Guillaume Habert, Arno Schlueter (eds.)

SBE16
ZURICH

EXPANDING BOUNDARIES

Systems Thinking in the Built Environment

Sustainable Built Environment (SBE) Regional Conference Zurich 2016



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Sustainable Built Environment (SBE) Regional Conference Zurich 2016

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Preface

Consuming over 40% of total primary energy, the built environment is in the centre of worldwide strategies and measures towards a more sustainable future. To provide resilient solutions, a simple optimisation of individual technologies will not be sufficient. In contrast, whole system thinking reveals and exploits connections between parts. Each system interacts with others on different scales (materials, components, buildings, cities) and domains (ecology, economy and social). Whole-system designers optimize the performance of such systems by understanding interconnections and identifying synergies. The more complete the design integration, the better the result.

System thinking theory is referring back to the early work of Donella and Dennis Meadows at MIT in the group created by Jay Forrester on System Dynamic. These theories have then been applied with success in many contexts. The application to the built environment is relatively new but is promising as buildings become more and more complex as well as interconnected.

System thinking is inherently linked to system boundaries. Spatial boundaries raise question such as where does the building stop and where does the neighbourhood start? Should we consider buildings as singular objects or as part of an infrastructure? Is it more effective to improve single buildings or entire districts? Temporal boundaries considerations can promote the use of dynamic assessment methods, which at each moment consider the real production and consumption of a system in order to calculate the environmental impact of energy positive neighbourhoods. Finally, expanding system boundaries also involves considering more than one single aspect of sustainability. Recent work focuses on a better description of the positive economic impact that new approaches and technology might have. Embracing the complexity of a socio-technical system such as the built environment is then difficult but seems to be required in order to propose grounded solutions for designers, planners and policy-makers.

In this book, the reader will find the proceedings of the 2016 Sustainable Built Environment (SBE) Regional Conference in Zurich. Papers have been written by academics and practitioners from all continents to bring forth the latest understanding on systems thinking in the built environment.

The editors would like to thank all participants for the inspiring conversations and extensive exchange of experience during the conference. We thank the authors of the papers for their efforts to provide outstanding and rigorous contributions. Finally, the editors are grateful to the various organisations and companies as well as the organising team for making this conference and these proceedings a success.

With kind regards,

Guillaume Habert, Arno Schlueter

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NNBS
Netzwerk Nachhaltiges Bauen Schweiz
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Network Costruzione Sostenibile Svizzera
Sustainable Construction Network Switzerland

UNEP Sustainable Buildings and Climate Initiative
Promoting Policies and Practices for Sustainability

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01
Topic & Program

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Systems Thinking in the Built Environment

Sustainable Built Environment (SBE)
Regional Conference Zurich 2016

Introduction

Consuming over 40% of total primary energy, the built environment is in the focus of worldwide strategies and measures towards a more sustainable future. To provide resilient solutions, a simple optimisation of individual technologies will not be sufficient. In contrast, whole-system thinking reveals and exploits connections between otherwise disparate parts. Each system interacts with others on different scales (materials, buildings, cities) and domains (ecology, economy, social).

The need for such system thinking is reflected by the current shift in research from the perspective of single buildings to small urban neighborhoods and districts. The expansion of system boundaries opens up vast opportunities for interaction and synergies but also poses challenges due to an increase in complexity.

The SBE Regional Conference Zurich 2016 acted as a platform to discuss this shift between students, researchers and professionals and to foster system thinking in the built environment. The conference took place from June 13 to 17, 2016. SBE16 Zurich formed part of the international SBE series of conferences focusing on a sustainable built environment. It was accompanied by keynote speeches, workshops, and site visits to recent, cutting edge building projects in and around Zurich.

On behalf of the hosts and organisers of this event – the city of Zurich, ETH Zurich, and the Swiss Federal Office of Energy – we would like to thank all participants for joining us in Zurich!

below:
View of Zurich, © Zürich Tourismus.

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A set of key conference topics were defined to prompt paper submissions that cover different aspects and scales of systems thinking. These key topics determined the content and structure of the main conference sessions.

Distributed Energy Systems and Infrastructure
Harnessing local, renewable energy sources is key to facilitate the transition towards low carbon energy systems. Rather than centralized and hierarchical, renewable energy generation will be increasingly decentralized, distributed and stochastic, which implies different strategies for design and operation. This calls for multi-scale modelling, simulation and analysis of different spatial and temporal resolutions, including the assessment of uncertainty and robustness. Understanding occupants and inhabitant's behaviour and comfort requirements leads to improved design and control of energy supply systems. Spatial distribution, local production and storage also demands considering urban morphology, infrastructure networks and potential links to transportation systems.

Life-Cycle Oriented Approaches
The consideration of all phases of the so-called life cycle of a building or a material is required when promoting new solutions for the built environment. Actually, the necessary quantification of the energy and materials needed for the production of products is not sufficient and a life cycle approach, integrating the energy and materials required during their use and demolition has to be considered. System boundaries of the studied objects are expanded from the cradle to the grave of objects, or even cradle to cradle when waste from one system can be used as new resources for a regenerated new one.

Integrated Approaches and Tools for Decision-Making
Systems thinking and integration is key to identify interdependencies and harness synergies between energy systems, material flows, urban form, program, transport and infrastructure. This requires new approaches, methods and tools to design, model and analyse such systems on different scales, from building to urban scale. Resulting tools need to address different stakeholders in design, planning, industry and public bodies.

Innovative Materials and Components
The new approach developed through systems thinking induces a new perception of resources available for construction and operation of our built environment. For instance, the appropriate use of low processed resources allows to develop low environmental impact building materials. But this approach also leads to new material and component needs such as components able to be reused and easily dismantled or new sensors for multi-scale and multi-criteria modelling such as radiant heat measurement.

