable for new office and residential buildings and existing buildings at the time of a major refurbishment. The paper shows, how the rating structures of Agenda2030/SDG's/GAPFRAME, ESCI City Rating System, DGNB and LEVEL(S) can be combined into a holistic evaluation system. If required, the developed portfolio analysis instrument can be coupled - with a more detailed building analysis as an intermediate step - directly with a DGNB renovation certification. It will show how sustaining property owners can be supported in this holistic way. Finally, the first findings from the practical application are explained. It will be shown how it is possible to support sustainably acting portfolio holders in this holistic way.

NOTES

The BNK Assessment Tool for the sustainability performance of small residential buildings in Germany – Lessons learnt

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Several instruments for the assessment of the sustainable building performance such as BREEAM (Great Britain), LEED (USA) and DGNB or BNB (Germany) have been developed in the last years. These methodologies have the same intent - advancement of the sustainable building performance. These systems focus mostly on commercial buildings. However the sustainability assessment of the residential sector is getting more important. Giving that around 115,000 owner-occupied detached houses are built up per year in Germany, a new assessment method (BNK system) for small residential houses was developed on behalf of the Federal Ministry for the Interior, Building and Community (BMI) in 2015. To ensure the suitability of the assessment system, the BNK method was tested in a pilot phase and from 2016 on it is available for general use and the assessment is financially supported by public funds (KfW Banking Group). To date more than 100 of small residential buildings have been certified with BNK. This paper will show the development and experience with the sustainability assessment of buildings in Germany in general, as well as the intents, indicators and real case projects of the BNK-Tool for small residential buildings (up to five dwelling units) and its further development.

NOTES

A stakeholder- and function-based planning method for space-efficient buildings

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Space efficiency has proved to be one of the basic parameters for achieving a high level of sustainability of buildings. By optimizing the required space to fulfil functional requirements, high potential savings can be achieved in terms of space, material and energy consumption. This presupposes, however, that – following the principles of an integrated design process - the use-related functional requirements of buildings have been determined in the early planning phases and that architects take these functional requirements into account accordingly - also with regard to possible organizational, logistic and process-related options. So, interdependencies and (temporal) overlays can be reflected and the topological structure can be transferred into space-efficient spatial structures. But adequate tools and methods are currently missing that support this process of user-based functional demand planning in the sense of an integrated participatory process. This contribution introduces a methodology for early planning phases, which is based on a stakeholder analysis and helps to specify process-related user functions as well as qualified functional correlations. The functional relationships can be described, for example, spatiotemporally or in relation to the flow of materials and can be mapped in an adjacency matrix. The planner is thus actively encouraged to think about area- and space-related optimization potentials and can transfer the topological structure of functions into an space-efficient floor plan concept. Also a prototypical implementation of this method will be presented as a web-based tool that supports a participatory user and stakeholder-related planning process.

NOTES

Sustainability assessment of a Flemish office building with Level(s): a Level 1 assessment

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Recently, Level(s) has been developed by the European Commission as a common EU framework to assess sustainability of buildings with the intention to provide a consistent and comparable framework across national boundaries. It aims at providing a general language for sustainability for buildings and to promote life cycle thinking. This paper describes the application and results of a Level 1 assessment for the design stage of a Flemish office building. Level 1 is a common performance assessment which aims to be used amongst others by building professionals. Common standards and simplified methods are used for the indicators. The paper focusses on the experiences of testing the method by evaluating the user-friendliness of the assessment method for architects considering the information and calculations needed. The added value of applying the methodology in the design stage is furthermore discussed. Based on the test phase, further improvement is recommended by aligning current national tools for data gathering and by providing default values. A Level 1 assessment allows to gain insights in various performances of a building but does not aim to evaluate the "sustainability" level. A level 2 assessment is probably more useful for practitioners to make well-founded choices between different design options.

NOTES

IEA EBC Annex 72 - Assessing life cycle related environmental impacts caused by buildings – targets and tasks

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Investment decisions for buildings made today largely determine their environmental impacts over many future decades due to their long lifetimes. Such decisions involve a trade-off between additional investments today and potential savings during use and at end of life - in terms of economic costs, primary energy consumption, greenhouse gas emissions and other environmental impacts. Life cycle assessment (LCA) is suited to identify measures and action to increase the resource efficiency and the environmental performance of buildings and construction. This paper gives an overview of an ongoing international research project within the IEA EBC with the overall aim to harmonise LCA approaches on buildings and foster life cycle thinking in the real estate and construction sectors. The objectives of the project are i) to establish a common methodology guideline to assess the life cycle based environmental impacts caused by buildings, ii) to establish methods for the development of specific environmental benchmarks for different types of buildings, iii) to derive regionally differentiated guidelines and tools for the use of LCA in building design and tools such as BIM, and iv) to improve data availability by developing national or regional databases with regionally differentiated LCA data tailored to the construction sector. To ensure practical solutions a number of case studies will be used to test and illustrate the consensus approaches and research issues.

NOTES

CITIES 1

Special Session Urban Resource Management

Chair: Philip Leistner
University of Stuttgart, Germany

Transition Towards
a Net Zero Carbon
Built Environment

Assessment of urban-scale potential for solar PV generation and consumption

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The rise of grid electricity price and a growing awareness of climate change is resulting in an increasing number of photovoltaic facilities installed in buildings. Electricity market regulation and climatic conditions, in particular solar radiation, are the main factors that determine the economic viability of a photovoltaic facility. This paper describes a method for evaluating the potential for photovoltaic (PV) production and self-consumption for the building stock of a particular city. A GIS 3D city map is used to calculate solar irradiation. Building-level electricity use is calculated based on building type, geometry and other characteristic inferred from building age, taking the cadastre GIS as main input. The methodology identifies the realistic potential for rooftop photovoltaic installations, as well as the optimum size to be installed from an economic perspective. To represent different regulations that can affect economic viability of PV installations, calculations should adapt for the specific installation conditions and regulatory situation, as for example self-consumption and net metering. The proposed methodology is applied to a case study in Irun (Spain), where results for potential of PV generation and self-consumption for the building stock are presented. The results offer public administration a realistic view of economically viable PV potential for the city and allow to analyse different mechanisms to promote their installations. It also serves for individual electricity consumers to evaluate and optimize new photovoltaic energy facilities. Finally, it serves policy makers to estimate the repercussion of electricity market regulations on the economic viability of PV systems.

NOTES

Building physics design of urban surfaces

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Structural-spatial form and urban land use are among the main transformative fields of action of cities. Quality of life and environment, identity and individuality as well as participation in local society are significantly influenced by urban surfaces. Most urban surfaces have so far been designed for the long-term fulfilment of individual purposes, but offer greater scope for design in terms of functionality and adaptability, quality and efficiency. It therefore makes sense to develop, evaluate, technologically expand and test the potential of urban surfaces in terms of building physics as a whole. In view of growing stress on urban structures due to climate-induced influences, such as flooding, extreme weather conditions or heat islands, new possibilities, processes, systems or materials are needed to improve resilience. The article presents exemplary developments that can be supplemented and combined. Hydroactive surfaces can buffer rainwater and release it with a time delay to reduce heat and flooding equally. Green façades improve city climate and air quality. Sound-absorbing façades reduce inner-city noise. Innovative transparent foil enclosures provide equally visibility and an optimum weather protection of objects to be protected throughout the year.

NOTES

Sustainability of innovative urban surfaces – a new approach of assessment

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The physical design of urban surfaces determines the management processes that are required to ensure that their intended functions are fulfilled within a set period of time and influences their linked material flows. Those flows are causing numerous environmental, economic, and social impacts. In the field of urban surfaces, there is a broad variety of innovations available that has the potential to contribute to a more sustainable environment and quality of life in cities. However, before implementing any kind of innovation, it is important to quantitatively and qualitatively assess its sustainability impacts in a holistic manner. While current assessment methods provide a suitable framework for the sustainability assessment of products and services, without modification, they cannot be applied to urban surfaces and related management processes. The herein introduced methodological approach is designed to overcome this problem by not only being tailored to the sustainability assessment of innovations in the field of urban surfaces but also by combining life cycle thinking with a holistic approach. By integrating SDGs, it will provide insight into the possible impacts of an innovation in all three dimensions of sustainability at the municipal level. This knowledge can be used to support the municipality in its decision on the design of urban surfaces and management processes by showing whether or not it is advisable to implement an innovation from a sustainability point of view. The focus of this publication is on the development of a general life cycle of urban surfaces and its interaction with product innovations.

NOTES

Land resource management of coastal areas in Indian cities: comparative assessment with prevailing methods

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Indian coastal cities, enriched with a variety of marine resources, are a major driver of economic growth where the Indian coast provides shelter to a large part (~49%) of the total population in India. Proper planning of coastal resources is crucial for sustainable development, which can be achieved through advanced planning methods. Current methods for the planning of coastal landscapes in Indian coastal cities are ineffective in sustainable utilization of coastal resources and need improvements. This paper evaluates the application of the new planning method for classification of coastal landscapes in Mumbai city. The new method incorporates geospatial technology and multicriteria decision-making approach. The existing method of coastal area classification is based on Coastal Regulation Zone (CRZ) notifications by the central government, which has ambiguities in implementation. In the new method, coastal areas of Mumbai city are classified based on the physical eligibility of the coast for management of coastal resources and spatially compared with prevailing unscientific classification of coastal areas. The most dense urban area is considered for quantitative comparison of prevailing and new classification approach. Results of coastal area classifications by both methods disclosed the significant differences among different classes of coastal land. The results are validated with field visits and ground truthing along the coast of Mumbai. The findings of this study will enable the stakeholders to utilize available coastal land resources in an efficient manner for developmental and conservational activities at regional and neighborhood scale.

NOTES

Turning the existing building stock into a resource mine: proposal for a new method to develop building stock models

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The construction sector is facing an important challenge to reduce its resource consumption. A promising strategy is to reduce the need of virgin resources by using the existing building stock as a resource mine. Various insights are needed to enable this. It should be clear how many materials are in the stock, when these will become available and to what extent these can be reclaimed in an environmentally and economically viable way. For this purpose a spatio-temporal building stock model is being developed and tested on the city of Leuven, Belgium. In a next step it will be assessed how these flows can be reclaimed in an environmentally and economically viable way. This paper provides a review on the methods used for building stock modelling and proposes improvements on the bottom-up archetypes scaling method. Building parameters relevant to material reuse and are introduced and a new methodology for upscaling is presented, using two data analysis techniques: a clustering algorithm and an artificial neural network.

NOTES

Seismic and solar performance of historical city. Urban form-based multicriteria analysis

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The understanding of the global performance of a historical city is a complex balance of several specific issues and requires a multi-disciplinary approach to face with actual urban phenomena and challenges, such as the seismic risk and energy efficiency, that are strongly influenced by urban form. This paper focuses on the potential of urban metrics and typological indicators for describing the seismic vulnerability and the solar radiation availability of distinct urban textures, and the correlation between the two aspects. Comparative analysis at fabric scale was conducted on the historical centre of Rieti (Latium, Italy), to underline the main seismic and solar indicators. In the last decade, we witnessed the spreading of urban scale assessment and analysis tools, but seldom using an integrated approach to face the complexity of the historical city. Relying on morpho-typological indicators, the proposed method characterizes the fabrics in terms of seismic vulnerability and solar availability through a multicriteria analysis. The analysis reveals substantial differences between fabrics using three groups of indicators: Plan, Space and Analysis-oriented. Each group describes different features of the urban fabrics that affect seismic and solar performance and suggests improvement strategies. The purpose is to support policymaker and designer in the urban renovation process.

NOTES

PROCESSES 2

Special Session Building Optimization Workflows

Chair: Martin Röck, Alexander Hollberg and Benedek Kiss
Graz University of Technology, Austria;
ETH Zurich, Switzerland,
Budapest University of Technology and Economics, Hungary

Transition Towards
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Built Environment

Consistent BIM-led LCA during the entire building design process

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Life Cycle Assessment (LCA) is a suitable method to analyse the environmental impact of buildings' design choices. However, the nature of the building design process leads to a dilemma when applying LCA in early phases. LCA can be fully performed only in the later design phases when complete information is available, but it is too costly to make changes. As a result, LCA is scarcely employed as a decision-making tool. Building Information Modelling (BIM) can assist LCA during the design process. So far, two different approaches are usually adopted to perform the BIM-based LCA of buildings. The first approach concerns performing LCA with a detailed BIM at the end of the building design process. The second approach involves simplified methodologies for early design stages with uncertain data. This study proposes a novel approach for applying a consistent BIM-led LCA from the early design stages to the detailed ones based on lower to higher level of accuracy. Since the BIM elements are specified with increasing level of detail in each design phase, the method uses different LCA databases for the Level of Developments (LODs) of the building elements. Accordingly, LCA calculations are based on mixing the databases in every design phase. This is possible as long as the databases use identical background data. The framework helps to provide consistent information for decision-making throughout the whole design process, both in the later design phases and early ones with a simplified BIM.

NOTES

BIM-integrated LCA - model analysis and implementation for practice

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Ecological impacts of buildings can be quantified using the method of Lifecycle Assessment (LCA). With the help of digital methods and semantic building models (BIM), those impacts can be reduced by investigation of variants and their LCA comparison. However, there is a large deviation in the results due to inaccuracies in the modeling and the calculation tools. This paper proposes an improved workflow of BIM-integrated LCA avoiding those inaccuracies. As a first step, various sources of error are identified using a model analysis, which is examined with 25 models focusing on geometry and materiality. Thereby different workflows are investigated, modeling recommendations are derived based on the error analysis, and the findings are implemented in a prototype. Through an optimized calculation process, the semi-automatic calculation of life cycle assessments becomes faster, more consistent and more accurate due to the improved integration in BIM.

NOTES

Identification and comparison of LCA-BIM integration strategies

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With increasing use of BIM (Building Information Modelling) in the design of construction projects, opportunities arise to integrate Life Cycle Analysis (LCA) in early design phases efficiently with minimum additional burden for the design team. Different levels of integration can be envisaged, ranging from a BOQ export (Bill Of Quantity) based on the BIM-model to import in native LCA-software, up to a real time LCA-calculation within the native design environment, giving real time feedback on design decisions, or alternatively utilizing the standardized BIM-information exchange format IFC. Based on the evaluation of existing tools, this paper focuses on the possible workflows for the integration of LCA and BIM. A comparative analysis between these different information flow structures exposes their advantages and disadvantages, depending on the design phase they are used in and the availability of generic, product-specific or manufacturer-specific LCA-data.

NOTES

BIM for public authorities: Basic research for the standardized implementation of BIM in the building permit process

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The building permit is an indispensable connection between the approval authority and the executive client within the construction process. Moreover, sustainability criteria do not have sufficient regard in the building permit process in the area of research. To lay the foundation for a state-of-the-art digitalization of the building permit process, the study identifies the information requirements relevant to implement the BIM methodology taking into consideration the available sustainability aspects relevant to the process. A detailed evaluation of the building permit process and the analysis of projects that have gained building permission in the last five years in the area of study of South Tyrol (Italy) gives us a better understanding of the organizational structure and responsibilities in the process. The authors use the data of in-depth process analysis to assess a defined catalogue of basic requirements for BIM methodology in the building permit process. As a result, the analysed BIM-integrated approach enables an early- stage identification of approval compliance, which can be evaluated in the building permit process. A good understanding of the current process must be considered a key factor of a successful introduction of BIM for the building permit procedure.

NOTES

A cross-platform modular framework for building Life Cycle Assessment

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In recent years the application of Life Cycle Assessment (LCA) for assessing and improving the environmental performance of buildings has increased. At the same time, the automated optimization of building designs is gaining attraction for both design and research purposes. In this regard, a number of issues persist when aiming to optimize building's environmental impacts along the design process. Firstly, as LCA applies a life cycle perspective, many aspects have to be considered (e.g. energy demand in operation as well as consumption of resources and energy for production and end of life treatment) and a variety of specific calculations is needed (e.g. building energy performance simulation, material quantity take-off). Secondly, sophisticated software packages are available and being used for each of these calculations (e.g. software for building modelling, dynamic energy simulation, quantity surveying). Though many of these software packages are currently standalone applications that rely on human interaction, there is an increasing trend to provide an application programming interface (API) that enables customization and automation. Thirdly, the mentioned processes and calculations are influencing each other in various ways and several scenarios have to be assessed. Thus, a comprehensive and modular approach is required that promotes interconnectivity of the different software solutions and automation of the assessment. In this paper we propose a modular cross-platform framework for LCA of buildings aiming to support flexibility and scalability of building LCA. We present a conceptual framework, example data exchange requirements and highlight potential implementation strategies.

NOTES

PRODUCTS 2

Recycled Building Materials

Chair: Antonín Lupíšek
Czech Technical University in Prague, Czech Republic

Transition Towards
a Net Zero Carbon
Built Environment

Ecological performance and recycling options of primary structures

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A sustainably and optimally building material is defined consequently in a well-balanced relation between ecological aspects and structural engineering requirements and should be selected depending on external conditions. By choosing environmentally friendly building materials and joining techniques, at least resource-efficient and sustainable construction can be achieved. As a contribution to the discussion about which building materials offer the most optimal and environmentally friendly properties for the construction industry, this paper gives an overview of sustainable construction. It illustrates the advantages and disadvantages of certain building materials and structural components by comparing their mechanical properties and ecological aspects using various types of life-cycle assessment (LCA). As far as construction materials are concerned, e.g. wood-based materials have the greatest potential in terms of renewable primary energy demand compared to all other constructions materials. Furthermore, due to the high recycling potential, wood has the lowest share of non-renewable primary energy demand, whereas the highest non-renewable primary energy demand is caused by mineral building materials. 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 primary structures, their effect on the design and decision-making process.

NOTES

Overview of recycled concrete research through development years (2004-2018)

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Along with the urbanization process, large amount of construction and demolition (C&D) waste during the construction, reconstruction, expansion or demolition of buildings is generated. Meanwhile, the impact on environment due to natural aggregate mining has become increasingly significant. These factors have driven the building industry to look for environmentally friendly materials and focusing on sustainable construction. Through nearly a decade of research, recycled concrete (RC) made with recycled aggregates manufactured from construction and demolition (C&D) waste has shown a competitive performance compared to natural materials and has already achieved industrial application. Researches on sustainably recycled concrete have become an essential part of sustainable development and continue to play a vital role for future research. This paper engages in the discussion and the overview of research done by the Research Group for Recycled Concrete Structures and Construction at Tongji University, Shanghai. The first part discusses the necessary mechanical and durability properties of recycled concrete with recycled aggregate as well as recycled powder focusing on workability, strength, Poisson's ratio, stress-strain behaviour along with carbonation, chloride penetration shrinkage and creep. The second part throws light on the elements and structures made with recycled aggregate concrete (RAC), discussing the behaviours of RAC components and structures.

NOTES

A comparative study on nonlinear damping behaviors of precast and cast-in-situ recycled aggregate concrete frames

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It has been well accepted that applying recycled aggregate concrete (RAC) into structural engineering is a sustainable method to solve the problem of construction and building waste (CDW) accumulation meanwhile to save natural resources exploitation. Precast RAC members in factories is beneficial to improve their qualities and will extend the RAC application. This study presents nonlinear damping behaviors of precast and cast-in-situ RAC frames after simulated earthquakes, as a reference of quality control of precast RAC members, and of damage detection under ambient vibration. The nonlinear damping of precast RAC slabs with different damage degrees was studied to validate the feasibility of applying the quadratic damping coefficient as a sensitive damage factor without any requirement of undamaged baseline. Meanwhile a comparative study on nonlinear damping behaviors of a precast and a cast-in-situ RAC frames was conducted. Results highlight a change of nonlinear damping mechanism for both precast and cast-in-situ RAC frames from a viscous damping into a nonlinear damping. The precast RAC frame had a comparatively larger quadratic damping coefficient before and after earthquake hitting, indicating it had more severe initial damage and damage developed more significantly compared with the cast-in-situ frame. A unified damage classification was proposed for both precast and cast-in-situ RAC frames based on quadratic damping coefficient and observation.

NOTES

Modification on Recycled Aggregates and its Influence on Recycled Concrete

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Recycled aggregates produced from waste concrete are widely accepted as green building material. However, demolition processes will bring recycled aggregates with a lower apparent density, bulk density whereas a higher porosity, silt content, water absorption, crushing index value when compared with natural aggregates. So the strengthening and modification of recycled aggregates have become a prominent technological issue in the producing process. This paper introduces current modification methods on the recycled aggregates, which mainly include: (1) physical technology, its basic idea is to remove the waste cement paste adhered to recycled aggregates, such processions as rubbing, heating, particle shaping, and micro-heating; (2) chemical technology, carried out by immersing recycled aggregates in different kinds of chemical grout, which can be mixed with additive Kim powder, silica fume, fly ash, and any other fine mineral powder or slag; (3) carbonation technology, when newly collected crushed aggregates are put into atmosphere with high CO_2 concentration, the adhesive cement paste can react with CO_2 and produce $CaCO_3$ that will precipitate in the capillary pores or cracks, which will improve properties of recycled aggregates; (4) nano technology, the use of nanomaterials can promote the hydration reaction, react with cement based materials, fill pores and control the process of crystallization. Conclusions are put forward and several problems concerning modification need to be considered for further research and application are proposed and discussed. Compared with natural concrete, RAC is superior to environmental value in the reduction of CO_2 emission in Life Cycle Assessment.

NOTES

Parametric life cycle assessment of a reusable brick veneer

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A possible design strategy to improve the sustainability of building products is facilitating their future reuse. This strategy inspires some manufacturers to design innovative products, such as reusable façade products. Although these products might have a higher environmental impact for production, their reusability could lead to an environmental saving from a life cycle perspective. A possible method to evaluate their environmental performance is life cycle assessment (LCA). Nevertheless, LCA studies of reusable products are still rare. Furthermore, although the general LCA frameworks is fixed by ISO and CEN standards, some methodological choices must still be made by LCA practitioners. This paper first presents a method (as four methodological choices) for a parametric life cycle assessment of reusable building elements. Then, this method is applied to a comparative LCA of reusable and brick-and-mortar veneers. With proposed method, the reusable brick veneer is environmentally advantageous if it is reused at least once and if it is properly recycled at its end-of-life. The parametric method also indicates the relative influence of various parameters such as reuse rate, number of interventions, transport distances and waste treatment. The manufacturers can use this LCA study as a retrospective assessment to validate the relevance of design choices, but also as target-driven product management support to know hot-spots in the product' life cycle management. This study will hopefully inspire other designers and manufacturers and accelerate the transition towards a sustainable built environment.

NOTES

Outcomes of a Student Research Project on Circular Building Systems – Focus on the Educational Aspect

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The growing need to shift from a linear to a circular economy has inspired producers of building materials and systems to innovate their products to match the requirements of a future circular economy. Others have been developing modular systems in the past to simplify the building process and are now reconsidering these products for their potential in a circular economy. However, at this early stage on the road towards a circular economy, claims of circularity are often made too easily and many producers as well as architects and builders are still struggling with the practice of circular building. In this context and within an assignment for master students in architecture, three cavity walls, each 9m² and composed with a different system for the inner and the outer wall, have been constructed and disassembled in order to test their potential for circularity. The extent of circularity has been critically analysed with an existing framework of evaluation criteria for design for change: three criteria on interface level (reversibility, simplicity, speed), three on component level (compatibility, durability, manageability) and three on composition level (independence, pace-layering, prefabrication). This analysis was complemented with an environmental assessment of the materials used and with interviews with contractors who have experience with these systems. In a final step, proposals for improvement of the products and systems have been made and tested on a mock-up scale, in order to better fit a possible future circular economy.

NOTES

EDUCATION & ECONOMY 2

LCC - Economic Challenges

Chair: Jan Tywoniak
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Transition Towards
a Net Zero Carbon
Built Environment

Visual tool to integrate LCA and LCC in the early design stage of housing

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Over their whole life cycle, buildings are responsible for high environmental impacts and require critical financial resources. Decisions in the early design phase have a significant impact on both. This study aims to develop a visual decision support tool for architects in order to integrate an environmental and economic life cycle approach for dwellings. To evaluate the environmental impacts of the building design, the tool uses the Belgian LCA method, 'Environmental Profile of Building Elements'. This method translates 17 environmental indicators in environmental costs by considering the cost to avoid, reduce or compensate the effects to a level that is bearable. The tool allows to combine these life-cycle environmental costs (LCEC) with Life Cycle financial Cost (LCFC). To estimate the operational energy use of the building, the "dynamic Equivalent Heating Degree Day (dEHDD)" method is used. This method allows for fast and relatively accurate heating energy estimations in the early phase, based on a limited number of input data. The tool visualises the results in a graphical way which can be easily understood by architects. Even more, visualisation is seen as a powerful communication tool to share information and ideas with all stakeholders.