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SBE16 Zurich Program

Seeking to involve different interested parties, the SBE16 Regional Conference in Zurich offered a varied yet well-coordinated conference program. It addressed students and academic scholars as much as planners, industry leaders and public representatives. The program combined lectures, discussions and tutorials with site visits and informal gatherings.

Workshops
SBE16 Zurich offered half-day, 1-day and 2-day workshops which – each in their own way – grasped the topic of the conference. These workshops took place on June 13-14 and thus represented a practice-oriented beginning of the conference. They aimed to provide an opportunity for students, researchers and professionals for focused debates as well as hands-on experiences and explorations of new methods or technologies. The workshop results were presented following the opening program on Wednesday.

Keynote Speakers
The SBE16 Zurich organising committee invited five renowned scholars and industry leaders to contribute to the conference through keynote lectures and to discuss the topic of sustainability in the context of built environments. Keynote speakers were Koen Steemers, Peter Edwards, Chrisna du Plessis, Serge Salat and Jens Feddern.Their lectures represented the theoretical frame of the conference. They have been recorded and can be viewed online. The individual links to each recording can be found in chapter *03 – Keynote Speakers*.

Poster Presentations
Short Poster Presentations of 1min each allowed to introduce the poster contributions which were on display in the foyer throughout the week.

Conference Sessions
Conference Sessions took place on June 15-17 and were divided into the four main conference topics as described above. Lectures of 15 minutes were followed by 5 minutes of Q/A. A detailed session schedule is provided on the following pages and papers of both poster presentations and conference sessions have been listed in chapter *05 – Conference Papers*.

Panel Discussion
On Friday morning, following the keynote lecture, participants gathered in the main lecture hall for a panel discussion with invited experts from science, industry, planning and public administration. Under the title <Smart humans or smart meters? – The role of human and technology for a future sustainable built environment> each speaker brought his/her individual background to the table.

Site Visits
A range of recent, cutting edge building projects in and around Zurich was selected to accompany the theoretical debate of the conference with practical examples. Conference participants had the choice between five site visits conducted by the respective project leaders or otherwise involved personnel. These visits took place on Thursday and Friday afternoon.

Social Events
In addition to the formal program, the organising committee invited all participants to join the social gatherings on Tuesday and Thursday. The main conference part was kicked off with a Welcome Apéro in the ETH Dozentenfoyer overlooking the city of Zurich while the Conference Dinner at the g27 restaurant was a great opportunity to further discuss the outcome of the conference in a more informal setting.

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below:
Overview of the SBE16 Zurich
conference schedule, June 13 – 17, 2016.

Mon, June 13	Tue, June 14	Wed, June 15	Thu, June 16	Fri, June 17
Workshops	Workshops	Opening Program	Keynote Chrisna du Plessis	Keynote Jens Feddern
		Keynote Koen Steemers	Keynote Serge Salat	Panel Discussion
		Poster Presentation / Coffee Break		
		Keynote Peter Edwards	Conference Sessions	Conference Sessions
		Presentation Workshops		
		Lunch Break		
		Conference Sessions	Conference Sessions	Conference Sessions
		Coffee Break	Site Visits	Closing Program
		Conference Sessions		**Farewell Coffee** / Site Visit
	Welcome Apéro		Conference Dinner	

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SBE16 Zurich Poster and Session Schedule

Poster Presentations

Posters were displayed in the conference foyer for the entire duration of the conference. We invited all poster authors to give a short presentation of 1 minute according to the schedule below. For the purpose of this book, poster presenters were asked to provide full papers. These have been allocated to the four conference topics and are included in chapter *05 – Conference Papers*.

Poster Session 1

June 15 / 10:30–10:45

Annette Hafner – Ruhr-University Bochum
Paolo Civiero – Sapienza University of Rome
Karina Krause – Ruhr-University Bochum
Nazanin Eisazadeh – KU Leuven
Alexandra Saur – Lucerne University of Applied Sciences and Arts
Lavinia Chiara Tagliabue – Politecnico di Milano
Daia Zwicky – HEIA Fribourg
Aoife Anne-marie Houlihan Wiberg – The Research Centre on Zero Emission Buildings, Trondheim
Sergi Aguacil – EPF Lausanne
Mehmet Aksözen – ETH Zurich

Poster Session 2

June 16 / 10:30–10:45

Lisa Wastiels – Belgian Building Research Institute
Catherine De Wolf – Massachusetts Institute of Technology
Herbert Claus Leindecker – University of Applied Sciences Upper Austria
Christian Steininger – Vasko + Partner Ingenieure, Vienna
Ferdinand Oswald – Graz University of Technology
Junjing Yang – National University of Singapore
Azza Kamal – The University of Texas at San Antonio
Eric Teitelbaum – Princeton University
Florian Gschösser – University of Innsbruck
Viola John – ETH Zurich
Cappai Francesco – École de technologie supèrieure, Montreal

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Conference Sessions

Conference Sessions were divided into four main topics and additional subtopics as defined below. Presenters gave a 15 minute presentation, followed by 5 minutes of discussion. All papers have been listed in chapter *05 – Conference Papers*.