NOTES

Life cycle environmental and cost evaluation of heating and hot water supply in social housing nZEBs

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This paper presents a comparative analysis of different space heating and hot water systems for a social housing project in Santurtzi, Spain. The building, comprising 32 apartment units and currently under construction, has been designed to minimize thermal energy demand, while ensuring comfort and quality of the internal environment for the social housing occupiers. The selection of the heating and hot water energy systems has been carried considering a life cycle perspective both for environmental and economic impacts. Different alternatives have been analysed which compare conventional gas boiler installation, which has been the norm for this type of social housing for the last decades, with various options based on heat pump technology. Life cycle analysis of the environmental effects of electrification of the thermal energy demand through heat pumps show a potential for reducing life cycle CO_2 emissions. The economic evaluation done through life cycle costing, comparing investment, maintenance, replacement and operational costs of gas boiler with aerothermal and geothermal heat pump solutions, have shown however that gas heating solutions are still the most competitive economically. Increasing the overall efficiency of those heating and hot water systems that include heat pump technology, while reducing their uncertainty in operation is a key element to ensure competitiveness of heat pumps in the current market.

NOTES

A case-based study on the use of life cycle assessment and life cycle costing in the building industry

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The environmental impact of human activities has been a concern for engineers and architects for centuries, from limitation of energy and raw materials to predicting future energy and resource demands. This review demonstrates how life cycle assessment (LCA) and life cycle costing (LCC) tools can be used to support design decisions in the building industry throughout the design process. The study is primarily based on DGNB certification projects in Denmark conducted by the engineering consultancy company Ramboll and focuses on how LCA and LCC tools can be used in the early design stages to quantify decision making and how tools are used in the final stages of a certification process to verify the building geometry with regard to life cycle costs and environmental impacts.

NOTES

Whole-Life Costing of a French Single-Family House Refurbishment: the “Bat-Eco2” case study

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Bat-Eco 2 is a research project on building refurbishment life cyle assessment (LCA) and whole-life costing (WLC). The project’s goal is to contribute to the development of a tool to help decision-making on refurbishment solutions, considering the environmental aspects along with the economic ones. This project has been split in four steps: (i) LCA of a standard single-family house refurbishment built in 1939 and located in Libercourt, Hauts-de-France; (ii) WLC of the same case study; (iii) crossing of LCA results with WLC ones; (iv) simplified tool specification in agreement with these results. This paper presents the WLC methodological choices and the corresponding WLC results. The WLC methodology complies with the ISO 15686-5. It details the refurbishment life cycle stages in compliance with the EN 15 978. The main choices are presented, i.e. system boundaries, economic rates, present costs for each life cycle stage, building residual value. Results enable to enumerate economic hotspots for the case study of this single-family house refurbishment. The whole-life costing is calculated using excel sheets, considering economic data from the social landlord Maison & Cités, house owner of the study case.

NOTES

BUILDINGS 3

Social & Affordable Housing

Chair: Frank De Troyer
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Transition Towards
a Net Zero Carbon
Built Environment

Mobile Tiny Houses – Sustainable and Affordable?

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The topic of „affordable accommodations" has affected the construction industry and the politics for many years, not least due to sharply rising real estate prices. Building plots in good locations are just as prohibitively expensive for young people as larger apartments in urban areas, especially in big cities. This raises the question: How much does a person need to live? Energy efficiency, sustainability and regionality are as equally important as coziness, which decisively defines the quality of life of the residents. As part of the "klimaaktiv" regional partnership, the Upper Austria University of Applied Sciences has carried out several research projects concerning the topic of small sustainable homes. In cooperation with an Upper Austrian prefabricated house company, a building technology concept for an innovative modular construction system was devised. The aim here was the development of an innovative, high-quality and inexpensive modular system that does not exclude increased ecological standards. As part of an interdisciplinary project, a group of students developed an energy self-sufficient cabin for almost every kind of application. Based on extensive research on existing building systems, a variety of topics were examined. The focus here was on mobility, modular assembly, ecological materials, self-sufficiency, energy efficiency and the water cycle. In the end, a single-family house, which considers most of the aforementioned aspects, was built.

NOTES

Challenges of retrofitting affordable housing to net-zero carbon in the United Arab Emirates

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Following the Paris Agreement, several governmental bodies in the United Arab Emirates (UAE) started working on further initiatives to improve the energy efficiency of buildings. Some of these hope to target net-zero carbon for new and existing buildings. As in most countries, the stock of existing buildings represents the bigger challenge for this target. In particular, existing affordable housing is the most challenging segment of the building stock. The limited access to expertise and financial resources makes it more difficult for owners of these buildings to retrofit them. Therefore, there need to be appropriate guidelines on how to achieve net-zero carbon in such building typology. This paper identifies both the technical and the financial challenges when trying to develop such guidelines within the context of the UAE. It also discusses the possible solutions that can be used to overcome some of these challenges. The technical challenges include the variation in construction systems, and the quality of construction for these buildings. It also includes energy modelling challenges such as selecting relevant weather data, and defining the patterns of using electricity for the different functions. The financial challenges include the subsidized price for electricity, the cost estimation for various energy conservation methods, and the payback for installing local renewable energy sources. Finally, the paper suggests a path for research activities to address these challenges and to develop the guidelines.

NOTES

Towards developing a building typology for Sudan

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Sudan suffers from hard summers with temperatures approaching 42 0C in the South and 48 0C in the North. In spite of that, the technical solutions in buildings for protection against solar radiation and natural ventilation are generally beyond reach. There isn't sufficient information provided on the characteristics of the building stock, building physics and energy use of buildings in Sudan. The main objective of this research paper is to collect the data from the population and housing census, scientific research papers and different reports, and to use these in preparing a building typology table. The climate in Sudan is divided into three zones: warm desert climate, warm semi-arid climate, and tropical savanna climate zone. The building varies according to the climate zones, geographical feature, and urbanization levels. Building materials range from natural ones like straw, wood, and mud to moderns one like bricks and concrete. Building typology varies from structures to provide temporary shelter to the permanent single or multi-family houses. The main result of this research paper is to identify a building typology in Sudan with reference buildings. This is the first paper that introduced the typology table of Sudan.

NOTES

Life cycle environmental impact of refurbishment of social housing

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The current focus on climate change mitigation is reflected in policy goals to reduce the energy use of buildings. However, buildings are not only responsible for a large share of energy use and corresponding GHG emissions, they moreover require a lot of resources, produce a lot of waste, and emit harmful substances. In this paper, an approach is developed to investigate the most preferred renovation strategies for social housing, considering various parameters such as efficiency of the current and future heating system, service life of the heating system and insulation level of the building envelope. Moreover the reduction in life cycle environmental impact due to the replacement of heating systems by systems with increased efficiency is studied. The results show that for non-insulated buildings an increase of the thermal resistance of the building envelope is more effective than replacing the heating system while for, even poorly, insulated buildings the efficiency of the heating system is more important. A holistic Life Cycle Assessment approach is preferred to assess renovation scenarios as focussing on energy reduction might lead to an increase of the life cycle environmental impact of the building. Although this paper focuses on social housing, the approach is broadly applicable.

NOTES

BUILDING DESIGN 3

Digitalisation in the Design Process

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Transition Towards
a Net Zero Carbon
Built Environment

BIM based iterative simulation - efficient building design: a case study

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The aim of this case study was to evaluate the energy performance of utilizing different external materials reaching sustainable targets. Buildings are responsible for 40 percent of energy consumption and energy performance of buildings is a key element to achieving the European Union's goals. The EU has pledged to cut its consumption by 20 percent by 2020. The main objective of this research was to explore the suitability of BIM for sustainability analysis at the conceptual design process. The procedure included analysis and discussion of the results for the lowest energy performance of materials. It was shown that changing the building envelope had a significant effect on the annual energy performance of the case building. The limitations of the study were the limitations in the software. For further research, the paper finds it expedient to perform an even more detailed simulation analysis on the building design with other energy supply systems. The value of the paper is to highlight the utilization of BIM to evaluate the material solutions to reach sustainable construction in the future, focusing on the need for lowering the energy consumption of tomorrows buildings.

NOTES

Application of Recycling Graphs for the Optimisation of the Recyclability in Building Information Modelling

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This publication discusses the application of RecyclingGraphs and ConnectionMatrixes in Building Information Modelling (BIM) for the assessment of the ability of structures to be decomposed and their components to be recycled. The assessment of recyclability of designed building parts is a data-rich task which requires expert knowledge and detailed analysis on a small scale, if complete recycling of the material content is desired. Today often only the main content of buildings, such as concrete and steel structures, are recaptured, while components of smaller quantities are lost or in the worst case, if they cannot be separated, lead to deterioration of the main material flows. BIM models will be connected to relevant databases and used in future to support the optimization of building parts for complete recycling through assisted design or even in automated analysis runs and workflows. Structural compositions are described by RecyclingGraphs and ConnectionMatrixes, which's components represent on the one hand material elements and on the other hand the connections between them. Materials are classified in terms of various characteristics, such as their recyclability, their ability to be incinerated and the harmfulness of their deposition. The connections are evaluated regarding their ability to be disassembled and the compatibility of the materials connected. The structures are translated into ConnectionMatrixes and the aspects of the evaluation are assessed individually and in combination. The translation of BIM models of four wall structures into RecyclingGraphs and ConnectionMatrix representations is analysed and potentials of such representations in new BIM-based workflows are discussed.

NOTES

Process model for BIM-based MEP design

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Planning quality is a key aspect for the development of sustainable buildings. This particularly applies to mechanical, electrical and plumbing (MEP) systems, which have a high impact on the building performance. The design of these systems considerably affects construction and operational costs. Moreover, it has a substantial impact on the consumption of resources such as energy or water and also on the building quality in terms of user satisfaction. Building information modeling (BIM) is a method capable of substantially improving the quality of MEP design. This requires adequate component models as well as processes describing the proper use of these models in a BIM project. This paper presents a Business Process Model and Notation (BPMN) model which describes the required interactions between project stakeholders during the design phase of a geothermal heat pump system. It describes the roles, tasks and responsibilities of the involved stakeholders and outlines which kind of information is required from whom at which point of time. The specific activities of the stakeholders are linked by information flows. In addition to the process model, a set of parameters describing a heat pump is presented. The parameters can be used as attributes in a BIM model. Each parameter is assigned to the design phase in which it is needed for the first time. This establishes a link between the attributes in the BIM model and the process model. Both, the process model and the parameter set were evaluated by MEP experts.

NOTES

Criteria catalogue and analysis model to manage complexity in prefabricated timber construction

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Prefabricated timber construction often comes with demanding planning processes and uncertainties due to higher complexity. Hence, a great potential to optimize design, construction, and economic efficiency is not put to use. In the future, the challenge will be to have project management that is able to handle complexity. The criteria catalogue and the analysis model, developed in my doctoral thesis at TU Munich, are a first step towards the systematic and typological structuring of prefabricated timber construction in terms of complexity. The criteria catalogue makes it possible to describe and record functional and technical specifications as well as the aspects of the design and construction process and implementation, in terms of less or greater complexity. The project-specific system presentation in the analysis model is the basis for a common understanding and a transparent and target-oriented exchange of information among different disciplines, including the client. The application of the model in practice is described by means of a case study. The outlook of this paper describes how the developed analysis model provides a new approach in order to support planning security in Building Information Modeling (BIM).

NOTES

Switching to a holistic perspective on semantic component models in building automation – tapping the full potential of automated design approaches

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Building automation systems are vital for reducing both energy consumption and carbon footprint of modern buildings. However, the engineering of such building systems is becoming increasingly complex, such that automating the engineering tasks is inevitable. Therefore, semantic component models of high quality and high expressiveness are required. But, as of today, existing models suffer from focusing on isolated aspects, high effort for component model specification, and low expressiveness in terms of the provided model structures. To close this gap, this paper proposes to adapt a holistic approach for modelling components. Firstly, we investigate different dimensions of component aspects and their interrelations and secondly, we develop BA-GSem, a graph-based semantic component model for building automation. Using a case study of a multi-variant room control unit, we illustrate that the correctness of system design results can be determined more precisely when using the detailed semantic model BA-GSem. The results offer a suitable foundation for improving the quality of automated design approaches for building automation, thus facilitating the creation of modern and sustainable buildings.

NOTES

CITIES 2

Net Zero Cities & Neighborhoods

Chair: Karen Allacker
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Transition Towards
a Net Zero Carbon
Built Environment

2 DEGREES – understanding the contribution of cities to a carbon neutral society

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Climate change is understood to be a factual situation to deal with and the world community has agreed with the Paris agreement of 2015 to limiting global warming to 2 °C above the pre-industrial state. Cities and urban areas are at the core of anthropogenic climate emissions. So far, however, cities are not generally recognized as major action fields for a climate neutral society. Yet, individual examples of cities with a strong climate neutral agenda prove the overall societal and economic advantage of their actions. This study analyses 15 European cities to understand the influence and potentials, local actions and political activities as well as targets that cities can take and define to mitigate climate change and contribute to the global 2-degree goal. The empirical evaluation of the cities was conducted in 2017, using the science-based targets approach on public buildings as initial pilot. The study identifies critical internal and external success factors for effective climate engagements, particularly from the 1/3 of the cities whose strategies comply with the 2-degrees target. Criteria and levers are derived that help cities transform into low carbon communities. From that, a framework model and operational guidance are developed, binging cities in the position to develop their individual path towards the 2-degree goal. The results of the study are demonstrated by the case of the Swedish community of Växjö, showcasing how the early and broad adoption of low carbon policies and actions results in overall economic growth and prosperity as a ‘green community’.

NOTES

On net zero GHG emission targets for climate protection in cities: More questions than answers?

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Two separate, but interacting, global agendas are now leading to new, additional requirements for the future development of cities: The UN Agenda 2030, putting cities at the heart of sustainable urban development with its Sustainable Development Goal (SDG) 11, and the Paris Agreement COP21 adopting the 1.5 °C target as a basis for global emissions reductions. Regulators and researchers have widely recognized the necessity to put cities, as an important object of assessment, and city authorities, as an important actor group, at the core of climate mitigation efforts. For cities themselves this topic becomes a factor of competition among peers. In their pursuit of a low carbon future, however, they are confronted with a number of theoretical and practical questions regarding target setting and subsequent planning for mitigation. As a contribution to the current discussion, the paper initially clarifies on which principles the allocation and accounting of city-related greenhouse gas (GHG) emissions are typically based. A good understanding of the GHG sources and reduction potentials is essential for defining feasible targets and designing efficacious reduction strategies. Built on this, the paper then presents how climate targets are defined at city level and analyses the methodological considerations that arise in the case of target-setting approaches involving bringing the emissions balance to zero. Although first definitions of “net zero emission” concepts on an urban scale can be found in literature, their precise meaning and applicability still remain vague, with unclear system boundaries, calculation and assessment rules. This paper provides a definition framework for clarifying such concepts.

NOTES

Visualisation of KPIs in zero emission neighbourhoods for improved stakeholder participation using Virtual Reality

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This paper addresses the role of virtual reality in addressing the specific challenge of the increasing complexity and decreasing usability when dealing with the level of detail required to model a zero emission neighbourhood (ZEN). In such neighbourhoods, there is a need to handle both ‘top down’ neighbourhood level data with ‘bottom up’ building and material level data. This can quickly become overwhelming particularly when dealing with non expert users such as planners, architects, researchers and citizens who play a key part in the design process of future ZENs. Visualisation is an invaluable means to communicate complex data in an interactive way that makes it easier for diverse stakeholders to engage in decision making early and throughout the design process. The main purpose of this work has been to make ZEN key performance indicators (KPIs) more easily comprehensible to a diverse set of stakeholders who need to be involved in the early design phase. The paper investigates how existing extended reality (XR) technologies, such as virtual reality, can be integrated with an existing dynamic LCA method in order to provide visualise feedback on KPIs in early phase design of sustainable neighbourhoods. This existing method provides a dynamic link between the REVIT Bim and the ZEB Tool using a Dynamo plugin. The results presented in this paper demonstrate how virtual reality can help to improve stakeholder participation in the early design phase and more easily integrate science-based knowledge on GHG emissions and other KPIs into the further development of the user-centered architectural and urban ZEN toolbox for the design and planning, operation and monitoring of ZENs.

NOTES

Crafting local climate action plans: An action prioritisation framework using multi-criteria decision analysis

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The COP21 target to keep global warming to well below 2 (or 1.5) degrees Celsius cannot be met without massive transformation in cities. A major challenge on the road to nearly greenhouse gas (GHG) emissions-neutral cities is the successful development of a climate action plan (CAP) by the local authority, sometimes within the framework of its participation to different initiatives (e.g. the Global Covenant of Mayors). While the identification of the best actions for reaching their long-term GHG emission reduction target constitutes a common decision-making problem for local authorities, it is also an intricate one: conflicting and incommensurable aspects such as environmental, economic, social and technical issues, as well as conflicting stakeholder interests should be dealt with simultaneously when actions have to be programmed. Multi-Criteria Decision Analysis (MCDA) methods are well-known to cope with these complexities and have already been used for decades in several fields. However, they have not been systematically used within the context of local CAPs. The methodologies which are normally implemented to support the prioritisation of actions wholly or to a great extent rely on economic analyses and do not capture the potential co-impacts. In this context, this paper proposes a general participatory framework for guiding collaborative prioritisation of actions as a methodology to help local authorities with the development of more sustainable CAPs, while using MCDA. Finally, advantages, limitations and further steps in research regarding the proposed framework are discussed.

NOTES

A systematic review of the international assessment systems for urban sustainability

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Planning and managing the rapidly growing cities in a manner that delivers a balanced solution for their environmental, social and economic long-term development constitutes one of the grand challenges of societies. In the urban planning field, several sustainability assessment systems emerged to guide the planning process towards these goals. After two decades of existence, there is a need to further analyze the lessons learned from the application of these systems and discuss the pathways towards more sustainable societies. This paper provides a literature review of the most widely used urban sustainability assessment systems: BREEAM Communities, LEED Neighborhoods, CASBEE Urban Development, Green Star Communities, and DGNB Urban Districts. Here, we analyzed 124 publications on the topic published between 2015-2018, using the selected assessment systems as keywords. This study revealed that there is a need for context customization of global targets into local actionable measures; involvement of regulatory bodies to ensure the successful application of such systems; and, consideration of socioeconomic factors as the assessment is still very focused on the environmental impact. This study provides insights for practitioners and researchers on the existing systems to assess urban sustainability and pathways for future research.

NOTES

Optimization-based planning of local energy systems - bridging the research-practice gap

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Optimization-based planning of local energy systems – though increasingly mature from a methodological perspective – is not commonly applied in practice. This paper synthesizes learnings from 4 case studies – focused on 4 different sites – in which optimization-based methodologies have been applied to the planning of local energy systems. The aim is to generate insights to facilitate the more effective application of optimization-based methodologies to local energy systems planning in practice. The results indicate that an intensively iterative methodology is critical not only as a basis for adapting the analysis based on stakeholder input, but also to facilitate learning on the part of stakeholders with regard to the value and limitations of the approach and the results. With regard to optimization methodologies, in particular temporal decomposition methodologies are identified as critical to preserving computational tractability in the optimization of complex technical systems, especially those featuring networks and those with many energy carriers or technology options. It is suggested that the methodological tailoring of an optimization model to a specific case and the calculation/visualization of key indicators can be largely automated, which could significantly accelerate future studies and reduce the knowledge required for their execution.

NOTES

PROCESSES 3

Building Information Modeling

Chair: Petra von Both
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Transition Towards
a Net Zero Carbon
Built Environment

6D BIM–Terminal: Missing Link for the design of CO_2-neutral buildings

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By 2050, the building sector has to become nearly CO2-neutral in order to achieve the climate protection targets of the Paris agreement. This tremendous challenge can only be met by taking the carbon neutrality into consideration from the early stages of the planning processes. The overall aim of the project is to provide a life cycle analysis throughout the entire planning and construction process of a building with a special focus on CO2-neutrality. To this end, Building Information Modeling (BIM) is an appropriate method. The project aims to close the gap between specialist consultants and BIM applications. For that, relevant data for cost estimation, scheduling construction planning and management or sustainable building aspects, shall be added automatically to BIM elements. This data exchange shall be carried out using open BIM and IFC interface according to ÖNORM A6241-2 via a central platform, the “6D BIM Terminal”. For more complex calculations the respective specialist planning software shall be made ready to exchange data in IFC format. Thus, life cycle analyses and life cycle cost assessment, as well as specifications for tender, can be performed on the basis of the building model. The expected results of the project are as follows:

- The prototype of a “6D BIM Terminal”
- Interface for existing specialist planning software to the 6D BIM Terminal
- Guidelines for planners
- List with the required properties (PSet’s)

NOTES

Step-by-step implementation of BIM-LCA: A case study analysis associating defined construction phases with their respective environmental impacts

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Building Information Modelling (BIM) supports construction processes by dealing with the variety and complexity of design in a single virtual model. The model may also be complemented by the static and energy performance of buildings. Facing the growing demand of sustainability strategies in the construction sector, the consideration of environmental information within the planning process influences the decision making of planners and stakeholders. Nevertheless, the life cycle assessment of buildings has been so far excluded in BIM, due to the high variety of accurate information and time required. In this paper, a systematic framework is presented and applied to a case study. BIM-LCA assists actors along the planning and designing phase, from the building conception as a whole, up to the elements' details and materials' definition. BIM and LCA intertwine in an application scheme of seven phases for integral planning and four levels of structural composition of a building. With respect to these, involved actors examine potential solutions through a tool which exploits alternative specifications in order to assess the environmental impacts. The goal of this paper is to demonstrate the application of a BIM-LCA model regarding decision making for reliable values of environmental impact in a given structural level of the building. The main findings of this framework are due to the multitude of actors and information orchestrated, namely to uncertainties which characterize the whole planning process and data handling. Through BIM-LCA, actors are assisted by ensuring flexibility of models and consistency of results throughout planning and designing.

NOTES

Connecting BIM and LCA: The Case Study of an Experimental Residential Building

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The aim of this paper is to present application of BIM models for the complex quality assessment and environmental analysis based on LCA. An experimental two storey building of TiCo Project representing a full scale part of a real multi-storey residential building has been used for this case study. The presented BIM model contains all relevant environmental characteristics and it will be used for environmental analysis, coordination, and operation (e.g. real-time data analysis from the sensors). Theoretical part covers development of the methodology for data transfer from BIM model to assessment scheme based on SBToolCZ, which is a national tool for building sustainability certification in the Czech Republic. Next step will be focused on describing connection of LCA and the BIM model databases and mapping data between them. Case study is focused on utilisation of BIM model with all relevant environmental characteristics for LCA analysis. All changes during construction phase and their impact on environmental analysis and LCA will be monitored and assessed.

NOTES

Towards a Life Cycle Sustainability Assessment method for the quantification and reduction of impacts of buildings life cycle

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The construction and building sectors are one of the highest consumers of resources and energy. Literature evidences the potentialities of the design phase towards the improvement of environmental, economic and social performance of buildings. Thus, the Life Cycle Sustainability Assessment (LCSA). approach is recognized as suitable method. It is based on the “triple bottom line” principle, to calculate environmental, economic, social impacts produced by buildings during its life cycle. The present paper aims to present a methodological framework based on an LCSA, used during design stages of buildings and integrated into a building’s design technology such as Building Information Modeling (BIM). A conceptual approach to conduct the data integration and a possible workflow to integrate the LCSA into BIM is proposed. The value of the present approach is the possibility to conduct quantitative environmental, economic and social assessment of buildings to guide designers to measure and predict the building’s performance.

NOTES

Digitalization of building LCA and international activities – in the context of German assessment system for sustainable building

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In this paper it is shown how digitalization and the establishment of an online infrastructure for life cycle assessment (LCA) in the context of the assessment system for sustainable building (BNB) by the German government forms starting point for an open international data network, as brought forward by the activities of InData ("International Open Data Network for Sustainable Building"). The establishment of the ILCD+EPD data format for EPD, the provision of interfaces, the development of workflow structures, guidelines and rules, which are openly published, internationally allow to access data from several databases. All these aspects are subject of the InData activities, and are decisive for a harmonization of LCA for sustainable building. With this concept of digitalization the propagation of the use of environmental product declarations (EPD) in building LCA was enhanced, and also new applications for using EPD data are offered, e.g. in BIM or other context.

NOTES

Computer-aided supporting tool for LCA evaluation of energy efficiency of the buildings – assessment method and case studies

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In the paper methods and the development of computer tool for the comprehensive life cycle assessment evaluation of the new or renovated buildings is presented. To support decision making process, computer tool was developed and consists of two computational units: the building description unit (BDU), and the life cycle assessment tool (Etool). BDU enables the determination of energy needs and final energy demand for the operation of EPBD systems. For the purpose of environment impact assessment, the life cycle inventory database is integrated into the BDU. Data are exported to LCA evaluation tool Etool that include two assessment modules: life cycle environmental impact module for mid-point and end-point assessment taking into account impact groups and damage factors from IMAPCT2002+ and ReCiPe methods and life cycle costs assessment module for evaluation of costs optimal values of energy efficiency measures for nearly zero energy buildings (nZEB). In the paper case studies are presented and discussed. The results show that energy use has dominant influence on buildings' environment impacts and that life cycle cost analysis show optimal thermal insulation thickness higher than required in current regulative.

NOTES

PRODUCTS 3

Low Carbon Building Materials

Chair: Adélaïde Feraille
Ecole des Ponts ParisTech, France

Transition Towards
a Net Zero Carbon
Built Environment

Integrating Earthen Building Materials and Methods into Mainstream Construction Using Environmental Performance Assessment and Building Policy

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Earthen building materials offer an environmentally sustainable alternative to conventional materials because they are locally available, minimally processed, and waste-free. However, they have not been comprehensively implemented because their technical data is highly variable, and they are not fully represented in building codes. To address these hurdles, this paper presents an environmental assessment and a policy repair review, including an environmental embodied impact analysis, and a discussion of the regulatory development required for earthen construction. The results of the environmental assessment show that earthen wall assemblies significantly reduce environmental impacts by 62-99% when compared with conventional assemblies such as timber frame and concrete blocks. Additionally, the policy discussion provides recommendations to overcoming materials variability and regulatory organizational collaboration. Overall, this paper highlights the importance of environmental and policy measures that could be used by policy makers and earthen building advocates in their endeavours to catalyse the representation of earthen building materials and methods in mainstream construction.

NOTES

Comparative analysis of an existing public building made from natural building materials and reference buildings designed from common building materials

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The paper examines a public building constructed of partially natural materials and two imagined buildings with the same geometry, using LCC and LCA methods, with self-developed software. The imagined buildings were designed using the building materials and building mechanical systems commonly used in Hungary which fulfil the relevant energetic requirements in 2010 and in 2019. As a sensitivity analysis the LCA performance of buildings was examined with residential building function. The paper introduces the environmental benefits that can be obtained with natural materials and with other tools in case of the examined building. Based on the results, design strategies can be phrase for environmentally conscious design of buildings with similar scale and function.

NOTES

Environmental impact of timber frame walls

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Timber frame walls are increasingly applied nowadays due to the stringent energy performance requirements of buildings. The aim of this study was to investigate the environmental impact of this type of construction. Therefore, a cradle to gate analysis was used. The study consists of three consecutive steps. First the impact of the constituting materials was studied. The results show e.g. that the environmental impact of LVL studs is significantly larger than that of SLS studs or I-joists. Based on these results on material level, in the second stage three timber frame walls were designed and evaluated. All walls had the same thermal performance. When comparing the results, it was noted that the environmental impact of the wall with the highest impact is three times larger than that of the wall with the lowest impact. Finally, the study also looked at the additional impact of tapes for guaranteeing the air tightness of timber frame constructions and at the impact of fasteners. It could be concluded that the impact of tapes is negligible when looking at the total impact of the wall (less than 1%). The fasteners on the other hand, lead to an increase in environmental impact with almost 20%.

NOTES

Linking construction timber carbon storage with land use and forestry management practices

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Consequential life cycle assessment was applied to forestry systems to evaluate the environmental balance of expanding forestry onto marginal agricultural land to supply more timber for the built environment, accounting for land use effects and product substitution. Forestry expansion to supply timber buildings could mitigate UK greenhouse gas (GHG) emissions by 2.4 Gg CO_2 eq. per ha of forest over 100 years, though net mitigation could be halved if beef production were displaced to Brazil. Forest thinning increases wood yields and percentage conversion of harvested wood to construction sawnwood, resulting in 5% greater net GHG mitigation compared with unthinned systems. Optimising the environmental sustainability of construction timber value chains in a circular, bio-based economy will require holistic accounting of land use (change), forestry management and complex flows of wood.

NOTES

Life cycle assessment of rammed earth made using alkaline activated industrial by-products

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Given increasing environmental concerns, lower energy building materials are being developed to reduce greenhouse gas emissions. The ancient technique rammed earth has been combined with modern industrial waste products to both reduce greenhouse gas emissions and reduce waste. The new rammed earth mixes have been developed using alkaline activation (sodium hydroxide) of industrial by-products: fly ash, ground granulated blast furnace slag and silica fume. This paper explores the 'cradle-to-gate' life cycle assessment, assessing global warming potential of these rammed earth materials, considering acquisition of raw or recycled materials and processing to final product of residential building envelope. These are compared with commonly used building envelope materials, brick veneer and cavity brickwork, and the more common rammed earth variety, cement-stabilised rammed earth. Results show that greenhouse gas emission savings can be made using these rammed earth mixes compared to the control building materials while achieving comparable or better material properties. Greenhouse gas emissions associated with the building envelope materials are reduced by more than half or one third when compared to cavity brickwork or brick veneer respectively. Following testing of the waste products in surplus in a given area, the same process could be followed for any geographic location.

NOTES

Butt-joint bonding of timber as a key technology for point-supported, biaxial load bearing flat slabs made of cross-laminated timber

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An efficient butt-joint bonding technology allows to build new types of timber structures. Under the name Timber Structures 3.0 a connection has been developed which connects timber elements with an end-grain to end-grain butt joint bonding. Therefore, it is now possible to build continuous, point supported flat slabs in cross laminated timber (CLT). Multiple CLT slabs are connected rigidly together and are only supported by columns. Some major challenges had to be solved in terms of bending strength of the glued connection and shear resistance of the part of the slab above the column. The research in both topics is successful and more projects were built in the last two years using this technology. Starting point was a real scale structure at ETH Zurich, followed by a working platform for a timber construction company and finally four three storey residential buildings. The research team is continuing to optimize the different elements of this innovative technology and will soon provide engineers with guidelines to design their own biaxial, point supported timber flat slabs.

NOTES

EDUCATION & ECONOMY 3

Actors, Markets & Business Models

Chair: Morten Birkved
Danish Building Research Institute,
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Transition Towards
a Net Zero Carbon
Built Environment

A survey of private landlords in Karlsruhe and their perception of deep energy retrofit

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Energy use related to buildings accounts for 35.3% of Germany's final energy consumption and nearly a third of greenhouse gas emissions. Thus, deep energy retrofit (DER) has a substantial role in the German energy efficiency strategy. Although many DER measures are economically viable, the pace of DER is below expectations and target value. A few studies investigated this phenomenon and conducted surveys mostly among owner-occupiers. However, 54% of the 40.5 million apartments in Germany are rented and a total of 15 million are let by private (not professional) landlords. Therefore, this investigation focuses on private landlords to find out what drives or constrains them to do deep energy retrofitting. A survey was conducted in a quarter of Karlsruhe, a large city in Germany with an above-average demand-driven real estate market. In this quarter, 83.2% or 8464 apartments are rented. 85 private landlords who own 10% of the rented residential buildings in the quarter responded and gave insight into their perception of DER. The results show that the buildings of the respondents originate from a construction period with large saving potential. Main strategies for investments in DERs are conservation of economic value of the property and the compliance with legal requirements. The main trigger is required maintenance. Despite an eco-friendly attitude, ecological criteria have a minor part in the DER decision. Finally, policy recommendations are made.

NOTES

New business models to support sustainable development: The case of energy-efficiency measures in buildings

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The German government has set ambitious climate-protection targets to limit global warming. The aim is to achieve an energy-efficient and almost climate-neutral building stock by 2050. This applies particularly to buildings, responsible for more than 20% of CO2 emissions. The aim is to reduce the primary energy demand of buildings by 80% by the end of 2050. Achiev-ing a nearly climate-neutral building stock requires targeted modernization measures that con-tribute to increasing energy efficiency. Barriers confronting the implementation of energy-effi-cient measures include lack of knowledge due to inadequate provision of information, lack of trust, and problems regarding financing possibilities. Therefore, solutions are needed for holistic concepts that make energy-efficient building and modernization more attractive. In addition to traditional business models (BM), measures that accelerate the implementation of energy-effi-ciency and BM that support the sustainable development of potential customers are sought. Ex-pert knowledge must be shared to close information gaps; savings guarantees must be considered to build trust, and finally, financing possibilities must be available to support implementing sus-tainable measures. The research focuses on a modification of BM under the aspect of increasing energy efficiency in buildings for customers. This approach considers specific functions, effects, and benefits of BM. The aim of this extension is to create a basis for systematizing existing BM on the one hand, and on the other, to extend the proposed methodology. Finally, the developed guide supports startups designing new BM.

NOTES

Social housing energy retrofitting: Business Model and supporting tools for public administration

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High refurbishment costs and uncertainty of the investment payback period account as the main reasons of low rate of energy retrofit of the European building stock. Moreover, assessing energy and economic benefits of energy retrofitting may result difficult e.g. due to the unpredictability of users' behaviour which may alter the effectiveness of energy refurbishment intervention. This paper deals with the question whether approaches exist, aimed at securing the profitability of energy retrofitting and at creating the market condition to incentivize the energy refurbishment on a large scale. The paper presents the operational tools, developed to support the public administrations along the entire retrofit process, and the Business Model (BM), structured to financially support the refurbishments by the energy cost savings. This tools and the BM has been developed for the South Tyrolean context, to promote the energy retrofit of the social housing building stock of the Autonomous Province of Bolzano. The results presented in this paper are part of the ongoing research project "KlimaKit", founded by operational programme European Fund for Regional Development of the Autonomous Province of Bolzano EFRD 2014-2020 – Investments in Growth and Employment.

NOTES

Effects of the tenants electricity law on energy system layout and landlord-tenant relationship in a multi-family building in Germany

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Multi-family buildings (MFB) accommodate 53% of the German apartment stock. Although PV-systems on single-family buildings are widely implemented, the PV potential on MFBs has barely been touched. Therefore, the German government introduced the Mieterstromgesetz, the tenants electricity law (TEL), in 2016. This law exempts electricity directly produced and consumed in a building from certain charges and taxes. Within the TEL framework, the landlord acts as the local electricity provider and can profit from selling electricity to the tenants and tenants can save electricity costs. This paper analyses the technoeconomic effects of the TEL on the energy system layout of a MFB in Germany. Furthermore, it gives implications on how the TEL affects the tenant-landlord relationship. In this analyses, a MILP model is used to maximize the net present value (NPV) and determines the optimal layout and dispatch of the energy system. The model can choose to invest in PV, CHP and a battery storage system. Additionally, one to six electric vehicles (EVs) are integrated into the model. The novelty of this paper is the model-based analysis of the German Mieterstromgesetz considering EVs. The results show that the combination of PV and CHP is the most profitable system layout with NPVs up to 31.9ke. An optimized charging strategy increases the self-consumption rate and the NPV substantially compared to a fast-charging-strategy. Thus, the TEL can create a symbiotic relationship between landlords and tenants.

NOTES

Implementing sustainable sourcing in construction: Results of a current analysis of the Austrian market

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Achieving the UN sustainable development goals, construction industry shows a great potential. Since 50% of the total resource consumption and 40% of the entire energy demand in the European Union are caused by the construction sector, procurement processes indicate a crucial starting point improving sustainable construction. Currently, organizations struggle with implementing sustainable procurement processes. Missing information on sustainability issues can be stated as an important problem in the sourcing procedure. Consequently, interactions of planning processes and sustainable procurement represent a fundamental topic. To investigate the current situation on procurement especially in Austria, an expert survey has been carried out. Therefore, a set of three central research questions has been elaborated that could be evaluated by a detailed survey. Based on the detection of relevant stakeholders, by means of a standardized online-questionnaire the implementation of life cycle-oriented sustainability issues has been surveyed. The contribution is going to illustrate the current situation of lifecycle-oriented planning, awarding and tendering of construction works in Austria. Furthermore, deductions were made based on the results of the survey, indicating action areas and presenting future potential of the application of building information modelling.

NOTES

Business-models of gravel, cement and concrete producers in Switzerland and their relevance for resource management and economic development on regional a scale

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Traditionally, gravel, cement and concrete producers focus on their role as material or resource suppliers. The higher the material turnover, the higher the economic success. Hence, the business-model conflicts with the societal goal of increased resource efficiency. Driven by stricter regulations, companies started to extend their business models with additional services in waste management and logistics. In the research project "Co-Evolution of Business Strategies in material and construction industries and public policies" the most relevant business-models of gravel, cement and concrete producers in Switzerland are identified based on case studies of ten different companies. The analysis reveals how these business-models differ with regards to value added, resource consumption and CO2-emissions. To analyse the relevance of the different business-models on regional scale, an assessment model is developed based on Material Flow Analysis. It is used to analyse the value chain of construction minerals in an alpine region and its effect on value added, resource consumption, waste generation and CO2-emissions. A comparison between the results of both analyses – companies scale versus regional scale – reveals how alternative business-models could affect resource management and economic development on a regional scale and which types of business-models accelerate or hinder the transition towards a sustainable built environment. The study will show, that it is essential to identify alternative business models in the building materials industry and understand their impacts on the use of primary and secondary resources. In this paper, we identify two business models, which, at first glance, seems identical as they produce and sell concrete and gravel, but show that the success of a business model highly depends on the source for raw-materials (gravel pit, river extraction or processing excavated materials with high gravel content), the possibility to landfill excavated material and the resulting effects on resource consumption.

NOTES

NATIONAL ISSUES 1

Strategies for Retrofitting the Building Stock

Chair: York Ostermeyer
Chalmers, Sweden

Possible strategies and obstacles in the pathway towards energy transition of residential building stocks in Switzerland

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The Swiss strategy for energy transition towards a sober energy world targets a 2000 W per capita society in 2050. This objective for an owner of a building stock is translated to a refurbishment of all existing residential buildings to near zero energy buildings, consuming less than 55 kWh/m² of primary energy for heating with a rhythm reducing the overall energy consumption by an average of 2.6 kWh/m² until 2050. The article analyses energy consumption of 10’000 residential buildings in Geneva Canton since 1994 and shows that the target of energy reduction at this rate has been achieved in the period 1994-2016, decreasing from 187 kWh/m² in 1996 to 134 kWh/m² in 2016. However, projections for the next 3 decades with the current refurbishment rhythm (0.8-1.5%) and the current real energy performance after deep refurbishment and energy upgrading, show that at this rate and with the performance gap not resolved, the final target will not be achieved. Based on the analysis of real energy consumption after refurbishment actions on statistically significant building samples and analysing the potential energy refurbishment actions of a 161 buildings stock, we have simulated possible and realistic ways to achieve the 2000 W society target.

NOTES

Fleet-based LCA applied to the building sector – Environmental and economic analysis of retrofit strategies

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CO_2 emissions need to be reduced by 40% in 2030 in Portugal as an intermediate target of the Paris Agreement. This challenging goal is expected to be achieved through incentive-based regulations and voluntary actions. This study improves the understanding of renovation strategies to reduce emissions caused by the built environment. A fleet-based Life Cycle Assessment (fb-LCA) is adapted and applied to the building sector. Fb-LCA integrates LCA and a fleet model to describe stocks and flows associated with a class of products over time. The method is tested for a neighbourhood in Lisbon, Portugal. The analysis compares 3 scenarios of dynamic renovation rates for the next 30 years: business as usual, a public economic incentive to renovate, and mandatory renovation. Different technology scenarios including bio-based ones, are compared. Among the latter, alternative material solutions, e.g. insulation cork boards, are emerging, providing carbon sequestration. Results highlight the environmental benefits of bio-based materials considering the temporal profile of renovation activity. Furthermore, the cost and sensitivity analysis help stakeholders to justify retrofit actions from an environmental and economic point of view. The adaptation of a fb-LCA approach proves to be an easy-to-use method to assess technology options and policy scenarios at a neighbourhood scale.

NOTES

Potential for energy savings in Czech residential building stock by application of a prefabricated mass retrofitting system

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Buildings are responsible for a significant share of EU energy consumption. To improve energy efficiency of the building stock, it is needed to significantly increase renovation rates. To overcome actual barriers related to this problem, such as partial and non-systematic renovations, lasting unrest during renovation or time-consuming wet processes, an industrialized construction system using prefabricated modular elements seems to be a possible way. Such system for mass energy retrofitting of residential buildings in Central Europe was developed in H2020 project MORE-CONNECT. The work presented in this article aimed to roughly estimate potential yearly energy savings by applying this new modular retrofitting system on one typology segment of the Czech residential building stock: non-renovated multifamily residential buildings built between 1946 and 1960 with total gross floor area covering over 7 million square meters. The main objective of the research presented in this paper was to make a hypothetic rough estimation of potential yearly energy savings by applying the new modular retrofitting system on a target typology of the Czech residential building stock. According to the calculations, application of proposed retrofitting system on the chosen building type would reduce the total energy consumption in Czech residential buildings by 2.9 % and by 1.8 % compared to energy consumption in all Czech buildings.

NOTES

ENERFUND - Identifying and rating deep renovation opportunities

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European Directive (EU) 2018/844 amending Directives 2010/31/EU (EPBD) and 2012/27/EU (EED) aims at decarbonizing the European building stock. Energy efficiency measures and renewable energy use play an important role, especially regarding retrofit of existing buildings. Identification of retrofit opportunities and aggregation of projects to benefit from economy of scale are a precondition for the implementation of large-scale renovation projects. The ENERFUND project, funded by the HORIZON 2020 programme, provides data from Energy Performance Certificates according to EPBD publicly available in the form of a map and combines them with other geo-referenced data and general information to allow for the rating of deep renovation and carbon reduction opportunities. In this way, the tool assists in identifying retrofit opportunities and aggregation of projects for financing. It also assists in supply-side energy spatial planning, because it shows where energy consumption is likely to decrease due to economic renovation potentials. This contribution shows an overview of data available for thirteen European Member States. Data sources and differences regarding the type of data are explained, and challenges such as data quality issues and data protection concerns are discussed. It is demonstrated that the ENERFUND tool certainly assists in decarbonizing the European building stock, although some improvements are still necessary.

NOTES

Defining a framework to apply retrofitting optimisation models for long-term and step-by-step renovation approaches

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The recast of Energy Performance of Buildings Directive (EPBD) 2018/844/EU introduced in the article 19a the possibility of building renovation passports which provide a long-term and step-by-step deep renovation roadmap for a specific building. Preliminary results showed that optimisation models for deep renovation of existing building almost exclusively optimise single stage retrofitting. Different from the single stage approach, in the step-by-step approach the retrofitting measures are not performed at the same time. In the present study, we aim to understand how the methodological approach of optimisation models for single stage retrofitting can be adapted to a step-by-step renovation concept. For this, first, the existing optimisation models were compared in terms of integration with external tools for energy demand calculation, definition of the renovation measures, objective function, and the question to which extent they consider long-term dynamic aspects of step-wise retrofitting optimisation over several years or even decades. Second, after identifying possible obstacles for adapting existing optimisation approaches towards step-by-step renovation, a framework for a step by step renovation optimisation model was outlined. The framework defines how the single stage retrofitting measures could be broken down in different renovation steps over a period of several years or even decades and which criteria should determine the time-wise prioritisation of the retrofitting measures. With this approach, we prepare the ground for the development of innovative tools, supporting the provision of individual renovation roadmaps. Next steps of the present study are testing and improving the outlined optimisation approach, as well as, extending the results to a building stock scale. By that, we aim to develop a method for analysing possible impacts of step-by-step renovation measures on achieving building stock's decarbonisation targets.

NOTES

Towards a model for circular renovation of the existing building stock: a preliminary study on the potential for CO_2 reduction of bio-based insulation materials

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In the context of strategies for mitigating the impacts of climate change within European cities, increasing attention is being paid worldwide to the use of urban green infrastructure which, in addition to the potential for improving the quality of the urban environment, allow significant amounts of CO_2 to be removed from the air. However, considering the peculiarities of the dense European cities, most of the available surfaces in urban areas are the perimeter walls of buildings of considerable age that are in urgent need of measures to upgrade their energy performance. Based on this premise, this paper investigates the potential for CO_2 storage resulting from the application of energy retrofit solutions using biogenic insulating materials. Starting from the analysis of the demand for insulation materials necessary for the energy requalification of the residential existing building stock in 28 European countries, following the renovation target fixed by EU, the research analyses, through the adoption of a dynamic LCA approach, the environmental benefits of bio-based materials compared to traditional solutions. The use of these materials, especially if they are fast-growing - as the study shows - offers several advantages in terms of climate change mitigation by reducing the energy needs and CO_2 emissions of the existing building stock and increasing carbon storage capacity within cities. The results of this study are intended to provide a robust database on which to build a model of circular building renovation that takes into account the environmental long-term effects of measures for increasing energy efficiency of buildings.

NOTES

BUILDINGS 4

Low Carbon Construction

Chair: Annette Hafner
Ruhr University Bochum, Germany

Transition Towards
a Net Zero Carbon
Built Environment

Improving Construction Efficiency with Digital Fabrication. An Environmental Insight

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This paper presents a case study of environmental evaluation of innovative shell-nexorade hybrid timber construction system designed within fabrication-aware technic and fabricated using robotic construction technology. The life cycle assessment of construction phase of the system has been performed; a sensitivity study of the robotic system's outlay has been effectuated. The results show that the contribution of robotic construction system to the overall result is fairly significant and, in some figures, can even exceed the material's one.

NOTES

A holistic approach for industrializing timber construction

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Many strategies have been investigated seeking for efficiency in construction sector, since it has been pointed out as the largest consumer of raw materials worldwide and responsible of about 1/3 of the global CO_2 emissions. While operational carbon has been strongly reduced due to building regulations, embodied carbon is becoming dominating. Resources and processes involved from material extraction to building erection should be carefully optimized aiming to reduce the emissions from the cradle to service. New advancements in timber engineering have shown the capabilities of this renewable and CO_2 neutral material in multi-storey buildings. Since their erection is based on prefabrication, an accurate construction management is eased where variations and waste are sensible to be minimized. Through this paper, the factors constraining the use of wood as main material for multi-storey buildings will be explored and the potential benefits of using Lean Construction principles in the timber industry are highlighted aiming to achieve a standardized workflow from design to execution. Hence, a holistic approach towards industrialization is proposed from an integrated BIM model, through an optimized supply chain of off-site production, and to a precise aligned scheduled on-site assembly.

NOTES

Massive timber building vs. conventional masonry building. A comparative life cycle assessment of an Italian case study

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This work aims to investigate the environmental friendliness of building materials, and in particular the benefit of using biogenic products as replacement of conventional materials. The sustainability of wood as a construction material is a complex issue since the environmental impacts are strongly related to forest management, service life and, finally, to end-of-life scenarios and waste treatment processes. In this study, a Life Cycle Assessment (LCA) comparison was carried out between a semi-detached house out of cross-laminated timber (CLT) and a conventional building with similar geometric characteristics and equal thermal performance (U-value), out of light-clay bricks with a reinforced concrete structure. Particularly, the environmental impacts from raw materials supply, transportation and product processing (cradle to gate) were investigated and the Recipe mid-point method was adopted for the impact assessment to compare the environmental burdens of the two equivalent buildings. The positive environmental values resulted in the massive timber building are mainly connected to the replacement of the reinforced concrete mass used in the structure. The outcome, in terms of global warming potential, show that the use of wood as a building material instead of conventional materials results in a reduction of greenhouse gas emissions of roughly 25%. This material replacement, if extended on a large scale, could give a valid contribution on achieving the community goals of reducing emissions from the construction sector.