1 **Distributed Energy Systems and Infrastructure**
1.1 Urban scale energy systems (and tools)
1.2 Smart living labs and campuses
1.3 Building performance and human interaction

2 **Life-Cycle Oriented Approaches**
2.1 Building stock (life-cycle) analysis
2.2 Building and infrastructure renovation and retrofitting
2.3 Life-cycle assessment of materials and processes

3 **Integrated Approaches and Tools for Decision-Making**
3.1 Engaging stakeholders and local communities
3.2 Indices and scoring systems
3.3 Design support

4 **Innovative Materials and Components**

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June 15 / 13:45 – 15:30

1.1 **Urban scale energy systems (and tools)**
Chair: Andreas Eckmans – BFE

Stephan Maier – Graz University of Technology
"Optimal Energy Technology Networks in Spatial Energy Planning in Austrian City Quarters"
Anja Willmann – ETH Zurich
"Energy and the City: Investigating Spatial and Architectural Consequences of a Shift in Energy Systems on District Level in a Summer School"
Raphael Wu – ETH Zurich
"Optimal Energy System Transformation of a Neighbourhood"
Thomas Schluck – Lucerne University of Applied Sciences and Arts
"Matching Renewable Energy Production and Consumption by Market Regulated Demand Site Management (DSM)"
Christoph Waibel – Empa
"Holistic Optimization of Urban Morphology and District Energy Systems"

2.2 **Building and infrastructure renovation and retrofitting**
Chair: Mehmet Aksözen – ETH Zurich

Eero Nippala – Tampere University of Applied Sciences
"Deep Renovations within Smart Asset Management"
Karen Allacker – KU Leuven
"A Multi-Criteria Approach for the Assessment of Housing Renovation Strategies"
Angela Greco – TU Delft
"Business Case Study for the Zero Energy Refurbishment of Commercial Buildings"
Alexander Passer – Graz University of Technology
"Impact of Building Refurbishment Strategies on the Energetic Payback"
Sébastien Lasvaux – University of Applied Sciences of Western Switzerland
"Economic and Environmental Assessment of Building Renovation: Application to Residential Buildings Heated with Electricity in Switzerland"

3.1 **Engaging stakeholders and local communities**
Chair: Guillaume Habert – ETH Zurich

Aoife Brophy Haney – ETH Zurich
"What a MES(S)!: A Bibliometric Analysis of the Evolution of Research on Multi-Energy Systems"
Giulia Barbano – iiSBE Italia
"Engaging Stakeholders through Local Project Committees"
Helmuth Kreiner – Graz University of Technology
"Management of User and Stakeholder Interests in Multi-Criteria Assessments"
Emanuele Facchinetti – Lucerne University of Applied Sciences and Arts
"Business Model Innovation for Local Energy Management: A Systematic Methodology"
Sébastien Cajot – EIFER and **Nils Schüler** – EPFL
"Establishing Links for the Planning of Sustainable Districts"

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June 15 / 16:00 – 17:40

1.1 Urban scale energy systems (and tools)

Chair: Forest Meggers – Princeton University

David Grosspietsch – ETH Zurich
"Matching Renewable Energy Production and Local Consumption: A Review of Decentralized Energy Systems"
Surabhi Mehrotra – IIT Bombay
"Built from Determinants of Urban Land Surface Temperature: A Case of Mumbai"
Jérôme Kämpf – EPFL
"Integration of Outdoor Human Comfort in a Building Energy Simulation Database Using CityGML Energy ADE"
Jérôme Kämpf – EPFL
"Multi-Scale Modelling to Assess Human Comfort in Urban Canyons"
Jimeno Fonseca – ETH Zurich
"Assessing the Performance and Resilience of Future Energy Systems at Neighborhood Scale"

2.3 Life-cycle assessment of materials and processes

Chair: Karen Allacker – KU Leuven

Florian Gschösser – University of Innsbruck
"Environmental Effects of an Alpine Summit Tunnel"
José Silvestre – University of Lisbon
"Selection of Environmental Datasets as Generic Data: Application to Insulation Materials within a National Context"
Laetitia Delem – BBRI
"€coffice-LCC and LCA as Part of the Integrated Design Approach for a High Performance-Low Cost Office Building"
Meta Lehmann – econcept AG
"Sustainable Stepwise Building Renovation"
Viola John – ETH Zurich
"Environment and Economy - An Alliance of Mutual Benefits in Residential Building"

3.3 Design support

Chair: Daniel Kellenberger – Intep

Claudiane Ouellet-Plamondon – ETS
"Ecological Footprint Analysis of Canadian Household Consumption by Building Type and Mode of Occupation"
Charlotte Roux – Mines ParisTech
"Life Cycle Assessment as a Design Aid Tool for Urban Projects"
Ayu Miyamoto – KU Leuven
"From a Simple Tool for Energy Efficient Design in the Early Design Phase to Dynamic Simulations in a Later Design Stage"
Elke Meex – Hasselt University
"Analysis of the Material-Related Design Decision Process in Flemish Architectural Practice"
Dimitra Ioannidou – ETH Zurich
"Economic Flow Analysis of Construction Projects to Support Sustainable Decision-Making"

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June 16 / 11:00 – 12:40

1.1 Urban scale energy systems (and tools)

Chair: Jérôme Kämpf – EPFL

Flora Szkordilisz – Hungarian Urban Knowledge Centre
"Facilitating Climate Adaptive Urban Design – Developing a System of Planning Criteria in Hungary"
Paul Michael Falk – Darmstadt University of Technology
"Comparison of District Heating Systems and Distributed Geothermal Network for Optimal Exergetic Performance"
Eric Teitelbaum and **Forrest Meggers** – Princeton University
"Campus as a Lab: Building- and System-Level Air Movement Investigations"
Georgios Mavromatidis – ETH Zurich
"Uncertainty and Sensitivity Analysis for the Optimal Design of Distributed Urban Energy Systems"
Dan Assouline – EPFL
"Does Roof Shape Matter? Solar PV Integration on Roofs"