NOTES

Comparative LCA of a concrete and steel apartment building and a cross laminated timber apartment building

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In this paper an LCA is carried out on a concrete and steel apartment building and a cross laminated timber apartment building to compare the greenhouse gas (GHG) emissions from the two buildings. The buildings are built by Veidekke Entreprenør AS and they are almost identical except for the structural system and the number of floors. They are connected by an underground car park of reinforced concrete. The product stage (A1-A3), transport to the building site (A4) and operational energy use (B6) is examined. Results show that the cross laminated timber building has 25% lower GHG emission compared to the concrete and steel building when looking at the production stage, and 13% lower emissions when looking at all stages. The results also show that the material that contributes to the most GHG emissions is reinforced concrete, and that the underground car park has a high GHG emission because it consists of a lot of concrete. What is new in this paper is that there are two real buildings close together that can be compared to find out which has the lowest environmental impact. The paper is valuable for people designing environmentally friendly buildings with a low carbon footprint.

NOTES

Potential of contemporary earth architecture for low impact building in Belgium

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Earth architecture during the 21st century has resurfaced worldwide as a sustainable, low environmental impact material with expressive aesthetics and textures. Contemporary projects attempt to modernize the traditional techniques of building with earth in order to adapt them to today's projecting needs. Examples of such techniques are unfired earth bricks and rammed earth. In order to disclosure and highlight future possibilities of earth construction, advantages and limitations of earth construction in a contemporary Western-European context are reviewed, based on a literature study. Because it is hard to generalise due to the case-specific context and constraints, a case study analysis of earth utilization in two contemporary architectural projects is presented. To assess if these contemporary projects meet the environmental benefits associated with traditional earth construction, several environmental aspects are taken into account, such as material sourcing proximity, production process, reuse potential, etc. Based on the literature study, case study analysis and current evolutions in neighbouring countries, promising applications for future development of earth construction for low impact building in Belgium are highlighted.

NOTES

leanWOOD – towards resilient design and building processes

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With the introduction of the concept of resilience in the discourse of building design, design and building processes have to react to complex challenges presented by the extension of the perspective from physical building structure to living space. Instead of conserving effort, resilience demands integrated and argumentative processes and interdisciplinary cooperation. Forerunners in industrialized timber construction have long-standing experience and are starting points for new advanced design processes. The international leanWOOD project (2014-2017) aimed at outlining the requirements for future timber building planning processes to put them on a broader base and thus contribute to advanced processes in the future. To achieve resilience in building design, rigid and sequential process-chains must turn into flexible, argumentative process approaches. The paper illustrates the key elements for resilience-oriented design processes, discusses procurement and cooperation models, identifies pitfalls in current development and outlines the impact on resilient buildings. Finally, the outlook shows the potential of the implementation of BIM to this change towards resilient design and building processes.

NOTES

BUILDING DESIGN 4

Special Session End-of-Life Information

Chair: Wolfram Trinius
Ingenieurbüro Trinius GmbH, Germany

Transition Towards
a Net Zero Carbon
Built Environment

The practical use of module D in a building case study: assumptions, limitations and methodological issues

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According to the EN 15804 and EN 15978, a material or building life cycle consists of three major life cycle stages or so-called modules: Production and Construction (module A), Use (module B) and End-of-life (module C). Potential benefits and loads occurring beyond the building's life cycle as a result of recycling, reuse or energy recovery can be declared in an additional module D. As part of the upcoming amendment of the EN 15804 a formula was developed to facilitate the calculation of module D. This paper provides a critical discussion on the practical use of module D. First of all, the development of the formula revealed specific methodological issues, such as the unequal approach to closed and open loop recycling. Secondly, the consideration of module D in a Belgian building LCA case study provided insights in the different methodological choices, interpretations, and assumptions related to the calculation of module D. This concerns for example the calculation of net output flows of secondary materials, modelling of avoided primary production, definition of the point of functional equivalence, efficiency of incineration, etc. Aspects that are not clearly specified in the standard and therefore can be open to interpretation are illustrated with concrete examples from the building case study. Where possible, recommendations for a harmonized approach are made. In any way, the results from the case study analysis reveal that the methodological choices can have a significant effect on the results and that module D results should therefore be considered with care.

NOTES

Reconciling recycling at production stage and end of life stage in EN 15804: the case of metal construction products

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With the current political focus on resource efficiency and circular economy, the consideration of all recycling aspects in LCA is becoming increasingly important, especially for metal products which are already recycled for many decades. For such purpose, a complementary module, the so-called Module D, was developed in EN15804 to report the additional environmental aspects resulting from the end of life stage. The metal industry and many LCA practitioners have already used this module for many years. This module D as well as module C (end of life stage) are now mandatory in the agreed amendments to EN15804 that will be published in 2019. This paper explains the methodology used by the metal industry to calculate modules A, C & D for a metal sheet in the light of the equation to be included in the amended EN15804. The calculation is then applied to 3 theoretical examples. Finally, the paper provides guidance on using LCI datasets developed by the steel and aluminium sectors. The collaborating authors have prepared this paper under the auspices of the METALS FOR BUILDINGS alliance that has been established to ensure reliable information on the sustainability of metal building products is available to policy makers and practitioners in sustainability appraisal policies and systems.

NOTES

Declaration of the End-of-Life for Building Products

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Increasing energy efficiency and related environmental performance improvements of buildings direct stronger focus on the environmental impacts related to building products. For product manufacturers, the provision of information in terms of environmental product declarations (EPD) is a market tool of continuously rising importance. The increasing concern related to environmental and resource efficiency promotes the concept of circular economy, especially reuse and recycling procedures at the end-of-life (EoL) play an increasing role in decision making. Manufacturers are often unsure how to include late life cycle stages in their product declarations. At the same time users of the information are confused as to what provided information really refers to. The concept of modular EoL-declarations with clearly identified and described scenarios aims to facilitate the inclusion of the full life cycle in EPDs based on reliable and realistic data. At the same time EoL-declarations promote the communication between the production and EoL-actors and enhance understanding of provided information, including judgements on potential demand and procedures for adaptation of provided information.

NOTES

The Reporting of End of Life and Module D Data and Scenarios in EPD for Building level Life Cycle Assessment

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This paper identifies the need for Environmental Product Declarations (EPD) to provide End of Life (EoL) and Module D data for products for use in building level Life Cycle Assessment (LCA). Although the provision of data for EN 15804 Modules A4-D is not currently mandatory for EPD, many currently report some or all of these. This paper provides an overview of the existing reporting of the end of life (Modules C1-4) and Module D and the types of scenarios used in European EPD. Using examples from existing EPD for two product groups, this paper examines the variation in approaches to scenarios for Module C and D. It explores the difficulties brought by this variation and discusses benefits from using default national scenarios at end of life, but additionally considers the advantages of providing alternative EoL scenarios for products to promote the circular economy.

NOTES

Modelling options for module C and D: Experiences from 50 EPD for wood-based products in Norway

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Introducing the EN 15804 standard as a core PCR for building products included several specifications for LCA end-of-life and benefits beyond the life cycle. There are however several issues that the LCA practitioner need to interpret during the modelling and generic data needs to be adjusted for being representative and in accordance to EN 15804.The modelling of module C and D has been developed in three different stages during making 50 EPDs over several years. First the model was mainly based on generic data from ELCD database. The second was a statistics-based mix of different treatment options, where the substation of other energy sources in module D was a representative mix of district heating mix, electricity, coal in cement production, wood chips in wood industry and ELCD for exported waste. The third represented a 100 % scenario for energy recovery in municipal waste incineration and substituting statistical mix of electricity and district heating. The objective of the study is to present the experiences from developing and implementing the module C and D in the 50 EPD that where verified at EPD-Norway and discuss in relation to requirements in standards and usability in a building context.

NOTES

A typology of digital building technologies: Implications for policy and industry

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Digitalization and digital technologies are buzzwords in today's building industry. Because of their promising opportunities to improve (among others) the sustainability footprint of the built environment, they have emerged as an important topic for policymakers, managers, and researchers. Yet, the debate is dominated by references to Building Information Modelling (BIM) and to the success of digital businesses in other industries; it thereby fails to consider other promising digital building technologies and ignores that—in the building industry—many digital technologies require alignment with buildings' physical components. For these reasons, it is unclear how the implications of digital transformation of the building industry for policy and business. In this paper, we develop a typology of digital building technologies, and categorize and assess 29 important building technologies. The substantive differences among different types of building technologies provide valuable insights into how digital building technologies affect the functioning, structure, and competition in the building industry and where digital building technologies offer opportunities to remedy the industry's sustainability footprint. Based on our findings, we offer recommendations to policy makers, companies, and researchers interested in digital building technologies.

NOTES

Life Cycle Assessment applied to construction and demolition waste treatment: proposal of a Brazilian scenario

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Important amounts of construction and demolition wastes (CDW) are currently generated in several countries. Considering the correct management of this kind of residue, and the search for its noblest use, several studies have focused on the environmental potential impacts from CDW management. Life Cycle Assessment (LCA) is often used to investigate the potential environmental impacts over the life cycle of a product, thus becoming an important tool to support decision-making. CDW recycling process produces coarse, fine and mix aggregate as outputs, characterizing a multifunctional process. But, how CDW's LCA should be run, considering a circular and more sustainable built environment? Thus, the objective of this work is to explore the basic premises in proposing a product system for the CDW recycling process in Brazil. For this, data available in the literature on the recycling process in Brazil and in other countries support the definition of the product system. The complexity of this management option is explored, considering how the use of the recycled materials interfere in the scope, objective, unit function and other modelling choices, as well as reliability of CDW studies. Finally, the datasets provided by Ecoinvent are examined in order to promote debate on data adaptation, followed by remarks on the most appropriate choices on allocation in the CDW LCA. The cut-off system modelling associated with the new perspective on the avoided burden approach is concluded by the authors to be the most suitable for this waste recycling multifunctional processes. Understanding system models is key. When no inventory adaptation is intended, available inventory datasets are more advisable to be used when performing end of life scenarios only, once burdens differ according to countries management scenarios, as well as life cycle inventory approaches.

NOTES

CITIES 3

Special Session Urban Green Infrastructure and Re-naturing Cities

Chair: Vera Enzi and Susanne Formanek
GRÜNSTATTGRAU GmbH, Austria

Integration of multiple methodologies to evaluate effects of Nature Based Solutions on urban climate mitigation and adaptation

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Nature Based Solutions contribute both to mitigate and to adapt the cities to the impacts caused by climate change at urban level. Several methods and tools exist for assessing each strategy. However, none of them allow to cover the whole steps included from analysing climate trends that could affect the cities, to NBS effectiveness. This paper reviews and classifies existing methods according to the relevant steps of climate resilience and NBS effectiveness, and a combination of various of those methods is presented in a practical case study. Bottom-up city energy, economic and environmental modelling have been performed to understand mitigation effects of NBS implementation at building and neighbourhood level. Urban hydrodynamics and fluid dynamics have been modelled too, allowing the estimation of the adaptation effectiveness of the NBS scenarios in flooding and temperatures reduction respectively. Moreover, city vulnerability and urban risks, considering IPCC scenarios regarding climate trends, have been assessed to understand the areas of the city more vulnerable to the impact of climate change. Results show that strategies and climate hazards has been worked in a split way and there is a need to connect better mitigation and adaptation information to facilitate the municipalities taking robust decisions regarding the NBS implementation.

NOTES

Fostering the implementation of green solutions through a Living Lab approach – experiences from the LiLa4Green project

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For dealing with participatory aspects in urban planning, the method of Living Labs (LL) currently turns out to be a most popular and promising approach. In our project LiLa4Green we apply such a Living Lab in the City of Vienna for implementing green solutions in densely built settlement areas characterised by heterogenous ownership and building structures, few public open space and green areas and the dominance of car traffic. In the first year, the potential analysis of the status-quo situation was completed, and the Living Lab had been established. First lessons from the now successfully running LL process can be drawn. The analysis and the initiated process revealed deficits, but also clear potentials for the implementation of green measures which could significantly improve the current situation. So far, the Living Lab process made clear that the people are generally affected and therefore interested in the topic of heat stress and greening the city, but it does not seem to have top priority for them. Although many people could be addressed and involved in discussions, only a small group of people were willing to take part in the first workshop. Confronted with such challenges the strategy for the next stage was to bring the LL process closer to the people's everyday life context and to extend the participatory methods. Innovative ICT-solutions which help to intuitively visualize and understand green solutions and their effects were tested, as well as a co-decision process for the realization of a first intervention was offered. The higher participation rate in the second green lab indicates that this is a promising approach which will be continued in the further LL process.

NOTES

The Potential of Greenable Area in the Urban Building Stock

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In the context of establishing green infrastructure in cities, urban retrofit has presumably larger area potential than ground-based green. To support the large-scale advancement of urban green, the assessment of greenable potential plots in the building stock, both on horizontal and on vertical scale, provides first indispensable indications for decision-making. However, reliable and solid data to the state of the buildings is currently not available. The research study Urbane GmbA explored a new methodological approach, based on publicly available geo-data, and applied it at two study sites in high-density urban quarters in Vienna. The combination of a GIS-based analysis with digital and on-site photos allowed for the creation of a Level of Detail 2 (LOD2) 3D-model and subsequently the estimation of the green retrofit potential of roofs and facades. Comprehensive maps with the data of the 2D building footprints provide valuable information for planners, including building characteristics and greenable area potential. The approach proved to provide more comprehensive information including building characteristics fundamental to the planning and decision-making process. The achieved results are merged with an evaluation matrix generated for attributing available facade and roof greening systems. This allows for more focused decision support for the retrofit of the building stock towards more sustainable and resilient district development.

NOTES

Mapping of innovative governance models to overcome barriers for nature based urban regeneration

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The implementation of urban Nature Based Solutions (NBS) projects is deeply determined by the novelty of the concept. Its innovation is both an opportunity and a challenge: as a new concept, it generates uncertainty due to lack of technical and operational preparedness, but it also allows to deploy innovative approaches, new ways to address old problems and more inclusive practices. Nature4Cities project has systematically conceptualized the barriers and drivers on NBS projects implementation by a review of the state of the art. To see how these barriers can be overcome by governance strategies, different urban and environmental governance models have been mapped and characterized to assess their suitability for different NBS projects. Five clusters have been identified where models are grouped according to the involved actors, their position in the spectrum from high to low government involvement and their level of participation. This theorical model has been applied to real cases to check the incidence of the different clusters. Results show that urban and environmental governance is a map where the different models coexist in different degrees regarding some key axes such as level of innovation, polycentric vs. monocentric, involved sectors, level of participation and scale. Collaborative, multisector, polycentric and adaptive governance models address significant number of previously identified cross-domain barriers showing their suitability. The work presented in this paper can be the basis to define new institutional and governance arrangements that will foster multi-stakeholder involvement, citizens' engagement, leveraging both public and private funding of NBS in cities.

NOTES

Green Resilient City - A framework to integrate the Green and Open Space Factor and climate simulations into everyday planning to support a green and climate-sensitive landscape and urban development

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Continued urban growth, densification and the constantly increasing number of days with excessive heat provide challenging conditions for urban green infrastructure (UGI) and intensify the Urban Heat Island effect (UHI). Therefore, new approaches are required to improve the urban ecological function of buildings and to provide high-quality (urban) open spaces that affect the meso- and microclimate in a positive way. Based on the research project “Green Resilient City”, this paper shows how climate simulations can support landscape and urban planning and development. A proof of concept for a multiscale tool set for the evaluation, regulation, and optimization of green and climate-sensitive urban planning projects is the overall aim. The tool-set combines a Green and Open Space Factor, as an urban planning index and controlling instrument, as well as three climate simulation models on different scales in order to harmonize them: the GREENPASS® as an optimization instrument on parcel and neighborhood level, MUKLIMO_3 on neighborhood and city level and Cosmo-CLM as evaluation tools on mesoclimatic and regional level. Several advantages arise from the unprecedented combination of these four instruments: It transfers the use of climate models to the planning process, enables the testing and optimization of different UGIs with a focus on how they can influence the climatic performance of the proposed design of an urban development or retrofit project and serves as a scientific basis for urban planning decisions on a political level.

NOTES

PROCESSES 4

Data & Information in LCA

Chair:
Marcella Ruschi Mendes Saade
Université de Sherbrooke, Canada

Transition Towards
a Net Zero Carbon
Built Environment

Information management throughout the life cycle of buildings – Basics and new approaches such as blockchain

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Ensuring sustainability for real estate is subject - among other aspects - to building related information. This information needs to be stored and updated continuously throughout the life cycle of a building. A delivery to buyers, tenants, consultants or other actors must be possible at any time. However, in most cases transactions cause significant loss of information while the issues associated with the “building passport” approach remains unsolved to date. Considering the long service life of buildings, various questions arise: (1) How to support data generation and storage within the life cycle and how to encourage actors to compete? (2) How to assure a high data quality and how to store it over a long period of time? (3) How to assure that all data users can track down the data owners at any point of time to manage compliance and legal issues? (4) Are there any new business models or new scopes for designers or other service providers? Information needs of actors along the life cycle are analysed and new information technologies (e.g. blockchain) are discussed. A relation to Building Information Modeling (BIM) is shown. Potentials of enhancing existing approaches regarding documentation retracing and accessibility of building and life cycle related information by using new technologies and IT are discussed; benefits of using a blockchain based system is pointed out by referring to existing pilot projects and first examples. Solution approaches for building passports are shown.

NOTES

Context-dependent information space for construction information processes

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The planning and construction of buildings and structures is based on collaborative building information processes. The information supply of these processes is characterized by the exchange of heterogeneous domain-specific information. For the treatment of most problems in the construction industry, the information involved is rarely considered in isolation, but rather elements from different information models are linked with each other. The concept of the information space has established itself for the persistence of such linked information models. For sustainable building, the continuous use of existing information models or information spaces is indispensable. Various implementation approaches exist for information spaces in civil engineering. One approach that is currently in the initial phase of standardisation and will therefore spread further in the construction industry is the multimodel approach. For large construction projects or more complex buildings, multimodels become very large and often contain information that is unnecessary for the respective processing situation. This makes the handling of such multimodels cumbersome and slows down the acceptance. One approach to reducing multimodels is to adapt them to the information needs of the respective information process. Information processes are embedded in a task context that essentially determines the information requirements of the process. In order to anticipate such situational information needs, this paper presents a method to define context-adaptive multimodel templates based on a formalization of the context dependencies of the information requirements. These can be evaluated at the time of application towards situation-specific information requirements and form a basis for the creation of situational information spaces for the realization of a context-oriented information supply.

NOTES

A design integrated parametric tool for real-time Life Cycle Assessment – Bombyx project

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Life Cycle Assessment (LCA) has become a widely accepted method for environmental assessment of buildings, but is still not commonly applied in design practice. The biggest potential for optimization and reduction of GHG emissions lies in the early stages of the design process. Therefore, a design-integrated approach for LCA is needed. The goal of this paper is to describe the development of a parametric LCA tool for application in early design stages in the Swiss context. The envisioned users of the tool are primarily architecture and engineering students, but also practitioners. The integration of LCA throughout the design process is solved through a modular strategy. In the early stage, pre-defined components are selected to model a complete LCA. In the following design steps when more information is available, individual materials can be input with higher level of detail. The Bombyx tool is developed as a plugin for Grasshopper based on Rhinoceros3D and includes an SQL material and component database. Users are able to choose different materials and building systems and quickly modify the building's geometry while continuously receiving the calculated environmental impact in real-time. Visualization of the results, e.g. colour code indicate how the design performs in relation to a benchmark or optimization potential. The project is developed in open source to broaden the user and developer community and foster new ideas, designs and implementations in Bombyx.

NOTES

Sustainable building information modeling in the context of model-based integral planning

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Solving complex issues of energy-efficiency – at the building as well as urban level – requires a holistic, integrated approach. The energetic behavior of a system should not only be considered in individual processes or phases, such as operation. A holistic optimization should rather consider the explicit energy flows as well as the material fluxes including the associated gray energies over the entire system life cycle. The realization of such a holistic integral planning process implies an integrated planning-accompanying evaluation and optimization of the planned object. The early use of LCA tools and sustainable building assessment systems (SBA) provides an important basis for assessing planning decisions at a conceptual level for their impact on the entire lifecycle of a building and for ensuring good sustainability performance. In practice, however, it is currently evident that the non-standardized and inadequate connection of simulation and balancing tools (e.g. LCA) to BIM authoring tools and the resulting high time expenditure for data acquisition and LCA application counteracts with a targeted stronger penetration of the market. For realizing a consistent integral planning process – especially in early planning phases – an IFC-based interface is being developed for the connection of LCA tools to BIM models (data input) and the preparation and configuration of the LCA result data for the designated use in different SBA. In this contribution, from the interface specifications for different levels of granularity and concretization in the different planning phases that are developed by means of norm-based processes of model standardization in an underlying research project, parts regarding the early project stages will be presented.

NOTES

IBPSA Project 1 : BIM/GIS and Modelica framework for building and community energy system design and operation – ongoing developments, lessons learned and challenges

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IBPSA Project 1 develops and demonstrates an open-source BIM/GIS and Modelica Framework for building and community energy system design and operation. The project builds further on the completed project IEA EBC Annex 60 ”New generation computational tools for building and community energy systems based on the Modelica and Functional Mockup Interface standards.” This paper describes the motivation and approach of the project, and it provides an update about recent activities. These activities include development of a core Modelica library for building and community energy systems; development of BOPTEST, a virtual test bed to test advanced controllers such as MPC; development of GIS/BIM data model translators for Modelica; development of new workflows for improved productivity and quality assurance of urban-scale energy simulation; and development of DESTEST, a validation test for district energy models.

NOTES

PRODUCTS 4

Sustainable Construction Products I - EPD and Labels

Chair: Dimitra Ioannidou
ecoinvent, Switzerland

Transition Towards
a Net Zero Carbon
Built Environment

Environmental Product Declarations (EPDs) as a competitive parameter within sustainable buildings and building materials

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The demand for technical and verified documentation of buildings and building materials is growing, along with the increasing focus on sustainability in the built environment. However, despite a common wish to build sustainably, it is still found that EPDs and LCAs are not always similarly interpreted, leading to misunderstandings on how they should be used to quantify and verify sustainability along with being a competitive parameter when choosing materials.
To overcome this barrier this project seeks to discover:

1. How can EPDs be used as a competitive parameter within the sustainable built environment?
2. How can product specific EPDs, used as an input to building-level LCAs, help to quantify the concept of ‘circular economy’?
3. How do some countries seem to succeed in introducing EPDs to industry while others only succeed to a lesser extent?

By involving the Danish building-industry’s value-chain through qualitative interviews, workshops and reference groups, as well as by contacting EPD programme operators throughout Europe and USA, a mapping has been performed on the tendencies of how and to what extend EPDs are used to quantify and support material decision-making in buildings. Further, the drivers as to why EPDs are used in some countries is investigated along with suggestions on how to boost the development, use and integration of EPDs with the aim of quantifying and documenting sustainability in the built environment.

NOTES

Roles of the reference service life (RSL) of buildings and the RSL of building components in the environmental impacts of buildings

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The Life Cycle Assessment of a building is a complex analysis that also involves the use of the predicted Reference Service Life (RSL) of the building components and materials, as well as the predicted RSL of the whole building. The RSL values of individual materials and building components can be obtained from different sources and are not exactly comparable. In the present study, the influence of selected RLS values on an LCA assessment was evaluated. Three different RSL databases were used as the sources of the data to estimate the environmental impacts of selected building components (internal wooden door and external finishing coat). Two scenarios were presented. In the first scenario a building component can be reused in another building, while in the second scenario the reuse of the building component is not possible. The study showed that dependent on the selected RSL database, the results can differ by up to a factor of five. Therefore, it is very important to describe clearly the maintenance scenarios for a building in order to have a reliable comparison of the results of LCA assessments.

NOTES

Economic valuation of life cycle environmental impacts of construction products - A critical analysis

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The aim of this paper is to identify existing methods for economic valuation or monetisation of life cycle environmental impacts and to assess its applicability in the broad European context. Although environmental awareness is more and more important in several industrial sectors, including the construction sector, easy to understand data are still missing for professionals to assess and manage impacts related to the whole life cycle of a building. Life Cycle Assessment (LCA) is one of the most commonly accepted methodologies to calculate potential life cycle environmental impacts of a product or service. However, the results of such method, even when published in an Environmental Product Declaration, meant for business to business communication, are not always comparable or easily understandable by non-practitioners. Economic valuation or monetisation of LCA results is a weighting step that can make it easier for non-practitioners to use LCA results to support decision-making. From the several monetisation methods analysed, it is discussed the one that is most suitable for use when LCA results already exist. It is concluded that further work is needed to improve such weighting methods or develop a common one that can be representative at a broader geographical level (for instance, Europe-wide).

NOTES

VinylPlus® and the VinylPlus Product Label. Could the industry label be integrated into independent sustainability certification schemes?