2.3 Life-cycle assessment of materials and processes

Chair: Peter Richner – Empa

Ardavan Yazdanbakhsh – City College of New York
"A Framework for Life Cycle Assessment of Concretes with Recycled Aggregates in Large Metropolitan Areas"
Snezana Marinkovic – University of Belgrade
"Life Cycle Analysis of Recycled Aggregate Concrete with Fly Ash as Partial Cement Replacement"
Jiangbo Wu – Chongqing University
"Eco-Efficiency of Construction and Demolition Waste Recycling in Chongqing, China"
Amnon Katz – Technion-Israel Institute of Technology
"Efficiency of Using Recycled Fine Aggregate for a New Concrete"
Philip Van den Heede – Ghent University
"The Cost and Environmental Impact of Service Life Extending Self-Healing Engineered Materials for Sustainable Steel Reinforced Concrete"

3.3 Design support

Chair: Annick Lalive d'Epinay – City of Zurich

Emilie Nault – EPFL
"Urban Planning and Solar Potential: Assessing Users' Interaction with a Novel Decision-Support Workflow for Early-Stage Design"
Carsten K. Druhmann – ZHAW
"Increase the Efficiency in Sustainable Construction Using BIM"
Daren Thomas – ETH Zurich
"The City Energy Analyst Toolbox V0.1"
Alexander Hollberg – Bauhaus-University Weimar
"A Method for Evaluating the Environmental Life Cycle Potential of Building Geometry"
Angela Greco – TU Delft
"Economic Factors for Successful Net Zero Energy Refurbishment of Dutch Terraced Houses"

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June 16 / 13:45 – 15:30

1.2 Smart living labs and campuses

Chair: Christian Schaffner – ETH Zurich

Arianna Brambilla – EPFL
"LCA as Key Factor for Implementation of Inertia in a Low Carbon Performance Driven Design: The Case of the Smart Living Building in Fribourg, Switzerland"
Lavinia Chiara Tagliabue – Politecnico di Milano
"Tuning Energy Performance Simulation on Behavioural Variability with Inverse Modelling: The Case of Smart Campus Building"
Sameer Abu-Eisheh – An-Najah National Unviersity
"Strategic Planning for the Transformation of a University Campus Towards Smart, Eco and Green Sustainable Built Environment: A Case Study from Palestine"
Endrit Hoxha – EPFL
"Introduction of a Dynamic Interpretation of Building LCA Results: The Case of the Smart Living Building in Fribourg, Switzerland"
Peter Richner – Empa
"NEST – Exploring the Future of Buildings"

2.3 Life-cycle assessment of materials and processes

Chair: Amnon Katz –Technion University

Alessandro P. Fantilli – Politecnico di Torino
"Eco-Mechanical Performances of UHP-FRCC: Material vs. Structural Scale Analysis"
Sofia Sanchez – Universidad Central de las Villas
"Low Carbon Cement: A Sustainable Way to Meet Growing Demand in Cuba"
Lara Jaillon – City University of Hong Kong
"Life Cycle Assessment of Precast and Cast-In-Situ Construction"
Ravindra Gettu – IIT Madras
"Process Mapping and Preliminary Assessment of LIfe Cycle Impact in Indian Cement Plants"
Alessandro Arrigoni – Politecnico di Milano
"The Environmental Relevance of the Construction and End-Of-Life Phases of a Building: A Temporary Structure LCA Case Study"

4 Innovative materials and components

Chair: Alexander Passer –TU Graz

Daniel Friedrich – Lucerne University of Applied Sciences and Arts
"Bio-Based Plastics-Composites for Sustainable Building Skins: Life Expectancy of Cladding Derived from Wind Suction Tests"
Marvin King – Lucerne University of Applied Sciences and Arts
"Holistic Observations on the Sustainability of High-Rise Building Facades"
Giuliana Iannaccone – Politecnico di Milano
"Integrated Approaches for Large Scale Energy Retrofitting of Existing Residential Building through Innovative External Insulation Prefabricated Panels"
Aurelie Favier – EPFL
"Limestone Calcined Clay Cement for a Sustainable Development"
Matthias Pätzold – Technical University of Munich
"Design-Engineering-Based and Material-Based Improvement of Precast Concrete-Facade-Elements"

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June 17 / 11:00 – 12:40

1.3 Building performance and human interaction

Chair: Zoltan Nagy – ETH Zurich

Zoltan Nagy – ETH Zurich
"What Should a Building be Controlled for? Ask the Occupants!"
Lavinia Chiara Tagliabue – Politecnico di Milano
"Prediction of Users' Behaviour Patterns Impact on Energy Performance of a Social Housing in Cremona, Italy"
Olivia Guerra-Santin – TU Delft
"Towards Sustainable Occupant Behavior and Organizational Change"
Nadine Haufe – Vienna University of Technology
"Modelling Load Profiles for the Residential Consumption of Electricity Based on a Milieu-Oriented Approach"
Junjing Yang – National University of Singapore
"A Methodology for Energy Audit for Commercial Buildings Using Machine Learning Tools"

2.1 Building stock (life-cycle) analysis

Chair: Suzanne Kytzia – HSR

Adélaïde Mailhac – CSTB
"LCA Enhancement Perspectives to Facilitate Scaling up from Building to Territory"
Adélaïde Mailhac – CSTB
"LCA Applicability at District Scale Demonstrated Throughout a Case Study: Shortcomings and Perspectives for Future Improvements"
Fritz Kleemann – Vienna University of Technology
"Combining GIS Data Sets and Material Intensities to Estimate Vienna's Building Stock"
Alessio Mastrucci – Luxembourg Institute of Science and Technology
"A GIS-Based Approach for the Energy Analysis and Life Cycle Assessment of Urban Housing Stocks"
Stefan Schneider – University of Geneva
"Geo-Dependent Heat Demand Model of the Swiss Building Stock"

4 Innovative materials and components

Chair: Claudiane Ouellet-Plamondon – ETS

Ken Zumstein and **Laurent Cattarinussi** – ETH Zurich
"Life Cycle Assessment of a Post-Tensioned Timber Frame in Comparison to a Reinforced Concrete Frame for Tall Buildings"
Gnanli Landrou – ETH Zurich
"A New Route for Self-Compacting Clay Concrete"
Alessandro Arrigoni – Politecnico di Milano
"Improving Rammed Earth Walls' Sustainability through Life Cycle Assessment (LCA)"
Andrea Klinge, Eike Roswag-Klinge – Ziegert | Roswag | Seiler Architekten Ingenieure
"Naturally Ventilated Earth Timber Constructions"
Sharon Zingg – ETH Zurich
"Environmental Assessment of Radical Innovation in Concrete Structures"

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June 17 / 13:45 – 15:30

1.3 Building performance and human interaction

Chair: Arno Schlueter – ETH Zurich

António José de Figueiredo – University of Aveiro
"Overheating Reduction of a Cold Formed Steel-Framed Building Using a Hybrid Evolutionary Algorithm to Optimize Different PCM Solutions"
Hongshan Guo – Princeton University
"Model Predictive Control for Geothermal Borehole Depth Determination"
Coosje Hammink – Hogeschool van Arnhem en Nijmegen
"Integrating Persuasive Technology in Prototypes of Interior Walls to Stimulate Behavioural Change"
Ali Motamed – EPFL
"Toward an Integrated Platform for Energy Efficient Lighting Control of Non-Residential Buildings"
Luca Baldini – Empa
"Dynamic Energy Weighting Factors to Promote the Integration of Renewables into Buildings"

2.1 Building stock (life-cycle) analysis

Chair: Sébastien Lasvaux – HES-SO

Yudiesky Cancio Diaz – Universidad Central de las Villas
"Economic and Ecological Assessment of Cuban Housing Solutions Using Alternative Cement"
Ahmed Mokhtar – American University of Sharjah
"A Sustainable Development Approach for Affordable Housing in Egypt"
Isolda Agustí-Juan – ETH Zurich
"Environmental Implications and Opportunities of Digital Fabrication"
Vanessa Gomes – University of Campinas
"A Novel Perspective on the Avoided Burden Approach Applied to Steel-Cement Making Joint System"
Jovan Pantelic – ETH Zurich
"Air Dehumidification with Novel Liquid Desiccant System"

3.2 Indices and scoring systems

Chair: José Silvestre – University of Lisbon

Karen Allacker – KU Leuven
"Which Additional Impact Categories Are Ready for Uptake in the CEN Standards EN 15804 and EN 15978? Evaluation Framework and Intermediate Results"
Daniela Pasini – Politecnico di Milano
"Integrated Process for the Evaluation and Optimization of Buildings Performance"
Damien Trigaux – KU Leuven
"Critical Analysis of Sustainability Scoring Tools for Neighbourhoods, Based on a Life Cycle Approach"
Olivia Guerra-Santin – TU Delft
"Building Occupancy Certification: Development on an Approach to Assess Building Occupancy"
Manuela Prieler – FH Salzburg
"Renovation in Austria – Analysis of the Energy Performance Certificates between the Years 2006 and 2015 of the County Salzburg"

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02
Workshops

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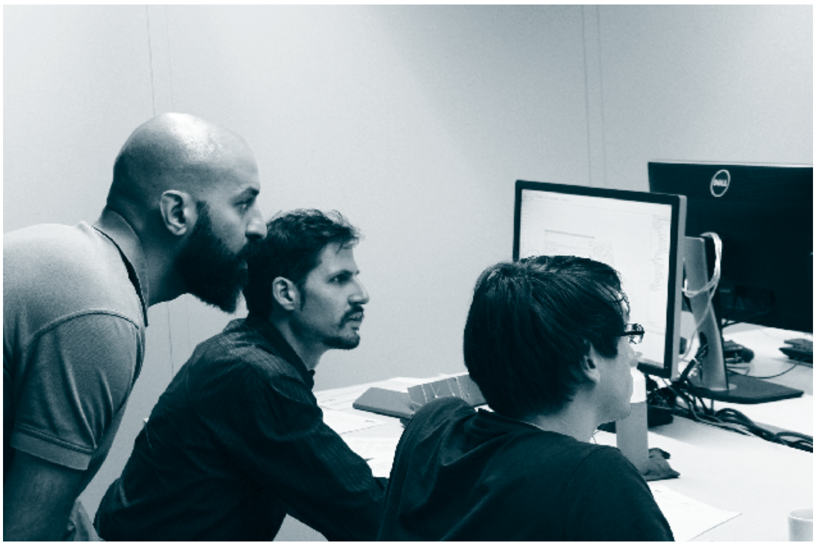

City Energy Analyst Toolbox
June 13 & 14 / 9:00 – 18:00

Description: The City Energy Analyst (CEA) is a novel computational framework for the analysis of building energy systems at neighborhood and district scales developed at ETH Zurich. The framework, which is based on ArcGIS, helps define strategies for minimizing energy intensity, carbon footprint and annual costs of energy services in an urban context.

Participants were invited to take part in the first public CEA Toolbox workshop, as part of the SBE16 conference held at ETH Zurich. The 2-day session consisted of theoretical input, as well as individual and group work. The participants came from a wide range of backgrounds from design-based disciplines (e.g. architects and urban designers) to engineering (e.g. mechanical, civil and energy systems experts and consultants) and ranging in position from PhD student to assistant professor. The workshop had a total number of 9 participants from 7 different countries in 3 continents representing 8 institutions.