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In building & construction (B&C), polymeric materials are being used for roofing and waterproofing membranes, coated fabrics ("textile architecture"), window profiles, electrical installation, flooring, pipes, etc. The most widely used plastic for such long-life applications in B&C is Vinyl (PVC). VinylPlus is the value chain's commitment for sustainable development. The voluntary commitment has a track record with publicly available progress reports, based on third party auditing and monitoring since 2001. More recently: After having substituted certain additives such as lead compounds, that had previously been used as stabilizers, and after abandoning mercury cell technology, VinylPlus is addressing further needs of the sustainability communities, e.g. by zooming in on additives and complementing standard LCA requirements. The VinylPlus voluntary commitment for sustainable development has been developing an additives sustainability footprint (ASF) and a set of criteria for its product label. The scope and the current status of those tools will be presented and examples be given in order to document the relevance of those efforts. The information given is intended to fuel the discussion on how can / to which extent should those value chain commitments be integrated into existing sustainability.

NOTES

PolyStyreneLoop – The circular economy in action

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For decades polystyrene (PS) foam is known as an efficient insulation material in the building and construction environment. At the end of its very long useful life, the waste remains a valuable material source for a variety of products. However, the flame retardant HBCD, which has been used since the 1960s until 2017, is considered a pollutant and millions of tons of PS foam waste can no longer be regularly recycled. PolyStyreneLoop is developing a solution with a physico-chemical recycling process, based on the CreaSolv® Technology. The applied technology turns PS foam waste into new high-quality raw material. During the recycling process, impurities, such as cement or other construction residues, as well as the imbedded flame retardant HBCD are safely removed. The HBCD is destroyed, while the valuable bromine component and polystyrene are recovered. In 2019 an industrial scale demonstration plant (with the capability to handle 3.3 kt of PS insulation foam waste per year) will be built in the Netherlands. The plant is aimed at starting up by the end of 2019. Subsequently the technical, economic and environmental viability of this new recycling process will be assessed. When proven to be successful, the process will be further rolled out with additional commercial plants in other countries throughout Europe.

NOTES

NATIONAL ISSUES 2

Strategies for Transition on National & Sector Level I

Chair: Rosemarie Stangl
University of Natural Resources and Applied Life Sciences, Austria

Transition Towards
a Net Zero Carbon
Built Environment

Implementation of Sustainable Development Goals in construction industry - a systemic consideration of synergies and trade-offs

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According to sustainability research the world has exceeded four out of seven planetary boundaries. The areas of climate change, biodiversity loss, nitrogen cycle and land use have left the so called safe operating space for humanity. The built environment is one of the major contributors to environmental impacts. Especially the embodied energy during the construction phase of the built environment and the energy demands during the use of buildings contribute to a high energy and resource consumption. In the year 2015 the United Nations adopted the Sustainable Development Goals (SDGs), a universal development agenda, which goals need to be fulfilled by the year 2030 and by all UN countries worldwide. Amongst other countries Austria has adopted the 2030 agenda and has committed itself to the SDGs. Research objective was to explore the application of systemic approaches in the field of SDGs. The work presents a systematic literature review (SLR) and discusses an application of a qualitative system analysis (carried out with the tool iMODELER) on the SDGs. Results show how interdependencies among SDGs and among chosen concrete actions, e.g. for the built environment, can be visualized for a better systemic understanding. By visualizing synergies and trade-offs, effects of decisions taken can be estimated from a holistic perspective.

NOTES

Retrofitting strata property - a tool supporting long-term retrofit strategy

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Strata property - ownership of apartments or townhouses consisting of private and commonly owned building components and areas - was established in Switzerland in 1965 and since has become very popular. But, well-needed retrofit work of these buildings is often postponed and long-term retrofit strategies are rarely considered. However, the low retrofit rate must increase to meet the global energy goals. Interviews and workshops with relevant actors showed that missing financial means are not the key issues for the low retrofit rate. Major challenges arise from a broad set of issues, such as difficult processes, unclear responsibility, insufficient communication, missing building information or underestimation of the commonly owned building components. “Luzerner Toolbox” provides eight folders that address the key clusters of challenges. Central to this toolbox are Excel-based tools, which transform accurate technical and financial information into a visual format. An ample diagram illustrates the remaining lifetime of the building parts and a graph relates upcoming retrofit costs and the annual payments into the contingency reserve fund with a forecast of the contingency reserve fund. As such, these tools assists in scheduling appropriate retrofit measures and establishing a balanced financial planning. But, various actors have reported that the retrofit timetable is too complex to be used in management firms. Feasibility studies and further research of their specific needs and work processes are needed to refine the tool accordingly. In a further study, interviews with management firms and architects are conducted to determine the key factors of a useful tool.

NOTES

Mobilizing Low Carbon Transition: Transnational Practice of Energy Efficiency in the Urban Building Sector

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In many countries worldwide, low carbon sustainable transition has been planned and implemented through decoupling the economic growth from GHG emissions. Some nations are leading the scene by developing corresponding low carbon development strategies and policy measures to encourage socio-technical innovations. One of the key areas for low carbon urban development is the energy efficiency in buildings. The tendency of the rapidly growing population and urbanization asks for better narratives and practices improving the built environment. Cities and countries are keen on learning from best practice. Through international joint development projects, the “knowledge resources” - transnational, governmental, NGOs, practitioners, and academic actors - are disseminating the low carbon urban development ideas globally. What drives a successful translation of knowledge emerged from one social, economic, cultural, political, climatic and geographical context into a new one needs better clarification. This study explores the process of global circulation of sustainable innovation from a mobility and transition perspective. A conceptual framework is explored and tested through analysing the Passive House concept transferred from Germany to China. The study shows how the succinct form, co-evolving and re-contextualising attributes are key factors in circulating urban sustainability across context. Acknowledging the notion of adaptation and mutation in the translation process is a first step to address the discrepancies between the knowledge lending and receiving side, and further to foster the transformative learning.

NOTES

Strategies for a sustainable energy transition: the case of the housing sector in Graz, Austria

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To facilitate a sustainable energy transition, the housing sector needs to be considered as a whole. Consequently, buildings as well as spatial structures have to be sustainable. Buildings, new and existing, need to be energy efficient, low carbon, considering diverse demands, while also providing a healthy indoor environment and a high quality of life. Spatial structures have to be efficient through compact development, supporting the transition to a post fossil society and mobility regime, that also provide high quality public spaces. In a transdisciplinary approach, strategies and policies, relevant for the case of Graz, Austria, were analyzed. Challenges and potential solution approaches were identified in a theory discussion, considering spatial development and construction aspects. A resulting set of measures to support the necessary sustainability transition is evaluated and iteratively enhanced by qualitative expert interviews with relevant stakeholders, i.e., researchers, practitioners and the administration. The aim of this research is to come up with a set of policy recommendations for decision makers. First results of this work in progress are already available and presented in this paper.

NOTES

Energy transition and technical energy regulations in the building sector

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Energy demand from buildings accounts for about 31% of global final energy demand and 23% of global energy-related carbon emissions. Technical energy regulations or building energy codes - policies that set minimum requirements for energy in buildings – have proven effective and efficient in decarbonizing the building sector. However, despite their long history and success, policymakers increasingly recognise that TERs in their current design have reached a point of diminishing returns. This study evaluates five countries with innovative building energy codes – Denmark, France, England, Switzerland, and Sweden – through reviewing legal documents and conducting expert interviews with researchers, practitioners, and regulators. Our results highlight the implementation challenges of innovative building energy codes and we provide learnings in form of six design principles.

NOTES

BUILDINGS 5

Special Session Circularity in Nature and in Buildings

Chair: Flora E. Szkordilisz
Hungarian Urban Knowledge Centre, Hungary

Transition Towards
a Net Zero Carbon
Built Environment

Construction, deconstruction, reuse of the structural elements: the circular economy to reach zero carbon

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The research work presented aims at setting up an infinite cycle of use of materials by their reuse and answering in particular to the problems of circular economy. Structural work and foundations represent the majority of the embodied energy of a building. The research effort is therefore focused on the structural elements. Reuse is here defined as the reuse of an element without transformation, unlike recycling which induces a new industrial cycle. It is therefore about reducing the consumption of materials and lowering GHG emissions. Today, it is impossible in France to reuse structures because of responsibilities, insurance and lack of traceability. How to make possible the reuse of structural components in order to reach a low carbon building? The challenge of this work is to find the best structural configuration making the components reuse easier at the EOL. The methodology we are implementing aims to design the structural elements by increasing the BIM parameters (6D, LCA), to attach the mechanical information, material durability, ageing to each object of the digital mock-up. A digital and physical traceability makes it possible to follow the evolution of the element over the years and to feed a database. At the end of its life the database is accessible and searchable for the design of a future building. A development of tools and gateways will then allow from a model of calculation to go to query the database to find an element resulting from the deconstruction that can be reused in the future structure.

NOTES

Sustainable design of vegetated structures: Building freshness

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City revegetation strategies seem appealing to mitigate urban heat island effects through shading and transpirational cooling. Moreover, other potential benefits that may derive, e.g. biodiversity enhancement, the reduction in buildings energy consumption, stormwater management, acoustic insulation or air purification, earned them the designation 'no-regrets approaches' for adapting to climate change. However, the lack of understanding and quantification of green infrastructures' environmental impacts prevents urban planning policies to be consistent and to turn attractive initiatives to effective implementations. The monitoring of existing green infrastructures is required to evaluate their cooling effect. For this purpose, an elastic gridshell in composite materials has been designed as a support for climbing plants at Ecole des Ponts ParisTech (Champs-sur-Marne, France). The life cycle assessment of the vegetated structure is performed in order to develop sustainable design strategies. Based on an energy balance approach, the collected thermo-hydric data can be used to determine which mechanisms are the most suitable for urban vegetation to enhance outdoor thermal comfort.

NOTES

Design concept for prefabricated elements from CDW timber for a circular building

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The EU funded project RE4 (REuse and REcycling of CDW materials and structures in energy efficient pREfabricated elements for building REfurbishment and construction) looks into opportunities for prefabricated, CDW timber elements (structural and non-structural) for circular buildings. Main goal is to minimise resource consumption for building construction but also waste generation related to building dismantling. An innovative design concept for a fully reversible, prefabricated, multi-story residential building from waste wood has been established that reflects robust but flexible and adaptable solutions to extend the buildings-life cycle. Reversible connections, reusable elements and recyclable materials shall minimise future waste generation, when such buildings reach their end of life. A prefabricated façade element manufactured for a two-story prototype shall deliver figures for easy installation, dismantling and future reuse. The study aims to show how current challenges can be overcome and design for disassembly can be promoted.

NOTES

Prototypology for a circular building industry: the potential of re-used and recycled building materials

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The growing scarcity of resources calls for a paradigm shift from linear material consumption to circular economy – especially in the construction industry. This shift involves a complete rethinking of design principles, materials, construction technics and technologies, as well as the introduction of new business models evolving from these reconfigurations within the field. This paper will show on-going research on these themes with a focus on direct material re-use and recycling through the discussion of a prototypology – the recently concluded Mehr.WERT.Pavillon (MWP) at the BUGA 2019 in Heilbronn. The research specifically addresses a reversible, mono-material structure that is made from re-used structural steel and recycled glass. The concept of cycles therefor is significant: Utilized materials are not consumed and disposed of; instead, they are borrowed from their material cycle for a certain period of time and later returned there at equal value and utility. Sourced from recycled materials, the prototypology is a built example of urban mining; designed for disassembly at the end of its service time, it also represents a material banks for future projects – while proofing the claim, that it is possible already today to build within a circular system.

NOTES

The secret ingredient – the role of governance in green infrastructure development: through the examples of European cities

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The first signs of considering green infrastructure in the process of urban planning appeared long before WWII with the developments of Chicago and Paris, for example, in the late 19th century. In order to relieve the increasingly crowded centres of fast-growing cities, the afforestation of public spaces and the creation of more liveable existing spaces became increasingly important; this includes the development and renovation of parks and water surfaces to adapt to urban needs and requirements, making the development of urban green infrastructure more important than in the past. Over time, green infrastructure developments grew more detailed and complex; since the end of the 20th century, they have become one of the most important goals of urban development, focusing on the environment and healthy living conditions. In the early stages of project development, the needs of urban residents and the active utilisation of green areas are factors of growing importance; refining design and construction has also become a more intricate process. Significant changes to the original style of plans has taken place over the past decades, evolving with the needs of the era and technological advances, requiring suitable action to maintain pace with enhanced developments.

NOTES

Mitigation strategies of the urban heat island intensity in Mediterranean climates: simulation studies in Rome (Italy) and Valparaiso (Chile)

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The Urbanocene, a proposed new geological epoch characterized by the urban living condition, is pressing the humanity to respond shortly to important challenges. Cities are at the same time the places where we live in and the big dissipators of the final energy to the environment. The simultaneous rules of heat dissipator and place to live are quite contradictory, because of the increasing temperatures of the dissipator surfaces, phenomenon known as Urban Heat Island (UHI). Mediterranean climates should suffer, in the next years, changes in the thermal needs of buildings and in the outdoor comfort sensations. A change in the energy demand from heating to cooling is probable and overheating reduction could be a priority in the future. Many mitigation strategies of UHI are being discussed in these years, such as the city greening, the use of cool materials for roofs and soils, the reduction of automobile dependence, the shift to new urban morphologies. In this paper an evaluation of impacts of different possible strategies is done, by using computational simulations for various sectors of Rome and Valparaiso. Results show the importance of greening and traffic reduction to achieve better comfort; while to reduce building energy consumption changes in urban morphology and traffic are suggested as the best strategies.

NOTES

BUILDING DESIGN 5

LCA challenges: Consequential LCA and Uncertainty

Chair: Ben Amor
LIRIDE Sherbrooke University, Canada

Transition Towards
a Net Zero Carbon
Built Environment

Consequential life cycle assessment of Brazilian cement industry technology projections for 2050

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In the upcoming decades, cement production growth is expected to exceed the increase in availability of clinker substitutes. Increased clinker replacement rates in cement and use of alternatives fuels were pointed out as the main alternatives for reducing emissions of the national cement industry, whilst increasing cement production in 2050. Consequential life cycle assessment (CLCA) offers a framework to capture environmental consequences from demand alterations. Modelling the cement production and markets involved is however challenging, given conceptual (only unconstrained markets are considered) and practical modelling limitations (e.g. model granularity compatible with CLCA interests). This paper refers to an ongoing work and adopts a two-stage approach to discuss the effects of the change on the average cement production process in Brazil. We first performed a CLCA without formal affected market identification to estimate the potential environmental impacts of the technology change proposed in the Brazilian Cement Technology Roadmap. Secondly, we used a Computable General Equilibrium (CGE) Model of the Brazilian economy to (more) realistically foresee short-term effects induced by such change. The CGE model comprises 102 economic activities, including cement production and its production chain. Our results indicate that (i) increasing the proportion of calcined clay and limestone filler as clinker partial substitutes and (ii) excluding charcoal from the fuel mix composition at the kiln would impact all economic sectors. Our preliminary findings suggest that the increased efficiency in cement production would create some rebound effect that would not invalidate the emission benefits from displacing energy and virgin materials. Additional impact categories and consequences in other economic sectors should be further investigated.

NOTES

Enhancing consistency in consequential life cycle inventory through material flow analysis

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Wood products are gaining interest in the building sector, due to their potential in sequestering greenhouse gas emissions. However, increasing wood materials use in the built market can have unforeseen changes in the material supply chains. Consequential Life Cycle Assessment (CLCA) allows the assessment of changes in material supply chain. To quantify and link those consequences, the affected physical flows need to be estimated. Material Flow Analysis (MFA) can bring to CLCA modelling more representative and quantitative information than the commonly used hypothesis in consequential modelling. Indeed, MFA considers physical constraints (technology performances and material availability), in addition to account for mass balance. The main objective of this presentation is to illustrate how such consistency is added to CLCA through an MFA of wood products in non-residential (NR) buildings in the province of Québec (Canada). Wood flows are tracked to identify their end-use markets and trends in consumption. To overcome the lack of data and bring insights on the sector's dynamics, such as stock variations and potential discarded flows that supply recycling markets, residence time model and also extrapolation and correlation between physical and economic parameters are used. Results show how flows can increase in the market before reaching their physical constraints, such as the available wood stock in the forest. These insights will significantly enhance the data collection for CLCA. In conclusion, the MFA brings support to CLCA by proposing a framework to model changes in the construction market.

NOTES

Consequential LCA of demountable and reusable internal wall assemblies: a case study in a Belgian context

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The transition from a linear to a circular economy is essential to reduce the environmental burden of our society. A key issue is to prevent a shift of the environmental burdens and take the consequences of a decision into account, for example based on a consequential life cycle assessment (LCA). However, limited practical guidance is available on how to implement consequential LCA in the context of the construction sector. Therefore, the aim of this study is twofold. First, to quantify the potential environmental and burdens of introducing circular design alternatives for internal wall assemblies to the Belgian market. Second, to review the methodological implications on the results of a consequential LCA with a particular focus on consistently identifying marginal suppliers and substitution routes, acknowledging the time dependence and closed-loop nature of the design alternatives. In total seven wall assemblies are assessed over a period of 60 years, with a refurbishment every 15 year. The results show that a low life cycle impact can be achieved for assemblies that are designed to be used again and have a higher initial impact, such as a plywood boarding connected reversibly to a demountable metal frame substructure, as well as for assemblies with no possibilities for direct reuse that have a low initial impact, such as a drywall system with a wooden substructure. Further, regarding the methodological scenarios on marginal supplier identification, the range of possible outcomes is however much larger for the demountable wall assemblies than for the conventional ones.

NOTES

Probabilistic LCA and LCC to identify robust and reliable renovation strategies

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Buildings are one of the largest energy consumers and greenhouse gas emitters in the world. As the largest part of the energy consumed by the existing non-insulated buildings occurs during the operation stage, retrofitting the building stock is crucial to reduce the environmental impact. To guarantee that the retrofit measures provide economic and environmental benefits, the whole life cycle should be assessed. However, the identification of environmental and at the same time cost-effective solutions is difficult due to the complexity and the uncertainty involved. Currently, simplified approaches based on limited assumptions are used that can lead to inaccurate results. This paper proposes a method for identifying robust renovation scenarios for residential buildings in Switzerland. The method and the developed tool use 47 uncertain parameters and Sobol' indices to identify the most influential parameters. As such, robust renovation strategies can be identified in the early design stage.

NOTES

Scenario uncertainties assessment within whole building LCA

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Uncertainties evaluation is increasingly gaining traction within life cycle assessment (LCA), due to its key role as environmental decision support tool. When applied at whole-building scale, the large variety of materials, subjective choices and long lifespans introduce parameter, scenario and model uncertainties throughout the life cycle. Since normative choices are unavoidable within whole-building LCA (wbLCA), in this article we carried out a so-called ‘scenario’ uncertainty assessment for one illustrative case study. First, three uncertainty sources were selected, to include the two drivers most frequently cited in literature (reference service life and end of life management alternatives) and material wastage, a relevant issue to factor in variable construction optimization levels in contexts like Brazil. Cumulative energy demand (CED) and CML 2001 v.2.05 methods were used for calculating deterministic values of non-renewable embodied energy and global warming potential in SimaPro 7.3 The uncertainty assessment combined scenario analysis, stochastic modelling (Monte Carlo simulation of triangular probability distributions for the uncertainty drivers investigated) and global sensitivity analysis (GSA). The GSA confirmed the dominant contribution of the operational phase - strongly influenced by components replacement rate - to of life cycle non-renewable embodied energy and global warming potential result variance, whilst construction and end of life stages showed no correlation with life cycle results. Findings from this research also highlight the strategic importance of gathering service life information adherent to the assessed context. Building components replacement rates induced by the Brazilian standard are overestimated relatively to international figures used in LCAs worldwide.

NOTES

Diagnosis of uncertainty treatment in neighbourhood life cycle assessments

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Urban areas are complex, multifunctional, long-lasting dynamic systems responsible for impressive resource consumption and environmental impacts. Assessments at the neighbourhood scale offers an important complexity compromise. This paper scrutinizes approaches for handling uncertainty analysis (UA) and sensitivity analysis (SA) in LCAs at the neighbourhood scale, aiming at identifying inconsistencies, limitations and challenges, and supporting the development of assessment guidelines. A systematic literature review was performed. Results from the final 35-paper sample show that only one-third of the papers actually performed some calculation. Two of the most recent ones used Monte Carlo (MC) simulations, whilst SA was mainly carried out through scenarios. Despite no clear trend is shown, this may indicate attempts to also apply MC at the neighbourhood scale. The basic quest in UA and SA, particularly global sensitivity analysis, is to balance quality and completeness of output information and computational force needed. Automating calculations, using lighter sampling methods and fast calculators should be further investigated. Finally, future studies could also focus on defining a minimum group of parameters to investigate and on which strategy to follow in specific data availability circumstances. Fuzzy sets seem better for environmental assessments with high degree of uncertainties and probabilistic distributions give results that are more precise. Dynamic models, future scenario uncertainty and spatial uncertainties propagation should also be further explored once the basic challenges for uncertainty assessment are overcome.

NOTES

CITIES 4

Spatial Planning in the Context of Sustainable Development

Chair: Zsuzsa Szalay
Budapest University of Technology and Economics, Hungary

Transition Towards
a Net Zero Carbon
Built Environment

Implementation of a sustainability monitoring tool into the dynamics of an urban brownfield regeneration project

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Within the context of post-industrial European cities, the regeneration of urban brownfields contributes to limit urban sprawl by increasing cities density while revitalizing neighborhoods. Yet because of their complex nature, urban brownfields regeneration projects (UBRP) are not automatically sustainable. To foster the integration of sustainability objectives into these projects dynamics, an operational monitoring tool was created. Entitled SIPRIUS+, this tool is a collaborative web-based software combining sustainability indicators adapted to UBRP issues and several management functionalities. Test applications conducted on case studies and presented to the related stakeholders gave positive insights about the potential of SIPRIUS+ to provide decision-making support. However, because of the long duration of UBRP, some aspects inherent to monitoring were not verified and the tool not piloted in real conditions. In order to confront SIPRIUS+ with the reality of the practice and its end-users, the tool is now being implemented for an 18-month period in the Gare-Lac neighborhood project located in Yverdon-les-Bains (Switzerland). The paper investigates how SIPRIUS+ is actually implemented into the project's ongoing urban planning procedure. Then, we analyze preliminary feedbacks to measure the level of adoption of the monitoring approach by the different stakeholders and to identify points of improvement.

NOTES

Pocket Mannerhatten - City renewal on the basis of spatial sharing strategies, bottom-up participation and common good-based incentives

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Cities worldwide and Vienna as well are facing an increasing pressure on space. Innovative strategies are required to tackle these challenges not only by creating new buildings but also by modernizing existing neighbourhoods. For decades Vienna counts on a gentle urban renewal approach. The question how to tackle new challenges, such as renewal towards energy efficiency, green spaces, alternative mobility or integration of multicultural lifestyles needs to be answered. The project Pocket Mannerhatten pursues the assumption that sharing building space across property outlines can offer an innovative approach for a city renewal. The spatial sharing is combined with a bottom-up-participation process and a compensation-oriented funding system. With the public funding program “Smart Cities Demo” (Austrian Climate and Energy Fund) a realization project will test the concept in Ottakring/Vienna. The multidisciplinary consortium accompanies the inhabitants realizing shared green spaces, community rooms, shared photovoltaic systems, car-sharing and Co-living apartments until the year 2021. In the future, these sharing and cooperation activities should become a city renewal strategy. Due to the slogan “who shares, gets more” and on the basis of a evaluated common good contribution not only monetary but also alternative, non-monetary incentives will be taken into account to foster urban renewal.

NOTES

Modelling of a sanitary landfill for developing countries to improve the reliability of Life Cycle Assessment studies

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In developing countries, such as Brazil, the main destination of municipal solid waste is sanitary landfills. In Life Cycle Assessment (LCA) studies, the entire life cycle of the product or process is considered, therefore it is necessary to take into account the destination of the waste and by-products of the process in question. For a reliable and representative LCA study, these destinations have to be illustrative of the place where the study is conducted in. Regarding the treatment and disposal of organic solid waste, the main LCA databases, such as Ecoinvent 3.0, consider sanitary landfills modelled in European standards, which include processes that are not common in developing countries. In light of this reality, the aim of this study was to model a sanitary landfill that corresponds to the case of the said countries and provide a methodology to improve the significance of environmental studies, which can also be used with primary data. The model used literature data based on Brazilian reality, considering the operation of the landfill (transport and emissions and diesel usage in the spreading of the waste); biogas generation and treatment; leachate generation and treatment using stabilization lagoons and its emissions. When compared to landfill based on European reality, differences up to 80% can be observed in some potential environmental impacts.