Organisers: Amr Elesawy, Anja Willmann, Martin Mosteiro (ETH Zurich, Chair of Architecture and Building Systems) and Jimeno Fonseca (Future Cities Laboratory, Singapore-ETH Centre)

Review by Organisers: The workshop intended to present the tool to a diverse audience and check its role in creating synergies between various scenarios in an urban context, with the aim of reducing energy consumption and GHG emissions. It also aimed to assess the user friendliness of the tool as well as its importance in the field. The first half of the workshop consisted of an introduction to ArcGIS as the underlying software and the concept of the CEA toolbox, a theoretical input on urban energy systems, the different demand types and how they are assessed, GHG emissions and the benchmarks used for evaluating the simulation outcomes. Afterwards, the participants were assigned a number of individual tasks to conduct their first simulations using the tool, as well as investigating the results and presenting them through various visualization techniques. Following this step, the main project of the workshop was introduced, in which 274 buildings in the center campus area of the city of Zurich were to be analyzed. The participants were organized in 3 groups and were presented a number of future scenarios for the city quarter to explore the impact of occupancy, varying climates and retrofitting existing buildings and energy sources. However, they were given flexibility to add, modify or choose new themes to work with. All simulation results were compared to the Swiss 2000-watt-society targets.

The participants demonstrated both the capability to work with the tool independently as well as expanding the proposed scenarios with considerations of urban densification and energy mixes, thus going beyond the workshop's original expectations. Following the scenario development and simulations, each group presented their results, consisting of 4 to 10 scenarios per group and 4 to 8 full simulations per participant.

At the end, participants were asked for feedback on the workshop and the toolbox itself. While the theoretical content of the workshop was generally considered adequate, a large number of participants expressed interest in a longer workshop, in which a third day could be used to analyse the calculation methods in detail. Regarding the toolbox itself, a majority of the participants rated the tool's user friendliness and their likelihood to use the tool again with 7 or more, though some participants expressed that they would like to see the tool being further developed in order to expand its usefulness and importance.

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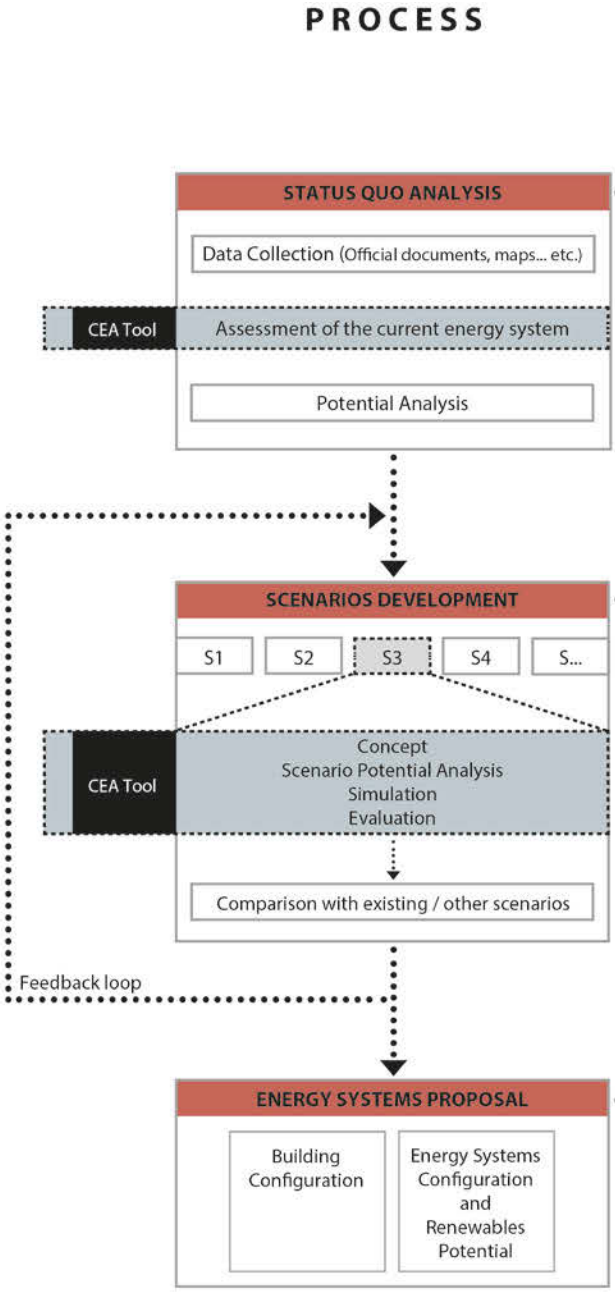