NOTES

Bike Model District “Alte Neustadt” in Bremen

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How to transform existing urban structures into zero emission cities by 2050 - especially if money is rare? The School of Architecture Bremen (SoAB) at the City’s University of Applied Science have initiated an innovative and collaborative project for the further development of the university’s neighbourhood, the “Alte Neustadt”. SoAB participated in the national climate protection by bicycle traffic competition and was granted funding for the transformation of the district into Germany’s first bicycle zone. In cooperation with the city district, NGO’s, cultural institutions, and other neighbourhood organisations, a network of bicycle streets in connection with new bicycle highways will be installed. By 2020 comprehensive new bicycle parking areas will be finished, as well as new cyclist and pedestrian friendly crossings over the main roads. The campus’ main street will be transformed into an “Open Campus” for the university and the neighbourhood. A multifunctional “Bike Repair Café” with cargo bike sharing and bike rental facilities will enhance the district’s transformation even further, thus creating a space to reflect environmental problems to be solved. The bike model district “Alte Neustadt“ is just a small step in the right direction, but a huge improvement of the district’s quality of life.

NOTES

Climate-resilient urban planning and architecture with GREENPASS illustrated by the case study ‘FLAIR in the City’ in Vienna

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Urban growth and climate change are 2 of the main challenges worldwide. Cities are growing rapidly while average temperatures are rising, and extreme weather conditions, as heavy rain events, are becoming more frequently. Soon 4 out of 5 EU citizens are living in cities. The results are increasing costs for health expenses and infrastructure damages. Urban planning processes have to consider future climate conditions and the impact on people, buildings and the urban environment. Until today there was no simple solution to measure and calculate the climate impacts of urban developments. GREENPASS® is a technological breakthrough, the world’s first software-based technology for climate-resilient and resource-efficient urban development. After 9 years of scientific research and development the technology can easily be used by urban planners as architects and be integrated into existing urban planning workflows and processes. With GREENPASS® the impact of buildings, materials and plants on urban climate become measurable and comparable in a standardized way – powered by ENVI-met®. It supports optimization of investments towards effects of Green Infrastructure (trees, green roofs and walls, ...) such as cooling, thermal comfort, water retention and carbon sequestration. GREENPASS® allows to identify the optimal solution for any urban development. Supported projects receive finally a GREENPASS® certificate on their overall performance. The technology has already been applied successfully for more than 25 projects within Austria and Europe and will be explained more in detail using the case study of ‘FLAIR in the City’ - the world’s first GREENPASS® Gold-certified residential building, located in Vienna/Austria.

NOTES

PROCESSES 5

Methods and Tools Supporting Early Design Decisions

Chair: Bernardette Soust-Verdaguer
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Transition Towards
a Net Zero Carbon
Built Environment

Sustainability Assessment in Architectural Competitions in Switzerland

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Architectural and urban planning decisions, that have a strong impact on all areas of sustainability, are often set during preliminary phases of project development. This work focuses on the architectural competition, that is traditionally an instrument for enhancing quality in architecture and urban planning in the preliminary phase. However, in Switzerland, only occasionally assessment criteria adopted in such competitions include principles of sustainable development (SD), as there are no specific references to SD in the specific national SIA 142 “Regulation of architecture competitions”. In the Swiss Canton of Ticino, in some architectural competitions the evaluation criteria of sustainable development have been already clearly enumerated in the tender documents. Those criteria were selected according to existing tools (Sustainable neighbourhood by SMEO, SNBS, SIA 112/1) widely used in Switzerland. In addition to the usual graphic documents each project team had to structure a sustainability report. The presented projects have been then assessed by an interdisciplinary team, after that the resultsin several representations (global index, dimension index, category index, bar graph diagram and spider web diagram) and compared them to show the strengths and weaknesses from an integrated point of view. A change in the competition culture is needed because the sensitivity for the topic depends strongly on subjectives purposes, namely primarily on the composition of the jury.

NOTES

Multi-objective optimization of building's life cycle performance in early design stages

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The early design stages of buildings have the highest potential for optimizing energy efficiency. From the aspect of architectural design, the architects can hardly make the best decisions of the complexed variables of geometries and materials. The choice and weighting of different optimization objectives also have no reference while considering the impacts from the whole view of the life cycle. In this paper, a simulation-based parametric approach through the use of multi-objective optimization method is framed. The extraction of geometry variables from the original design and the principles of explaining optimization results obtained from different objective combinations are discussed. This process is carried out in Rhino and Grasshopper. To fully consider the aesthetic and building performance step by step in early design stages, the geometry and material parameters are tested simultaneously. The life cycle inventory data of materials and energy resources are imported by programming, and local data is partly used. Life cycle environmental impacts (PED and GWP), life cycle cost, and operating energy consumption are used as optimization objectives. A case study is verified on a project of a small campus museum building in northern China. The results indicate that the combination of geometry and material values in the optimal solution set is various and needs to be artificially selected according to actual needs. The optimization objectives should be considered comprehensively; an incomplete set may result in poorly behavior of the unselected objectives.

NOTES

Early Design Stage Building LCA using The LCAbyg Tool: New Strategies For Bridging The Data Gap

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There is an increasing demand for Life Cycle Assessment (LCA) as a method for environmental impact and resource assessments of buildings. At early design stages, where major design decisions are made, the potential for improving the environmental performance using LCA is greatest. However, detailed building information is usually not available at this time. This paper presents the recent extension of LCAbyg, the official Danish building LCA-tool, integrating an LCA approach for situations, where building design and material choices are not yet fully determined. The tool assists the user in establishing a complete building inventory by providing a default component library including building services and a guide for estimating quantities. Default components in the library are based on the integrated product database Ökobaudat. A convenient generation and comparison of variants improves usability, while a new LCA design guide shall increase the uptake of LCA in larger parts of the building industry. The methodological choices of the approach are laid out and discussed. The presented approach is not limited for use in early stages, but may improve feasibility in building LCA in general as default and estimated values may be refined towards more detail in later stages of the project.

NOTES

Early Design Stage Building LCA using the LCAbyg tool: Comparing Cases for Early Stage and Detailed LCA Approaches

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Life Cycle Assessment (LCA) is used and accepted as a method to assess environmental impacts and resource use of buildings. In practice, LCA is typically used in stages where the design of the building is already finalized. However, LCA-calculations from early design stages can be used actively in design and optimization of the building. One of the obstacles to early stage LCA is that extensive data input on precise material types and amounts is needed, which is limited in early design stages. The simplifications needed for a designer in an early design LCA is addressed in a research project, where an extensive library of predefined building components and installations were developed and integrated into the existing Danish LCAbyg tool. The library assists the user in establishing a full building inventory by simple inputs of geometry of the building and a selection from the library of building element layers. However, the simplified approach to LCA of a building at early design stages inevitably affects results compared with results of a calculation made at later design stages where more, specific data is available. This paper presents an evaluation of building cases, modelled with the same background database and life cycle stages, using the simplified early design LCA approach and a detailed LCA approach. The evaluation includes testing of how well the predefined components in the early design approach fit with the case buildings and comparisons of the total material input and precision of the final LCA results.

NOTES

Evaluation of BIM based LCA in early design phase (low LOD) of buildings

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Building Information Modelling (BIM) is a convenient tool that is capable of collecting information throughout the whole life cycle of a building in one platform. The evolution in the digital BIM model in early design stages is not standardized, but Level of Development (LOD) is a concept that systematically structures the design processes divided into five levels. LOD is assessed in this paper as an opportunity to enhance the calculation of the environmental impacts in different early design stages more efficiently, using the methodology Life Cycle Assessment (LCA). Enlightening the building elements that contribute to highest release of CO_2, permits early building material selection. This facilitates a pathway towards sustainable and environmentally friendly buildings. This study evaluates BIM based LCA in early design stages (low LOD) through literature reviews and a case study. This papers' case study executes LCAs at different LOD levels using the LCA software One Click LCA (OCL). Assessments in LOD 200, LOD 300, LOD 350 and an additional LOD 350 were utilized. The additional LOD 350 was deployed when LCA experts had implemented changes within OCL. Moreover, a concretized suggestion where today's unpredictable development of BIM becomes part of a LOD framework is proposed.

NOTES

Lessons learned from assessing life cycle impacts for an environmental product declaration: Examples for run-of-river power plant

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When conducting life cycle assessments (LCA) for environmental product declarations (EPD), researchers struggle with many methodological questions. For certain products there are several standards (e.g. ISO and EN) and Product Category Rules (PCR) available which all seem applicable. These standards, however, might lead to different results. Depending on the standard, system boundaries might be drawn differently than typically done in ones preferred background database. Another common issue is a lack of a clear definition of assessment methods (version, download of factors) to be applied. Or on a more practical level, you might not know how or where to obtain certain requested figures from your LCA data or even how to start with building an appropriate model in the LCA-software. The authors of this paper explain each of these issues with an example from their practical work, provide their instant solutions and make suggestions for general improvement of the situation. In general, they call for a more precise and practical guideline and easy-to-use LCIA methods for conducting EPDs.

NOTES

PRODUCTS 5

Sustainable Construction Products II

Chair: Tajda Obrecht
Slovenian Building and Civil Engineering Institute, Slovenia

Transition Towards
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Building Physics as a Tool for Development of New Components: Roof Window

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Knowledge and instruments of building physics (calculation methods and measuring procedures) can be used as key tools and perspectives to develop new components for building envelopes. This paper illustrates this fact by presenting the successful development of a roof window fulfilling higher requirements on reduction of overall heat losses and avoiding the risk of water vapor condensation on surfaces at very low external temperatures (thermal transmittance below 0.7 W/m²K in the first generation, close to 0.5 W/m²K in the second one) and better daylight distribution for the interior. This is the result of a publicly supported project with an industrial partner: from a general idea through detailed analysis of thermal performance in geometrical and material alternatives up to construction, prototyping, and verification by measurements and certification. Building physics tools applied in the project are discussed here together with lessons learned which are important for technical design. An effective shading system equipped with PV elements for energy smart harvesting is mentioned in the conclusion.

NOTES

Environmental performance of window systems in patient rooms: a case study in the Belgian context

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Hospitals produce high amounts of emissions due to their continuous operation, high flow of people, and intensive HVAC requirements. In order to reduce the environmental footprint of hospitals, it is crucial to improve energy performance while still maintaining a comfortable indoor environment for the occupants. Also to avoid high environmental burdens, it is important to understand the impact of building material selection from the full life cycle perspective. Window systems influence the energy loads and comfort in buildings and provide access to daylight and views. Therefore, windows contribute significantly to the energy consumption and indoor environmental quality of buildings and impact the well-being of occupants. The aim of this study is to determine the influence of various window system design configurations on the environmental performance of patient rooms in Belgium through life cycle assessment (LCA). The method is innovative as it combines dynamic energy simulations and daylight analysis and integrates these in the LCA study of the window systems. The influence of several components is investigated, such as the choice of glazing and shading system. The results are analysed and compared in terms of energy cost for heating, cooling, and lighting, daylighting performance and life cycle environmental impacts. A typical patient room from a hospital design in Belgium is used as a case study. Based on comparative analysis, the paper discusses potential window system design configurations that allow for energy efficient, daylit and environmentally-friendly patient rooms.

NOTES

Partially dynamic life cycle assessment of windows indicates potential thermal over-optimization

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To reach the environmental goals set by EU, Energy Performance of Buildings Directive (EPBD) and national building regulations will demand reductions in building's energy consumption. Energy consumption goals for buildings are pursued through high thermal performance building components (HTPBC). Paradoxically, building regulations have no requirements regarding the embodied energy of buildings and components. To meet the requirements set by governments, HTPBCs in most cases require an increasing embodied energy (from insulation), assumed to be paid back during the service-life of HTPBCs. Accounting for decarbonization of the future energy supply, the expected payback might not be feasible in terms of total environmental footprint, since the future energy supplies are expected to be greener than the building's embodied energy. Using roof windows as a case study, we assess if strict demands for building's energy consumption, will lead to more sustainable buildings if all temporal variations in terms of global warming impacts across the service-life are taken into account. A comparison of double and tripple glazed windows reveals that the expected net energy savings obtained during the use phase are compromised by relatively higher impacts induced in the production stage. The case study indicates requirements of building's energy performance might compromise the overall sustainability of building component solutions, as the additional embodied energy required to produce triple glazed windows most likely will not be compensated for by saved operational energy, when taking into account the forecasted decarbonatization of the building energy future supply.

NOTES

Perimeter blocks in different forms – aspects of daylight and view

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The perimeter blocks in cities are usually rectangular and follow the streets. The buildings are mostly of similar height within each block. However, perimeter blocks can be developed in many various forms. Geometric options such as chamfered corners, varied building heights and different positioned openings in a broken perimeter block are analyzed in this paper regarding the aspects of views and daylight in city planning. The choice of evaluation criteria is based on scientific discourse in the field of daylighting. As in the new European standard, “Daylight in Buildings”, the following three parameters are included in calculations: solar radiation, daylight level and view out. Computer-based daylighting simulations and calculations of view parameters are performed for different designs of the perimeter blocks with equal density, FAR = 1.33. The simulations have been carried out for Stockholm. That means roughly the same shadows as in Oslo, Helsinki, Tallinn, St Petersburg and Anchorage, all close to the same latitude (60°N). In lower latitudes, e.g. Southern and Central Europe the shadows are shorter. Nevertheless, the ranking of the alternatives will be similar. This study confirms that geometrical changes can improve the conditions for views and daylight in the perimeter blocks. The advantages in the tested urban design alternatives are considerable compared to the perimeter block of the standard type.

NOTES

Lifecycle analysis of finishing products enhanced with phase changing materials

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Applicability of phase changing materials (PCMs) in buildings by their integration into the structure of finishing materials structure in the form of particles is especially high as a mean of providing heat-insulation during summer. Materials containing particles with phase changing behaviour are successfully applied at objects with large daylight areas, focused on active utilization of sunlight energy, among others. Utilization of PCM components allows saving considerable amount of energy due to possible refusal of air-conditioning while providing heat-insulation during summer. The paper deals with the lifecycle analysis of gypsum-based finishing products. Main challenges with respect to the lifecycle of products with PCM components are the preservation of their longevity as well as their potential for reuse/ recycling. Through the example of PCM-enhanced plaster covering and gypsum plasterboard factors affecting the preservation of the advantageous thermal properties of PCMs over extended periods were studied, along with options of refining materials and products containing different amounts of PCM components. The results of the research allow comparing similar materials with the use of PCM components and without them as well as analyzing the life cycle related environmental performance of PCM-enhanced finishing materials.

NOTES

Designing a smart factory for mass retrofit of houses

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The North Sea Region (NSR) contains 22 million houses built in 1950-1985 that cause 79 Mton CO_2 emissions annually. Current deep retrofit home renovations are carried out on a limited-scale production and only in small projects. This results in the problem that nowadays renovation costs are way too high and the pace of renovation is far too low. Large scale renovations of existing homes towards energy-neutral are currently not addressed in the North Sea Region. Still, the retrofit of houses in the North Sea Region is essential to reach the European energy and climate objectives. However, the building sector in Europe is not creating the necessary production facilities. The target of the just started INTERREG project INDU-ZERO is to develop a blueprint for a production facility that can produce wide suitable renovation packages at a high volume and low cost.

NOTES

NATIONAL ISSUES 3

Strategies for Transition on National & Sector Level II

Chair: Christof Knoeri
ETH Zurich, Switzerland

Transition Towards
a Net Zero Carbon
Built Environment

Achieving net zero status in South Africa

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The purpose of this research is to determine how net zero buildings in South Africa can achieve net zero status. Net zero buildings are defined as energy efficient buildings with energy supply from renewable sources on-/ or off-site or through offsets. The Green Building Council South Africa launched and certified the first four buildings in South Africa under its Net Zero Pilot Certification scheme in October 2017. Net zero status can be achieved in waste, water, carbon and ecology respectively. The concept of net zero buildings is thus new to South Africa and certain barriers needs to be overcome. A semi-structured questionnaire was sent out to developers in order to establish the perceived barriers by developers. Net zero buildings still needs to be commercially justified in South Africa. Cost and lack of incentives are definite barriers. The National Building Regulations of South Africa is a barrier to the development of net zero buildings as is does not require buildings to aim for net zero status. Requirements from national authorities could greatly impact changes in the approach to developments. There is a knowledge gap in the construction industry of sustainable and net zero buildings in South Africa regarding the benefits, implementation thereof as well as the actual costs.

NOTES

A top-down approach for setting climate targets for buildings: the case of a New Zealand detached house

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Climate change mitigation requires the construction of low/zero-carbon buildings, and this is a challenge for designers. The use of Life Cycle Assessment (LCA) provides useful information to support eco-efficiency improvements and therefore, to reduce the climate impacts of building designs. However, it does not provide information about whether a proposed design aligns with achieving the global climate target of limiting global warming to below 1.5°C or 2°C. This study, therefore, introduces an LCA-based top-down approach for setting climate targets for the whole life cycle of buildings in terms of greenhouse gas emissions. It involves assigning a share of the 2°C global carbon budget for 2018-2050 to a country, to the construction sector of the country, and finally to a building. The approach includes a stock model that accounts for the projected growth in the number of buildings and associated climate impacts in a country up to 2050. The proposed approach was applied to a detached house in New Zealand, the most common residential building type in the country; it was found that the climate target of a New Zealand detached house over a 90-year lifetime is 71 tCO_2eq. This modelling approach has potential to guide designers and other interested stakeholders in development of building designs enabling the building sector to operate within a selected global climate target (such as the 1.5°C or 2°C target).

NOTES

Analysing the impact of retrofitting and new construction through probabilistic life cycle assessment. A method applied to the environmental-economic payoff value of an intervention case in the Albanian building sector

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The EU building stock is relatively old with 40% of it built before 1960. In Albania the building sector accounts for 26,9% of final energy consumption, offering high energy saving potentials due to the great number of old residential buildings. Intervention is not always possible and, in order to achieve significant environmental savings, the national action plans cannot rely only on the physical improvement of existing buildings. This paper proposes a probabilistic LCA and LCC evaluation model using MC simulation, for the prediction of intervention options in existing buildings. The potential environmental and economic impacts of three intervention options: standard, ambitious retrofitting and new construction during the whole life cycle of a building are analysed. A framework is defined, with the purpose of estimating the value of a building in a specific time during its life cycle. Comparing the generated values of potential environmental impacts and associating them with the changes on the buildings value enables the process of deciding upon the most desirable and/or agreed combination. The results of the SLED Study 2015 on Albanian building typology are used, while the new construction model is defined according to German EnEV2014 requirements. The GWP values from the LCA/ LCC assessment of the intervention scenarios, done through the SBS tool of Fraunhofer IBP, are used to create a prediction model for future alternative solutions especially in early planning phase. Decision-making through this model can encourage a sustainability strategy for energy efficiency improvement in the building sector of Albania.

NOTES

Towards conceptual understanding for the adoption of building environmental sustainability assessment methods in the UAE built environment

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The UAE is witnessing increased interest for sustainable development which poses challenges on the development processes for the large amount of built environment projects taking place in this emerging economy. While, great attention has been given to the development of tools and methods to measure and assess the performance of buildings to meet specific environmental sustainability targets, however, less is known about the effect of these assessment methods on the built environment development process itself. This paper addresses this gap through the investigation of the adoption of building environmental sustainability assessment methods for development projects in the UAE. Currently, there are two assessment methods in the UAE; Pearl Building Rating (PBR) and Al Sa'fat systems. Background study revealed that both systems: are developed in parallel to the development of building codes, adopt performance-based approach for assessment methods, and their adoption for development projects is basically mandatory. This paper draws from diffusion of innovations theory and growing literature in the adoption of similar assessment methods in projects, with the objective of proposing a conceptual framework that conceptualizes PBR and Al Sa'fat methods as innovations and the development projects as the social system for adoption, while focusing on the adoption process dynamics rather than the decision to adopt or not. The proposed framework captures specific conceptual themes, providing the foundation for further empirical investigation. As such, this paper contributes to the growing literature on the adoption of global energy assessment tools and specifically addresses the UAE's sustainable development policy and regulation.

NOTES

BUILDINGS 6

Special Session Environmental Benchmarking of Buildings

Chair: Damien Trigaux
KU Leuven, Belgium

Transition Towards
a Net Zero Carbon
Built Environment

Using a budget approach for decision-support in the design process

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The use of Life Cycle Assessment (LCA) during the design phase can help to improve the environmental performance of buildings. However, designers and clients find it difficult to set environmental performance targets and interpret the results obtained through LCA in order to improve the building design. Therefore, performance levels or benchmarks are needed that provide design guidance towards reducing the environmental impacts of buildings in the life cycle. This paper uses a dual benchmark approach. The main concept consists in combining building-related top-down targets with building component-related bottom-up benchmarks. The overall top-down targets per capita and year are derived from the capacity of the global eco system. The bottom-up benchmarks for building elements are calculated following a best-in-class (top 5%) approach. A workflow of applying these benchmarks is proposed. It provides guidance on how to optimize the environmental performance of a building and its components efficiently by differentiating between material and design-related options. The approach is exemplified by means of a case study of a multi-family house.

NOTES

Dynamic Benchmarking of Building Strategies for a Circular Economy

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Increasing building demands from a growing world population puts enormous pressure on natural resources. Management of resource consumption and environmental impacts is therefore vital to secure contemporary and future well-being and progress. Circular Economy (CE) is perceived as an industrial economy model potentially minimizing resource consumption, waste production and environmental impacts by the means of increased material circularity e.g. reuse. In order to promote CE in buildings, there is a need for benchmarks to support building designers in choosing environmentally viable solutions. Although life cycle assessment (LCA) help policy makers and building practitioners to define such benchmarks, benchmark studies often rely on static LCA approaches. Hence, uncertain and unknown dynamic changes during a buildings' long service life influencing the performance of long term sustainable building design principles are not accounted for. Through a literature review the paper at hand identified dynamic technological progress such as resource and energy consumption, energy grid mix, waste management, design and innovation and production efficiency as potentially essential to include when defining realistic CE building strategy benchmarks. How these dynamic factors may affect LCA results were demonstrated through a case study of a concrete column based on a range of possible scenarios. This included estimated future projections and the uncertainty relating to prospective assessments resulting in an output in the form of a span of possible future developments and environmental impacts instead of a single output. Based on the literature review and case study, main challenges of incorporating dynamism within building LCA benchmarking were identified.

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Carbon Heroes Benchmark Program – whole building embodied carbon profiling

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Reducing the embodied carbon of the building stock requires a better understanding of the life cycle impacts of the materials used in those buildings. However, the characteristics of the building stock vary significantly by geography and building type. The "Carbon heroes benchmark program" is a cooperative initiative for carbon profiling by building type across different countries. The program's aim is to create uniform, full life-cycle of materials benchmarks for common building types. The benchmark program is on track to achieve 1000 fully completed and verified buildings by end of 2019, and contains data breakdowns for over 100 different material types and essential structural parts of a building. All data used in the program is rigorously anonymized and statistically small sets of data are also not used to protect data anonymity. The program implements the EN 15978/ISO 21930 standards as the basis of measurement, and includes life-cycle stages A1-A3, A4, B4-B5, and C1-C4. This presentation will share the preliminary findings of this project. 659 verified buildings (February 2019 cut-off), with substantial datasets for many European countries for some of the most common building types. The benchmark is generated using One Click LCA.

NOTES

Inventory of the existing residential building stock for the purpose of environmental benchmarking

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The current renovation rate in Belgium is less than 1% and should be increased to 2,5% to reach the European targets to reduce the GHG emissions by 2050. There is a need to rapidly increase the renovation rate and at the same time guarantee that these renovations reduce the environmental impact on our planet. In order to define environmental benchmarks for existing buildings and their renovation targets, a better understanding of the existing building stock is needed. In this paper, the approach used to model the existing building stock is presented for the specific case of Leuven. The methodological steps, challenges and data gaps are presented in detail. The proposed building stock model uses GIS data in order to gain insights in the geo-spatial distribution of the impacts of the stock. These spatial maps moreover allow to clearly visualise the impacts which can improve communication and contribute to policy actions.

NOTES

Life-Cycle Assessment as a decision-support tool for early phases of urban planning: evaluating applicability through a comparative approach

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While ambitious environmental objectives are being set for new constructions in Switzerland, the assessment of urban-scale projects and comparison of their performance to national targets are made possible by a growing number of life-cycle assessment (LCA) tools. However, previous research emphasizes the lack of existing tools to support the decision-making process at the early design stage, characterized by a low level of project details. This paper presents a comparison between three LCA tools. The first, stemming from a research and development project (SETUP), is an exploration tool relying on a database of urban-level scenarios and their environmental performance, able to convert district targets (e.g. 2000-Watt society objectives) into specific sub-targets at the building or component levels. The other two are online LCA tools currently available to practitioners (Sméo and Calculation tool for 2000-Watt-society-sites RH II), that allow assessing the project and verifying its compliance with a given target. Each tool was applied to a low-carbon case study, the blueFactory district in Fribourg (Switzerland), in two hypothetical contexts corresponding to the schematic and detailed project development phases, characterized by different levels of details. When used for the assessment of a project at a more advanced development stage with a high resolution of detail, findings indicate that Smeo and RH II provide similar environmental performance results. However, in early planning stages, SETUP shows better abilities to support decision-making by providing ranges of results and highlighting uncertainties and the influence of design parameters that have not yet been fixed.

NOTES

Critical analysis of environmental benchmarks for buildings

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To reduce the environmental impact of the building sector, environmental targets should be defined considering the full life cycle of buildings. In recent years various benchmarks based on Life Cycle Assessment (LCA) have been developed as part of regulations, labelling systems and sustainability rating tools. This paper presents the results of a critical analysis of six existing benchmarking systems. An overview is given of the different benchmark approaches, scope, applications and communication. The strengths and weaknesses of the various systems are highlighted. Based on the analysis, recommendations are formulated for the development of future LCA benchmarks for the building sector.

NOTES

BUILDING DESIGN 6

Regenerative Strategies for Improving Resilience

Chair: Anna Braune
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Transition Towards
a Net Zero Carbon
Built Environment

The regenerative building: A concept of total sustainability

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The concept of building's sustainability is progressively evolving, from the mere issues of limiting the energy needs of the building, extends to include new areas. The long-term sustainability visions (in Switzerland the "2000 W Society" by year 2100) imply not only technological changes but above all radical changes in the human behaviour. A multidisciplinary study, carried out by SUPSI and specialists, proposes a method for determining the parameters for the design of a building by year 2100. It also shows that in order to achieve long-term sustainability goals (primary energy reduction and CO_2 emissions per capita, 2000 W and max 1 ton CO_2), alimentation can be considered as a building need. The high potential in reducing primary energy needs in this area makes possible to compensate others energy consumptions and CO_2 emissions of the building inhabitants and of the building itself. The sustainable building of the future shall therefore: - present a zero or compensated operating energy need; - present minimal energy need for construction; - allow food production (Urban Farming, Building Integrated Agriculture) through natural and regenerative agriculture (self-production); - promote and act as a shelter for local flora and fauna (regenerative); - respect the soil stratigraphy (reversible).

NOTES

HYBRIDisation – a resilient strategy in times of change and transformation

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Our built environment consists of spaces, buildings, and cities that are subject to ever-changing social, economic, ecological and cultural demands. The demand for high quality living space is becoming ever more significant for densifying urban areas. When lifestyles, modes of working and recreational activities intertwine, new concepts on all scales must follow. Consideration of resilience of all kinds is becoming an important part of planning. It requires typologies with resilient characteristics, which can also take on new tasks perhaps not yet known of today. This paper recognises such a typology in the hybrid. Hybrids possess a variety of characteristics and benchmark parameters. A code inherent in them renders them capable of reacting to various situations and differing requirements. Depending on its constitution and purpose, the hybrid code affects a variety of architecturally relevant, environmental levels, namely district, neighbourhood, building, unit, components, infrastructure and processes. “Hybridisation” describes the process of the deliberate application of this code on all levels (“design and injection”), albeit also its decoding, i.e. activation of processes of change. In this way “new genetic alliances” are created, in which differing hybrids interact. By offering advanced adaptability through HYBRIDisation, buildings become resilient to change and allow for diverse modification and development throughout their lifespan, resulting in improved learning ability. This paper explores strategies of HYBRIDisation and the consequences for the interlinked levels to enable hybrid and resilient levels of environment.

NOTES

Hydrological and thermal response of green roofs in different climatic conditions

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The paper presents a study on the thermal and hydrological response of lightweight extensive green roofs with lightweight mineral wool growing media in different European climate conditions. The green roof heat and mass transfer model was developed and experimentally validated. It was then integrated into a developed software tool for the whole year analysis of the green roof thermal and hydrological performance. The results of performed numerical analysis showed that heat losses in heating season and heat gains in summer months of the green roof is smaller compared to the reference non-vegetated roof in all considered climate conditions and depends on thickness of lightweight mineral wool growing media and especially on the green roof's irrigation scenario. The results of numerical analyses also demonstrated that the water retention of green roofs can be considerably improved if irrigation scenario considers the weather forecast. The weather forecast based green roofs´ irrigation also improves retention at stormwater events.

NOTES

Integrating climate change in life cycle assessment of buildings: literature review

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The operational energy use and related greenhouse gas emissions of buildings are typically influenced by changes during the building service life such as climate change, technological evolution and energy mix evolution. Only few LCA studies consider these temporal variations. This paper investigates how climate change is currently considered in LCA studies. Three aspects related to the influence of climate change on the life cycle impact of buildings are focused on: (1) changes in operational energy use (heating and cooling) due to changes in the climatic context of the building, (2) changes in operational energy use due to technological evolution or climate regulations and (3) changes in energy mix due to climate regulations. All three influence the energy use and related environmental impact but the extent of the effect depends on the considered region, time step and environmental indicators. It is hence recommended to choose an appropriate time period when considering climate change in LCA and consider variations within a time period via dynamic building simulations or to include a static correction. A holistic set of impact categories should be focussed on to avoid burden shifting and the most influencing parameters should be checked via a sensitivity analysis.

NOTES

˝PET tool˝ – a software tool for lightweight extensive green roofs performance analyses

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Due to energy, environmental, and social benefits, green roofs are recognized as a bioclimatic technology and sustainable construction systems and are becoming a predominant solution in connection with urban planning and building envelope retrofitting. To support design and marketing of Urbanscape® lightweight extensive green roofs a special software tool was developed, which is presented in the paper. Performance evaluation tool (PET tool) is validated based on extensive and continuous 5-years in-situ monitoring of thermal and hydrological response of different Urbanscape green roofs. The key performance indicators of Urbanscape green roofs are evaluated based on calculated thermal and hydrological response. To emphasize the advantages of green roofs thermal response and performance indicators are determined also for non-vegetated roof for the same boundary conditions. PET tool enables i) evaluation of Urbanscape green roofs' whole year thermal and hydrological response, ii) to search for the optimal design of the Urbanscape green roof system in terms of energy and water performance, iii) evaluation of comparative advantages compared to non-vegetated roof, iv) energy savings and CO_2 emission reduction analyses for heating and cooling season. Analyses can be made for arbitrary worldwide climate conditions since meteorological parameters are gathered from Meteonorm database.

NOTES

CITIES 5

Greening the Infrastructure

Chair: Eike Roswag-Klinge
TU Berlin, Germany

Transition Towards
a Net Zero Carbon
Built Environment

Public procurement for carbon reduction in infrastructure projects – an international overview

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Carbon emissions emanating from infrastructure construction projects are substantial and stem primarily from production of construction materials and use of energy for construction transport and site activities. In recent years, public infrastructure clients world-wide have begun to include carbon reduction goals in their procurement requirements. This is however a new and complex field where practices vary and are still developing. In this paper, we compare models for carbon reduction requirements in infrastructure construction projects based on case studies of large projects in Australia, USA, the Netherlands, Sweden and UK. We found that open, functional carbon reduction requirements were considered innovative but entailed costs for calculating baselines and risks for speculation. Also, high time pressure in projects limits contractors' opportunities to explore reduction opportunities. Thus, specific, prescriptive requirements may play an important role in client-led, long-term innovation processes. Organizational competence and resources on the buyer side are essential, and policies for carbon reduction should aim to increase client capacity. Further, procurement practices are developed in mutual interaction between clients and suppliers over longer periods of time, which limits possibilities to transfer procurement policies and requirements between contexts.

NOTES

Influence of cross passages temperatures on the life-cycle cost of technical equipment in a railway tunnel

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In order to achieve the climate goals, the implementation of sustainable construction is becoming more and more topical in the construction sector. Due to very long service lifes especially in railway projects, the consideration of life-cycle aspects into the early design process is of great importance. Regarding the assessment of the economic pillar of sustainability, lifecycle costing has become an established method. This study presents the application of lifecycle cost analysis (LCCA) for decision aiding in railway construction. The two tunnel tubes of the project Koralmtunnel (KAT) are connected with approximately 70 cross-passages (CPs) at intervals of around 500 m. These CPs serve as escape-ways and additionally host utility rooms for technical equipment (telecomunication, power supply and remote control). First thermal simulations revealed indoor temperatures up to 80_C due to the heat release of the technical equipment without implementation of technical cooling systems in operation phase. This is caused by the limited heat transfer with the surrounding rock and with the adjacent running tubes. Therefore, the implementation of a cooling system is necessary. It is stated that higher indoor temperatures lead to reduced service lifes of the installed telecommunication systems. By the application of Arrhenius equation, the influence of several indoor target temperatures on the expected life time of the installed telecommunication systems has been determined. In order to meet target temperature requirements appropriate scenarios including different cooling scenarios have been designed. Finally, LCCA by application of the net-present value-method (NPV-method) was conducted in order to determine the most economical solution regarding CPs cooling systems based on selected target-temperatures.

NOTES

Integrated evaluation of energy and emission reduction potential and management strategies for urban road systems

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Solving the problems of high energy consumption and high emissions generated by the urban road systems is of great importance for the construction of low-carbon cities. Several tools have been developed to establish a method to evaluate the carbon emission related to the life cycle of road pavements. However, the lack of key basic data such as energy consumption, pollutants and carbon emissions, and accurate management policies have hindered the transition of urban roads to clean, low-carbon systems. The HERMES project aims to compile long-term dynamic inventory of urban road energy consumption and environmental emissions and build a life cycle model. The Data Envelopment Analysis model will be used to predict the energy saving and emission reduction potential of urban roads depending on the technological solution, establish a multi-criteria evaluation system that includes energy, environment, and economic parameters, identify the best available technological solution in different cities, and propose a more targeted and effective clean low-carbon management policies. The study will provide an accurate understanding of the environmental impact of urban roads in China and Europe, evaluate the potential for energy saving and emission reduction, and provide theoretical data and decision-making reference for a clean, low-carbon transition.

NOTES

Life Cycle Assessment of Alternative Road Base Materials: the Case of Phosphogypsum

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Phosphogypsum (PG) is the most abundant by-product generated by the phosphate fertilizer industry. Formed during the production of phosphoric acid from natural phosphate rock, PG is mostly disposed in stacks or released into coastal regions' waters. Due to the expected increase in the world PG production – currently estimated to be around 250 Mt per year – and the environmental impacts of actual waste management scenarios, there is a call for a paradigm shift, by considering PG not as a waste but as a resource. About 15% of the total PG production is nowadays used as fertilizer, retarder, road base material or building material. The load of radionucleids and heavy metals contained in PG however questions the sustainability of such valorization routes. This paper aims to compare the environmental impacts of different PG valorization scenarios through life cycle assessment. Based on Moroccan conditions for phosphoric acid production, it discusses the key parameters influencing the assessment as well as assumptions regarding the allocation of emissions and resource use over PG and phosphoric acid.

NOTES

PROCESSES 6

Monitoring & Data Analysis

Chair: Natalie Essig
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Transition Towards
a Net Zero Carbon
Built Environment

Large scale smart meter data assessment for energy benchmarking and occupant behaviour profile development

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This paper will present objectives and first results of the research project entitled "Large Scale Smart Meter Data Assessment for Energy Benchmarking and Occupant Behaviour Profile Development of Building Clusters," implemented in the geographical scope of Hungary. The project seeks to utilize a new and unique opportunity for accessing and processing an enormous dataset collected by smart meters. Recently in Hungary, nearly 10 000 buildings have been equipped with smart meters within the "Central Smart Grid Pilot Project". By means of advanced data analysis techniques, consumption trends and motivations of building users are being investigated. The aims are to help building designers and engineers design more energy efficient buildings at lower investment costs by avoiding system oversizing, and to obtain better knowledge about hourly, daily and monthly energy consumption trends. Furthermore, standard net demand values for normative energy calculations can be updated and specified more precisely since consumption habits change with time and depend on the region.

NOTES

Monitoring results of innovative energy-efficient buildings in Austria

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The objective of this paper is to present real-world energy monitoring and sustainability assessment results of innovative energy-efficient service buildings in Austria. In the investigated buildings, the energy flows for the supply and distribution of heating, hot water and cooling energy, the object-related electricity consumption and, if available, energy generation with PV and solar thermal systems were recorded during a period of at least twelve months. The room parameters temperature and relative humidity, and in some cases the CO_2 content were also monitored. The use behavior was described based on the users of the building as well as on the operation and parametrization of mostly fully automated energy facilities. The buildings were classified in a sustainability assessment according to the Austrian Total Quality Building (TQB-) system. The buildings investigated are three office buildings, a research laboratory building, a supermarket, a hotel, a nursing home, a culture and event center and a student dormitory. The main findings presented in this paper include energy efficiency potentials identified in the automated operation of the energy facilities in the investigated service buildings. Recommendations also relate to challenges of energy monitoring itself.

NOTES

An innovative user feedback system for sustainable buildings

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A lot of research is currently focused on studying user behavior indirectly by analyzing sensor data. However, only little attention has been given to the systematic acquisition of immediate user feedback to study user behavior in buildings. In this paper, we present a novel user feedback system which allows building users to provide feedback on the perceived sense of personal comfort in a room. To this end, a dedicated easy-to-use mobile app has been developed; it is complemented by a supporting infrastructure, including a web page for an at-a-glance overview. The obtained user feedback is compared with sensor data to assess whether building services (e.g., heating, ventilation and air-conditioning systems) are operated in accordance with user requirements. This serves as a basis to develop algorithms capable of optimizing building operation by providing recommendations to facility management staff or by automatic adjustment of operating points of building services. In this paper, we present the basic concept of the novel feedback system for building users and first results from an initial test phase. The results show that building users utilize the developed app to provide both, positive and negative feedback on room conditions. They also show that it is possible to identify rooms with non-ideal operating conditions and that reasonable measures to improve building operation can be derived from the gathered information. The results highlight the potential of the proposed system.

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Hook-and-Loop fastener – application for the technical building equipment

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The Hook-and-Loop fastener (better known for its commercial name Velcro®) is omnipresent in many fields today. Astonishingly it is far from utilizing its full potential in the construction industry although its properties could have a variety of positive effects on the industry. Commonly the building installation lines (such as electricity, water or ventilation, to name just a few) are walled-in, screwed, or glued at the construction site. Would these instead be assembled and mounted using the hook-and-loop similar fasteners, the following effects with corresponding consequences could arise. Simplified assembly processes: They would decisively accelerate the construction phase of a building and would additionally be less prone to performance-related quality deficiencies. Flexible mountings and adaptability: They would enable the building to react to short-notice planning changes as well as to adapt to a new spatial program more efficiently. Damage-free connections - both for the base-surface and for the component to be fastened to it - would enable a pure separation of different materials and thus easy re-use. The possibility of easy re-use of specific components could prolong the component's in-use phase of the lifecycle, which would contribute to sustainable usage of resources. The aim of this exploratory project was thus to develop concepts for the production of surfaces with hook-and-loop-compatible surfaces in buildings, which could serve as a base-surface for simplified mounting of building`s installation lines.

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Image-obfuscation as a means for privacy-conscious visual data acquisition from building systems

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In the last two decades, numerous studies have demonstrated the viability of using High Dynamic Range Imaging (HDRI) to quantify lighting conditions in the built environment. Several human factor studies have demonstrated correlation between visual comfort perceived by occupants and glare metrics calculated by analysing HDR images. However, the use of HDRI in real-world applications has been severely limited owing to privacy concerns. This research investigates the feasibility of employing obfuscated (i.e. deliberately distorted) HDR images for analysing glare. The authors present a pilot study where visual conditions inside an office-space were simulated and captured as HDR images using a validated, physically-based renderer. The images were then obfuscated to various degrees by application of blur filters. Glare metrics calculated for the obfuscated images, when compared with the metrics generated for the original HDR images, were found to be within 2%-12% relative error. The proof-of-concept demonstrated through this study provides the framework for field-testing of an HDR-based lighting control system in a real office space.

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The Three Sisters, klimaaktiv object of the month 12/2018

Kranzl M

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In the lakeside city of Aspern in the 22nd district of Vienna, the homebuilding association for private employees has established the residential complex “The Three Sisters” on the construction site D22, a plot of land measuring 5,200m². When planning the building envelope of the three buildings which range from four to six floors, the responsible persons consciously decided to use the Wienerberger “Porotherm 50 W.i. Plan” brick. Thus, the first multi-storey residential building project has been constructed using the latest brick generation. The use of a mineral and monocoque construction method makes a significant contribution to eliminating the need for petroleum-based full heat insulation. Therefore, the building complex can throughout be categorized as a low-energy building. Further notable advantages of the applied construction method and building design include the use of an exterior wall system without additional insulation (upgraded insulation on the outside) to obtain a U-value of 0.12 W/m²K which corresponds the passive house standards. The high demands of the construction design in terms of ecological, economical and socio-cultural quality of the three building components are reflected in the ecological selection of construction materials, the persistence of the building complex and the stability of value, as well as apartment sizes, assisted living, smart-start-apartments, integrated green space concepts, roof terraces, urban gardening, etc. The TQB certification with 769 out of 1000 points has been obtained and the project has been awarded with klimaaktiv GOLD to prove the quality of the project and ensure quality assurance and management.

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SPECIAL FORA

Transition Towards a Net Zero Carbon Built Environment

Level(s)[1] and its place in the tool box for sustainable construction

Andreas Rietz
Federal Institute of Research on Building, Urban Affairs and Spatial Development, Germany

Moderation:
Thomas Lützkendorf, Karlsruhe Institute of Technology

SUBJECT

Systems for describing, assessing and certifying the contribution of individual buildings to sustainable development are impor- tant tools for motivating building owners and assisting architects in the design process. So far, they are used in Europe for only a limited number of objects. potential users fear a high nancial expenditure for the collection of additional data and detailed documentation combined with additional costs for the certi cation process itself. Thus, the question arises for an additional entry point into the topic through the scope and type of sustainability assessment. Level(s) is a voluntary reporting framework for describing and documenting relevant building features with respect to their sustainability related characteristics.The Special Forum will discuss the role of Level(s) in the overall system of instruments and tools to promote sustainable design, construction and operation, and how interdependencies with other approaches can be shaped.

As part of the Special Forum, four presentations and a detailed discussion with all participants with inter- active elements are planned:

Presentation 1	Overview of the Level(s) framework/Results of test applications Josefina **Lindblom**, DG Environment, European Commission
Presentation 2	Level(s) in Austria – 2 case studies Martin **Röck** & Alexander **Passer**, TU Graz
Presentation 3	Results of Level(s) testing process in Denmark Harpa **Birgisdottir** & Kai **Kanafani**, Danish Building Research Institute
Presentation 4	Demand for building related information to support appraisal and green finance – (how) can Level(s) help? Ursula **Hartenberger**, Head of Sustainability, RICS
Presentation 5	Job sharing between Level(s) and Sustainability Assessment Systems Andreas **Rietz**, Head of Division Sustainable Building, BBSR

[1] http://ec.europa.eu/environment/eussd/pdf/factsheet_DEF.pdf

QUESTIONS

During the discussion with the participants the following questions will be discussed, among others:

(1) How can obstacles be overcome in the context of a broad application of design process accompanying sustainability assessment systems?

(2) What new approaches and indicators does Level(s) offer?

(3) What are the experiences with Level(s) in practical application?

(4) How can a division of labor between Level(s) and other instruments and tools designed to support sustainable planning, construction and operation?

The results of an interactive opinion-forming and the overall discussion are summarized and made available to the participants of the Special Session, the organizers of the SBE19 Graz and the European Commission.

„Die 3 Schwestern in der Seestadt Aspern Bauplatz D22“ – Paradebeispiel für nachhaltiges Wohnen

Natürlicher Baustoff Ziegel als ideale Voraussetzung für wohngesundes Bauen und Wohnen

Wienerberger Österreich GmbH

ÜBERBLICK - Vorstellung des Bauprojekts „Die Drei Schwestern“ in der Seestadt Aspern

In der Seestadt Aspern wurde auf dem 5.200 m^2 großen Baufeld D22 nach den Plänen der Kirsch ZT GmbH gestalteten Architektur die Wohnhausanlage „Die Drei Schwestern“ von der Wohnbauvereinigung für Privatangestellte (WBV-GPA) errichtet. Im Zuge der Planung der Gebäudehülle der drei mehrgeschossigen Baukörper (Bauteil A-NNA, B-ELLA, C-LARA) entschieden sich die Verantwortlichen gezielt für den Wienerberger „Porotherm 50 W.i. Plan“ Ziegel. Aufgrund der durchgängig in mineralischer und einschaliger Bauweise als Niedrigstenergiehaus errichteten Baukörper, wurde ein wesentlicher Beitrag zum Verzicht auf erdölbasierten Vollwärmeschutz geleistet. Das Gebäude erreichte bei der ÖGNB Gebäudezertifizierung 769 von 1000 Punkten und wurde mit klimaaktiv GOLD ausgezeichnet.
Im Zuge des Special Forums sollen die hohen ökologischen, ökonomischen und soziokulturellen Qualitätsansprüche der Planung diskutiert werden. Aspekte der Nachhaltigkeit spiegeln sich beispielsweise in der ökologischen Materialauswahl, Langlebigkeit, Wertbeständigkeit, etc. wider.

GEPLANTER AUFBAU DER MODERIERTEN DISKUSSION

Neben einer interaktiven Diskussion sind folgende Impulsvorträge geplant:

- Vorstellung des Gebäudes durch den Bauträger und Architekt
  Franz Pranckl (GPA-PlanungsgesmbH)
  Clemens Kirsch (Kirsch ZT GmbH)
- Erläuterung der beiden Nachhaltigkeitszertifizierungen von ÖGNB und klimaaktiv
  Franziska Trebut (ÖGUT)
  Robert Lechner (Ökologie-Institut)
- Informationen über das verwendete Baumaterial
  Mario Kubista (Wienerberger Österreich GmbH)
- **Round-Table mit Publikumsfragen**

Die Moderation wird von Fachjournalistin **Sabine Müller-Hofstetter** geführt.

CONDEREFF – European project regarding construction & demolition waste

Improve environment and resource efficiency and enhance reuse

Land Steiermark - A14 Abfallwirtschaft und Nachhaltigkeit

SUBJECT

In 2015, 10 million tons of construction and demolition waste have been generated in Austria. To foster a move towards circular economy and minimize this high amount, Styria is part of the EU project CONDEREFF. CONDEREFF is an interregional cooperation project, which brings together 8 partners from 7 countries to accelerate their policy work on improving resource efficiency at territorial level.

Furthermore, Styria has developed a guideline for the deconstruction of buildings to enhance the amount of recycled materials. The country aims to increase the volume of reused construction materials.

PRESENTATION

Four presentations are planned, focusing on:

Presentation 1 – CONDEREFF: interregional cooperation project (Construction & demolition waste management policies for improved resource efficiency)

Presentation 2 – Guideline for construction and demolition waste: implementation of reuse

Presentation 3 – Reuse in Styria: state of the art

Presentation 4 – Implementation of recycling in planning phase

DISCUSSION AND INTERACTIVE PARTICIPATION

During the discussion with the participants, following questions will be discussed:

- How to handle the separation duty, hazardous waste, appearing during demolition work, how to carry out the examination of contaminants and undesired substances and how to develop the recovery concept
- Practical problems occurring on-site
- Problem end of waste status and the transfer of construction materials to second parties
- Recycled construction materials/ recycling aggregate production, use and awareness raising activities
- How to implement reuse in public procedures and in regulatory framework
- How to implement reuse already in the planning phase
- Improvement of the construction and demolition waste management policy

The role of background databases in the environmental assessments of buildings: what is the way forward?

ecoinvent Association

Dimitra Ioannidou, ecoinvent
Gregor Wernet, ecoinvent
Marisa Vieira, PRé Sustainability

SUBJECT

The availability of accurate and up to date life cycle inventory (LCI) data is important to support environmental decision making in the construction sector. However, as the data needs of life cycle assessment (LCA) practitioners, including those working in Environmental Product Declaration (EPD), continuously evolve, the role and structure of background LCI databases must also develop to ensure that the needs of users are met. The ecoinvent Association, which publishes and manages one of the largest global LCI databases, is organising this forum to provide information on and discuss the role of background databases in environmental decision making and EPD creation.