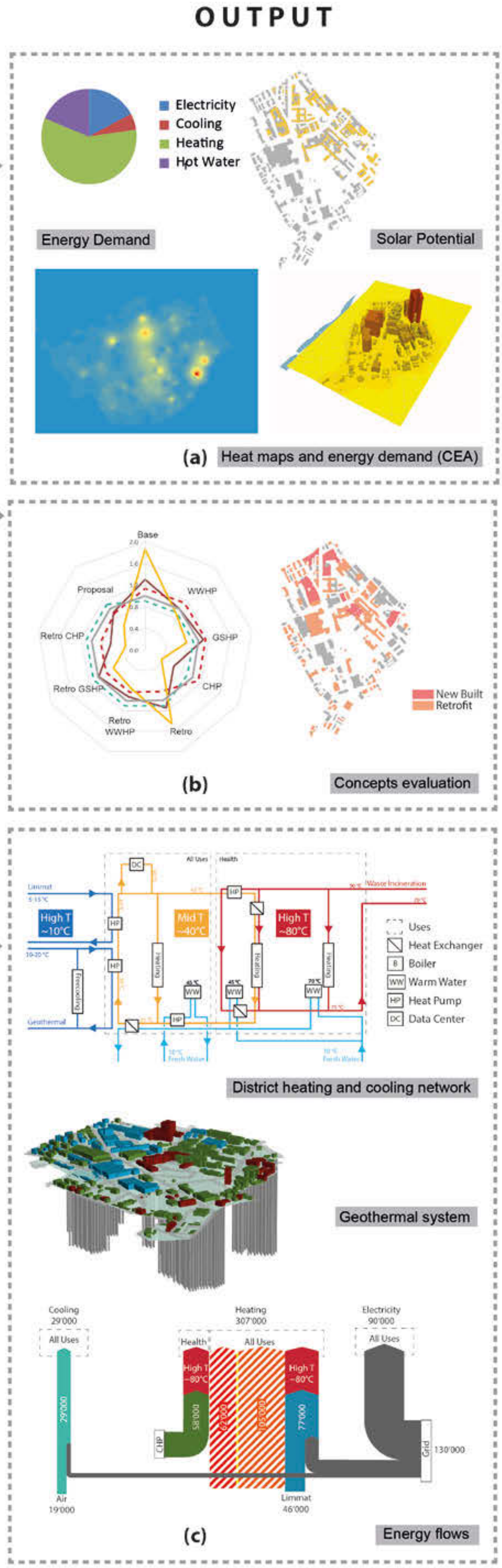

opposite page:
Workshop organiser and participants,
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right:
CEA Toolbox – process and output,
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Management Game of a Building Material Supply Chain
June 14 / 14:00 – 17:00

Description: Building material supply chains form part of the complexity of built environments. They involve multiple actors and a constant flow of material and information between them. This system dynamics management game involved a supply chain with four companies and the respective material and information flows. Participants took the role of a company and decided – based on their inventory situation and customer orders – how much to order from their suppliers. All companies had a common goal: Minimizing costs for capital in the supply chain by maintaining low stocks but managing to deliver all orders. The players experienced decision-making and coordination problems as well as the pressure that emerges from other actors and from 'the system'.

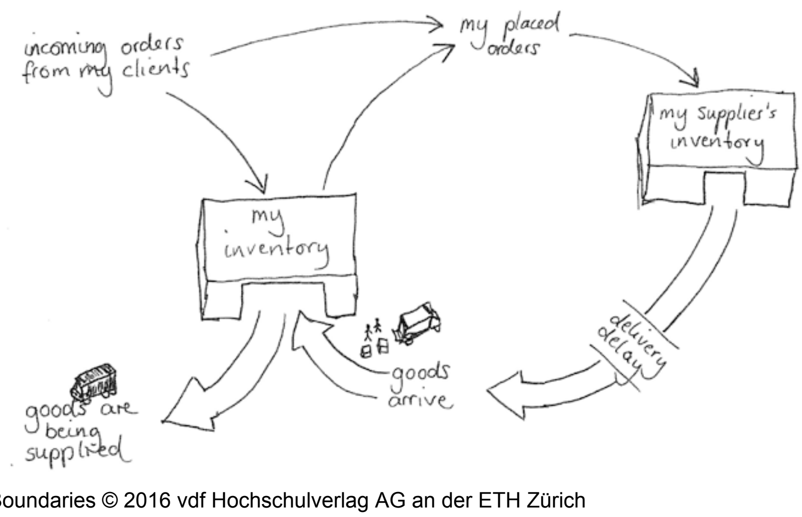
This exercise enhances general systems thinking capabilities. Players are introduced to important concepts of systems thinking and causal loop diagrams.

Organiser: Nici Zimmermann (Institute for Environmental Design and Engineering, University College London (UCL), The Bartlett)

Review by Organiser: The players experienced all the ups and downs of managing a complex supply chain. They were engaged and eager to keep their inventories within reasonable bounds, but they had to cope with backlogs of up to 100 items, caused by an increase in demand of only 4 items per week.

These difficulties are a typical outcome of this learning experience, of tool and even commodity supply chains. We used the concrete experience to discuss the structure of supply chains in general and how its information and material delays create ripple effects and the so-called 'bullwhip effect'. We also explored how we can change the underlying structure, e.g. by linking the retailer's information directly with the factory that is many kilometres and organisations apart. Then we discussed the ability of transferring insights from the very lean automotive supply chains to the housing construction context, limited e.g. through a different distribution of power across organisations and through the transient nature of project-based construction supply chains.

It was an exciting and successful workshop!



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opposite page:
System diagram.

right:
Workshop in progress,
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Sustainable Hybrid Building
June 13 / 9:00 – 19:00

Description: *A multidisciplinary approach to mixed-use buildings in small urban districts.* The demand for high density together with the demand of maintaining the diversity of services, retails, cultural facilities, and social mix raises the question whether mono-functional buildings are still adequate to provide resilient sustainable solutions for the city of tomorrow. A hybrid building combines several programs in one fabric. It could be managed by public-private partnerships and could be accessible 24/7. The workshop discussed the design of small to medium size hybrid buildings as one of the possible responses to the shortage of housing land, to reduce transport carbon dioxide and energy consumption in urban areas, to preserve resources and to reduce operating costs. Mixed-use, hybrid buildings foster integrated approaches to energy and resource efficiency.

Organisers: Paola Tosolini (HEPIA Geneva/ HES-SO University of Applied Arts and Sciences of Western Switzerland), Jessen Page (HEVS Valais-Wallis/ HES-SO), and Ricardo Lima (HEPIA/HES-SO)

Review by Organisers:
The 1-day workshop was organized in two sessions, – one including theoretical input on hybrid building design, the other with group work on a case study in Grand-Sacconex - Geneva, in a sector near the airport. Participants identified and defined synergies among different buildings programs that can improve the sustainability of the building. Reduced energy consumption, preservation of natural resources, and social cohesion are some of the issues that have been discussed.