In the first part, the ecoinvent Association will provide an overview of the latest updates to the ecoinvent database in relation to the construction sector and the EN 15804 standard. In the second part, a variety of users, including stakeholders with policy backgrounds, will provide their inputs and insights on the amended standard and on potential challenges regarding data. The forum will conclude with a general discussion with participants on the role of background databases related to EPDs.

QUESTIONS TO BE DISCUSSED

The participants are invited to provide their insights and experiences with using background datasets for Environmental Product Declarations or Product Environmental Footprints. Among others, the following questions will be addressed:

- What are the expectations of users in a background database, especially with respect to EPDs?
- What should be the role of a background database in supporting efforts to harmonise different methodological approaches, choices and assumptions used in EPDs and LCA?

Implementing BWR 7 „Sustainable Use of Natural Resources“ in Europe

Peter Maydl, Graz University of Technology
Thomas Lützkendorf, Karlsruhe Institute of Technology
Alexander Passer, Graz University of Technology

SUBJECT

In 2013, Construction Products Regulation (CPR) has come into force including the new Basic Work Requirement (BWR) 7 “Sustainable use of natural resources”. Although CPR is well established and BWR 7 is in this context a legal demand, it is not yet common practice to take it into account in most of the member states. One of the reasons may be the current wording, which sometimes lacks in clear definitions (e.g. “environmentally compatible raw materials”). In 2020 CPR will be modified by the EC. This is a good opportunity to create a better wording, to ask for more clarity in the case of targets, assessment rules and ways for communication.

Therefore, it is interesting how member states handle these questions and how they are prepared for. This Special Forum shall give the opportunity to all participants to discuss the present situation and future possibilities, exchange experiences from different member states, experts and involved parties and to develop some suggestions for a more precise concept and wording.

OPENING STATEMENTS/ IMPULSE-LECTURES

- Presentation by Manfred Fuchs, DG GROW, European Commission: What European Commissions intends with BWR 7
- Thomas Lützkendorf, Peter Maydl and Alexander Passer: Handling BWR 7 in practice: obstacles, opportunities and proposals for a new wording within a next generation of CPR
- Robert Jansche, Provincial Government od Styria, OIB – Austrian Institute of Construction Engineering: Implementing BWR 7 from the perspective of a national legislative body
- Representative from construction materials industry

Discussion with the possibility of interactive participation

- analyse EC´s intentions and expectations in terms of implementing BWR 7 in the context of the new CPR
- share experiences made in the member states so far
- discuss proposals for an amended BWR 7
- assess the need for action
- develop recommendations for a change of the current BWR 7

Certified Sustainability: Should the VinylPlus® Product Label be Integrated in Existing Sustainability Label Schemes for Buildings?

Heinz G. Schratt
PlasticsEurope Austria, industry spokesperson for all plastics, representative of VinylPlus®

SUBJECT

Sustainability and PVC may go together well—admittedly not all PVC, and not all applications. Hence, it is the goal of industry to provide a tool for the specifier to discriminate between PVC that fits and supports a sustainable built environment. The PVC value chain demonstrates the thinking and the science behind their new VinylPlus® Product Label and invites participants to discuss the potential of that very label, which is being applied to qualified window frames from May 2018.

Long service time of all construction elements and, consequently, of the entire building is in the core of sustainability. The most common materials in B&C undoubtedly provide such longevity: concrete, steel, glass… but so do certain plastics, particularly PVC, in pipes, window frames, roofing and waterproofing membranes, flooring, and coated fabrics ("textile architecture").

However, not all PVC is created equal. Process technology and/or formulations (additives) of PVC may vary. It is this state of uncertainty that led many environmentalists to putting Vinyl under general suspicion and to discourage the use of PVC. Nevertheless, in the right applications, using PVC might substantially contribute to sustainability.

TOPICS TO BE DISCUSSED

Formal presentations

- The four system conditions of TNS – The Natural Step
  A scientific basis for a sustainable development | Richard **Blume**, Senior Consultant, TNS
- Overview of popular evaluation schemes for „Sustainable Buildings“ in the D-A-CH region | Austrian Ministry of Sustainability and Tourism (tbc)
- Documentation of „Responsible Sourcing“ as a central requirement for sustainability assessment | *N.N., VinylPlus®*
- Presentation of the VinylPlus label | Heinz G. **Schratt**, Secretary General PlasticsEurope Austria

AUDIENCE DISCUSSION / PANEL DISCUSSION

- Open questions
- Pros and cons of the VinylPlus product label

- A fundamental paradigm shift inside the PVC industry versus a “marketing smokescreen”?
- Status quo: Does the label make life easier for the sustainability schemes and/or their auditors?
- Should the VinylPlus product label be integrated in existing or future sustainability label schemes for buildings?
- Other topics from the participants
- Conclusions

EPD thought through to the end?

Proposals how to deal with the modules C and D in Environmental Product Declarations (EPD)

Eva Schmincke, Thinkstep AG Tübingen
Thomas Lützkendorf, Karlsruhe Institute of Technology

SUBJECT

A pre-requisite to achieving circular economy as contribution to resource efficiency and environmental relieve is the provision of appropriate information. The amended EN 15804+A2 requires the calculation of environmental impacts during modules C (End-of-Life) and D (recycling potential).

Questions resulting from such requirements will be discussed in this forum. We will show the results of a project funded by the German federal EPA, which essentially describes the involvement of the waste management industry (recycling, recovery, incineration) with the calculation of the environmental performance of construction products.

QUESTIONS TO BE DISCUSSED

- How to deal with Modules C, considering different possibilities of dismantling, recovery processes and national waste management regulations within Europe?
- Companies dealing with waste management or recycling have the relevant experience and access to data needed for the quantification of modules C and D. How can this knowledge be applied in EPD?
- How to model the Lifecycle (focusing on EoL) of complex products, e.g. windows or thermal insulation composite systems (ETICS)?
- Is it possible to include the product category rules for the calculation of the EoL stage in product standards?

IMPULSE – LECTURES

- Who is afraid of module C? New approaches and solutions for EoL in EPD
- Why do the waste industries not participate in developing product category rules for EoL scenarios in EPD?
- Traps to be considered when developing recycling routes.

Possibility of interactive participation in the discussion for all participants
Technical equipment for everybody's participation is provided

Beton als Baustoff - wieviel ist uns Nachhaltigkeit wert?

Bewertung, Kosten und Mehrwert von Stahlbeton für Infrastrukturbauleistungen

Joachim Juhart
Graz University of Technology, Institute of Technology and Testing of Construction Materials

INHALT

Beton bzw. Stahlbeton ist aufgrund seiner hervorragenden Eigenschaften der für Infrastrukturbauwerke weltweit meist verwendete Baustoff. Diesen Baustoff nachhaltig herzustellen – also Ressourcen effizient, umweltfreundlich, dauerhaft und wiederverwertbar – ist ein erstrebenswertes Ziel in Zeiten des Klimawandels.

Folgende Themen und Fragen werden in dem Workshop diskutiert:

- Wie wird Nachhaltigkeit speziell in Bezug auf Betonbauwerke spezifiziert?
- Wie können Nachhaltigkeitskriterien der Baustoffe Beton und Betonstahl in Ausschreibung und Vergabe von Bauleistungen berücksichtigt werden?
- Kostet nachhaltiger Beton mehr als Standardbeton oder ist er sogar günstiger?
- Welchen Mehrwert in Bezug auf Umweltfreundlichkeit, Ressourcenschonung etc. bringt nachhaltiger Stahlbeton für die Gesellschaft? In welcher Maßeinheit wird dieser Mehrwert gemessen?
- Wie sind Umweltauswirkungen und die Lebensdauer von Stahlbeton zu monetarisieren?

MODERIERTE DISKUSSION UND INTERAKTIVE TEILNAHME

Impulsvorträge im Rahmen des Forums:

- **Definition von „nachhaltigem Stahlbeton“**
  Umweltwirkungen, Dauerhaftigkeit und Kreislauffähigkeit von Beton; Ökozemente, Ökobetone, Lebensdauer und Performance [J. **Juhart**, TU Graz]

- **Ökobilanz von Betonstahl - eine Einordnung der Ergebnisse in Österreich**
  [A. **Passer**, TU Graz]

- **Die Schweizer „Ökobilanzdaten im Baubereich“ – Grundlage zur effizienten Umweltbeurteilung von Gebäuden und Baustoffen**
  Datengrundlagen (Ecoinvent etc.) und Bewertung am Beispiel Schweiz
  [R. **Frischknecht**, treeze Ltd- Life Cycle Assessment]

- **Environmental Cost Indicator: its application in tendering in the Netherlands (MKI („Milieukostenindex“) – Ausschreibungspraxis in den Niederlanden)**
  Kosten für Umweltauswirkungen von Umweltindikatoren von Beton
  [U. **Hofstra**, SGS Intron]

- **Weiße Wanne plus – ein Standard für nachhaltiges Bauen mit Stahlbeton in Österreich?**
  Bewertung, Kosten und Performance bezüglich Nachhaltigkeitskriterien am Beispiel Weiße Wanne
  [ÖBB bzw. ASFINAG, A. **Hüngsberg** / M. **Kleiser**]

Plastics in Sustainable Building & Living: Protection of Health and the Environment

International Sustainable Chemistry Collaborative Sentre (ISC3)

SUBJECT

International Sustainable Chemistry Collaborative Centre (ISC3) is a new international organisation founded by the German environmental ministry with its Headquarters in Bonn. It is aiming at sustainable solutions for chemicals. Among other topics the ISC3 has a workstream Plastics in Sustainable Building & Living. The centre has installed an expert group to prepare a transparent report that will show the innovative fields in the construction sector and provide guidelines for industry, politics and consumers, on how to drive construction products towards sustainability in sense of SDGs. ISC3 is in dialogue with stakeholders from academia, industry, NGOs and international organisations. The fundamental questions in workstream are: How to drive construction products towards sustainability in sense of SDGs? And, what are the most relevant innovative areas and potentials for Sustainable Chemistry in the field of Building, Living and Plastics? The current workshop is devoted to the topic Protection of Human Health and the Environment aiming at Polymers in Building and Living area.

THE GOALS OF THE WORKSTREAM ARE:

- to transform chemical products in building and living towards Sustainability
- to give impulses for the research and entrepreneurship
- to investigate the innovative fields and set the agenda for the near future
- to show the potentials for the Sustainable Chemistry regarding SDGs

The following questions will be discussed at the workshop:

- Where do plastic materials provide benefits for affordable housing in times of rapid urbanisation without compromising health and the environment?
- Which plastics might be substituted for health and environmental reasons?
- What are alternative solutions for plastic products?
- What properties and special features of plastic products contribute to sustainability?
- How can construction plastics be reused and/or recycled at the end of their lifecycle?
- What plastics are subject for concerns regarding waste and emissions throughout the lifecycle?

At the workshop the following presentations are planned:

Welcome and Introduction

- Introduction of ISC3 – C.Cinquemani, Director Science & Innovation
- Workstream Plastics in Sustainable Building & Living, O.Ditkovskiy, Workstream Manager
- Preliminary Study Plastics in Construction, Prof. Dr. H. Friege, Leuphana University

Session 1 TBC

- Presentation: LEVELS Framework – EU Commission, DG Environment (TBC)
- Presentation: Application of Building Physics for Climate Change Mitigation, Czech Technical University (TBC)
- Presentation: Plastics & Environment, President of Think Beyond Plastics (TBC)
- Presentation: Plastics in Building, Plastics Europe (TBC)

Session 2:

- Discussion on the leading questions in a round table with all participants

Was leistet grüne Infrastruktur in stark verdichteten Städten und wie lässt sie sich weiter ausbauen?

Handlungsspielräume zur Erhaltung lebenswerter und kooperativ genutzter Städte

green.LAB Graz Projektkonsortium

INHALT – VORSTELLUNG green.LAB GRAZ

Green.LAB Graz ist ein aktuell stattfindendes angewandtes Forschungsprojekt im Smart City Stadtteil in der Waagner-Biro in Graz. Das green.LAB Graz verfolgt das Ziel, Erkenntnisse über grüne Infrastruktur als eine zentrale Klimawandelanpassungsmaßnahme in Städten zu gewinnen und zu vermitteln.
Grüne Infrastruktur kennen lernen, erleben sowie selbst umsetzen und mitgestalten ndet innerhalb drei verschiede- ner Schwerpunkte und Herangehensweisen statt:

- innovative Zwischennutzungen von Brachflächen unter Bezugnahme auf das Thema grüne Infrastruktur und Klimawandelanpassung als strategisches Instrument einer nachhaltigen Stadtteilentwicklung praxisnah und ko- operativ umzusetzen
- ein innovatives Demogebäude zu errichten als Weiterentwicklung der „Urban Boxes" in Richtung transportabler modularer Holzbau in Kombination mit Bauwerksbegrünung, Biodiversität, Stadtteilgarten, Regenwasserma- nagement, ef zienter Energieversorgung und Einsatz erneuerbarer Energiequellen
- Spezifizierung eines technischen Monitoring-Systems inkl. Messgrößen sowie Maßnahmen zur Auswertung des „social impacts"

GEPLANTE INHALTE DER IMPULSVORTRÄGE

- Aufzeigen der Problemstellung und des Bedarfs für das Vorhaben Modulare Bausysteme mit integrierter Begrünung als Elemente nachhaltiger Stadtentwicklung
- Warum macht grüne Infrastruktur für verdichtete Städte und Stadtteile Sinn? Welche Kriterien und Maßnahmen können zur Auswertung des „social impacts" herangezogen werden?
- Aufzeigen von Zwischennutzung von Brachflächen in Kooperation mit lokalen Initiativen als strategisches Ele- ment für eine nachhaltige Stadtentwicklung. Der Frage nachgehen, inwieweit Möglichkeiten der Replizierbarkeit von Zwischennutzungen bestehen.
- Welche Fördermöglichkeiten bestehen für die Umsetzung grüner Infrastruktur in Graz?
- Vorstellung der begrünten Uniqua-Fassade in der Annenstraße in Graz

MODERIERTE DISKUSSION UND TEILNAHME DURCH DAS PUBLIKUM

Begehung des Projektgebiets Smart City und vorstellen der Aktivitäten des green.LAB Graz, Erfahrungsaustausch mit AkteurInnen im Bereich Stadt- und Bauwerksbegrünung und Motivation der TeilnehmerIn- nen / BesucherInnen zur Umsetzung von Begrünungsmaßnahmen, Bewusstseinsbildung über Kosten und Nutzen von Grünflächen, Vernetzung.

Holzbau im urbanen Raum – eine Chance für Städte?

Holzcluster Steiermark

STADT GEMEINSAM ENTWICKELN

Vortragende: **Barbara Hammerl** / StadtLABOR GmbH

Die Zukunft der Städte stellt uns vor große Herausforderungen und offenbart gleichzeitig enorme Potentiale für die Stadtentwick- lung. Entlang bestehender Infrastrukturen wird, wie beispielsweise in Graz, verdichtet und eine Stadt der kurzen Wege entsteht. Welche Aspekte der nachhaltigen Stadtteilentwicklung werden dabei berücksichtigt? Wie verändert sich das Mobilitätsverhal- ten der Menschen? Welche Bedeutung bekommt die Gemeinschaft? Wie kann kooperative Planung gelingen?

URBANER HOLZBAU – Holzbau 2.0

Vortragende: **Markus Lager** / Architekturbüro Kaden+Lager

Nur wenige Referenz- und Leuchtturmprojekte wurden bislang im mehrgeschossigen Wohnbau bzw. im Nichtwohnbau (z. B. Büro- und Verwaltungs- oder Industriegebäude) in Holz errichtet. Dies obwohl die technischen und wirtschaftlichen Vorteile des Baustoffs auf der Hand liegen, wenn es darum geht, den wachsenden Bedarf an bezahlbarem Wohnraum in den Städten zu decken. Kurze Bauzeiten, ein geringes Gewicht bei hoher Tragfähigkeit und Flexibilität bei der Aufstockung von Gebäuden oder der Wohnraumerweiterung sind Pluspunkte gerade bei der Nachverdichtung im urbanen Raum.

LEAN WOOD – Optimierte Planungsprozesse für Gebäude in vorgefertigter Holzbauweise

Vortragende: **Sandra Schuster** / Technische Universität München

Der moderne Holzbau zeichnet sich durch die Produktion von Bauelementen in der Werkstatt mit hohem Vorfertigungsgrad aus. Die Vorfertigung ist eine Prämisse der Wirtschaftlichkeit sowie der Qualitätssteigerung, erfordert aber eine vertiefte Pla- nung, die die Fertigung der Bauelemente, deren Transportlogistik und die Montage berücksichtigt. Für einen störungsfreien Planungs- und Bauablauf beim vorgefertigten Holzbau ist die heute übliche Projektorganisation mit den separierten Einzel- schritten Planung, Ausschreibung, Produktion und Montage eine große Erschwernis.

MODERIERTE DISKUSSION UND INTERAKTIVE TEILNAHME

Fragestellungen der Diskussion:

- Warum hat der Holzbau eine Schlüsselfunktion in der wachsenden Urbanisierung?
- Wie kann die Leistungsfähigkeit des Holzbaus weiter verbessert und der Einsatz forciert werden?

Realising Smart City Graz

Implementation of Innovative Urban Demonstration Projects at City and District Level

Kai-Uwe Hoffer
Smart City Coordinator, City of Graz

OVERVIEW

Realising Smart City Graz -
Implementation of Innovative Urban Demonstration Projects at City and District Level

Since 2013 the Smart City Graz Strategy is legally effective as an integral part of the Urban Development Concept 4.0. It can be seen as innovation strategy for an integrated application and implementation of sustainable development projects at city and district level. The strategy paves the way to develop Graz into a „Smart City“ and to become an energy-efficient, resource-conserving and low-emission city of the highest quality of life.
Its focus lies above all on human needs of the urban population than on technology applications as an end in itself.

At the SBE19, the City of Graz and its development partners of the first Smart City projects invite all participants to discuss experiences, insights and possible needs for adapting this strategy.

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Bauen und Sanieren

Mit zukunftsfitten Gebäuden zur #mission2030

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Das Programm Bauen und Sanieren ist ein zentraler Baustein von klima**aktiv**, der Klimaschutz-Mitmachbewegung des BMNT. klimaaktiv.at/bauen-sanieren

Die #mission2030, die Klima- und Energiestrategie der Bundesregierung, setzt klare Ziele, um den Weg in eine positive Klimazukunft zu ebnen. Der Gebäudebereich ist dabei ein zentraler Hebel zur Erreichung dieser Ziele. Daher hat das Bundesministerium für Nachhaltigkeit und Tourismus (BMNT) mit dem klima**aktiv** Gebäudestandard ein zukunftsorientiertes Gütesiegel entwickelt.

Qualität und Sicherheit

Der klima**aktiv** Gebäudestandard ist für Wohnbauten und Dienstleistungsgebäude für Neubau und Sanierung verfügbar und gibt Hilfestellung für Immobilienentwickler, Architektur- und Bauschaffende, Wohnbauträger genauso wie für alle, die ein Haus bauen, sanieren oder nutzen.

Das klimaaktiv Bewertungssystem

Energieeffizienz und erneuerbare Energien stehen im klima**aktiv** Bewertungssystem für Gebäude im Mittelpunkt, aber auch viele weitere Aspekte werden berücksichtigt. So spielen Gesundheit und Komfort, die Umweltverträglichkeit der Baustoffe und die Wirtschaft eine wichtige Rolle.

Eine Erfolgsgeschichte

Rund 800 Gebäude wurden bislang nach den Qualitätskriterien errichtet und bewertet. klima**aktiv** ist damit europaweit das erfolgreichste und gleichzeitig anspruchsvollste Gütesiegel für nachhaltiges Bauen und definiert die höchsten Anforderungen im Bereich Energieeffizienz.

Zentrale Anlaufstelle für alle Fragen zum Bauen und Sanieren nach klima**aktiv** Standard ist die ÖGUT GmbH. Das Programm wird in allen Bundesländern von Partnern unterstützt.
E-Mail: klimaaktiv@oegut.at

Mit klimaaktiv nachhaltig Bauen und Sanieren

Energieeffizienz, ökologische Qualität, Komfort und Ausführungsqualität – dafür steht klima**aktiv** Bauen und Sanieren. Ob Neubau oder Gebäudesanierung – beides stellt für BauherrInnen und ArchitektInnen eine große Herausforderung dar. Ganz speziell dann, wenn eine Sanierung höchste Ansprüche erfüllen muss. Der klima**aktiv** Gebäudestandard bietet dabei Orientierung und Unterstützung. Er ist das österreichweite Qualitätszeichen des Bundesministeriums für Nachhaltigkeit und Tourismus für nachhaltige Gebäude mit besonderem Fokus auf Klimaschutz und Energiesparen. Mit klima**aktiv** wird die Einhaltung hochwertiger Standards in folgenden Bereichen garantiert:

- **Niedriger Energieverbrauch:** Der Wärmebedarf wird gegenüber Standardbauten um rund ein Drittel reduziert.
- **Mehr Behaglichkeit:** Durch hochwertige Dämmung wird ein hohes Maß an Behaglichkeit im Sommer und im Winter erreicht.
- **Raumluftqualität und Gesundheit:** Durch das Zusammenspiel von schadstoffarmen Baustoffen mit automatischen Lüftungsanlagen werden höchste Ansprüche bei der Raumluftqualität erfüllt.
- **Ausführung und Wirtschaftlichkeit:** Hohe Qualität bei der Planung und Ausführung sind die Basis für langfristige Wirtschaftlichkeit.

Musterhaft saniert mit neuem Gesicht

Bauten aus den 1950er bis 1980er Jahren bauphysikalisch und energetisch auf Stand zu bringen ist eine herausfordernde Aufgabe. Die Fakultät für Technische Wissenschaften der Universität Innsbruck stammt aus dem Baujahr 1969 und ist nach ihrer Neugestaltung und Sanierung nun Vorbild im Bereich zukunftsorientiertes, klimaschonendes Bauen. Nicht nur was die energetische Performance angeht ist das Passivhaus beispielgebend, sondern auch im Hinblick auf die gelungene Zusammenarbeit vieler Beteiligter. Das Gebäude wurde für den Staatspreis Architektur und Nachhaltigkeit 2017 nominiert und erreicht mit 1.000 Punkten den klima**aktiv** Gold Standard.

klimaaktiv Gebäudestandard sorgt für Qualität und Sicherheit

Der klima**aktiv** Gebäudestandard ist ein idealer Leitfaden, um energieeffizientes, ökologisches und behagliches Wohnen sowie Arbeiten zu garantieren – sei es im Falle eines Neubaus oder einer qualitativ hochwertigen Sanierung. Über 800 Gebäude wurden bislang nach den Qualitätskriterien errichtet und bewertet. Damit kann klima**aktiv** die bei weitem höchste Anzahl an deklarierten Gebäuden sowohl im Neubau als auch in der Sanierung in Österreich aufweisen.

Über klimaaktiv Bauen und Sanieren

Das Programm klima**aktiv** Bauen und Sanieren ist ein zentraler Baustein der Klimaschutz-Mitmachbewegung des Bundesministeriums für Nachhaltigkeit und Tourismus, wenn es um energieeffizienten Neubau oder eine qualitativ hochwertige Sanierung geht.

Mehr Informationen zum Programm finden Sie auf **www.klimaaktiv.at/bauen-sanieren**

Alle Details zur Gebäudebewertung und den Kriterienkatalogen finden Sie auf **www.klimaaktiv.at/bauen-sanieren/gebaeudedeklaration**

Zentrale Anlaufstelle für alle Fragen zu klima**aktiv** Bauen und Sanieren ist die ÖGUT GmbH – Österreichische Gesellschaft für Umwelt und Technik.
E-Mail: **klimaaktiv@oegut.at**

Bauphysikalisch und energetisch auf Stand bringen war ein zentrales Ziel der Sanierung der Fakultät für technische Wissenschaften der Uni Innsbruck – ATP architekten ingenieure

Das Gebäude erreicht mit 1.000 Punkten den klima**aktiv** Gold Standard.

Fotos: Kurt Hörbst

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