The workshop paricipants first identified the best strategic location for the hybrid building in the Susette Sector and then sketched it by defining a program based on a multidisciplinary approach. They considered local urban needs, evaluated the potential range/degrees of interaction among program spaces, defined the thermal zoning of the building, and finally explored and combined energy demand profiles of the diverse programs in order to optimise energy efficiency and renewable energy consumption.

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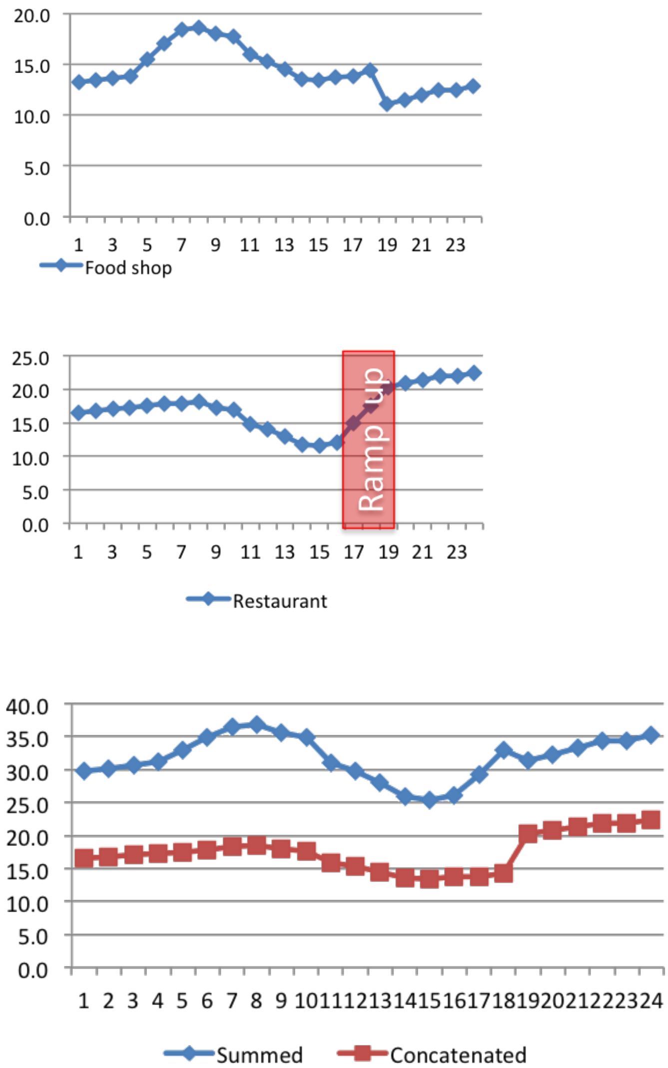

above:
More efficient use of heating/cooling systems due to concatenated demand.

opposite page and right:
Workshop organisers and participants, © ETH Zurich, Chair of Sustainable Construction 2016.

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Sustainable Building Operation
June 14 / 15:00 – 17:00

Description: What means "sustainable operation"? Several guidelines, norms, certification schemes etc. are available for sustainable construction, but few are dealing with sustainable operation. And those who address the issue have different structures (e.g. product or process orientated), approaches (e.g. performance or qualitative orientated) and viewpoints (planner, investor etc.). This leads to the following sub questions, which were to be discussed during the workshop in order to arive at a common, further understanding of the topic:

- Which approach is useful for a description and assessment of sustainable building operation?
- What are the linking points of contact between sustainable planning and construction and sustainable operation?
- How should the different responsibilities and roles be distributed?

The workshop followed the *World Café* format – short impulse presentation by organisers, 3-4 tables for discussion (stakeholder views) with 1 moderator per table. For each sub question, the results obtained in the groups were summarized in a document, including a photo protocol which was presented at the conference.

Organisers: Carsten K. Druhmann (ZHAW – Zürcher Hochschule für Angewandte Wissenschaften, head of «FM digital», Institute of Facility Management) and Stefan Jäschke (ZHAW, Institute of Facility Management, Energy Management)

Review by Organisers: The workshop started with a brief introduction of the participants; the most represented profession was architecture. So a short introduction to Facility Management and Building Operation was given by the organisers. It was followed by an introduction to sustainable building operation, information about the pre-project *Standard Sustainable Operation Switzerland*, including an insight into existing assessment systems. This led to a lively discussion around two central topics:

- How to involve users and tenants of buildings in sustainable operation or encourage them to support it instead of counteracting sustainability optimised buildings during operation (keywords: e.g. green lease contracts, performance gap).
- The certification of FM service providers was considered, important so that companies, like certificates for sustainable buildings (e.g. SNBS, DGNB), can provide proof of meeting their sustainability goals. Sustainable building operation would be best applicable if the triad of owners, users / tenants and service providers works.

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right:
Building operation manuals and certificates.

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03
Keynote Speakers

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Koen Steemers
University of Cambridge

Koen Steemers was recently named in *Building Design*'s inaugural list of the "50 most influential people in UK sustainability". He studied Architecture at the University of Bath and subsequently joined Energy Conscious Design, (now ECD Partnership, London). His PhD work at the University of Cambridge developed new insights into the links between urban design and energy consumption. He acted as consultant on various projects; became a Director of Cambridge Architectural Research Ltd (1991) and of architectural practice CH+W Design (2015). He has been Director of the Martin Centre (2003-08) and Head of Department (2008-14).

Koen Steemers's expertise is based on being a registered architect (CH+W Design); environmental design consultant (Director of CAR Ltd); consultant to UN-HABITAT; President of PLEA (Passive & Low Energy Architecture international association); Fellow of Jesus College, Cambridge; Guest Professor at Chongqing University, China and at Kyung Hee University, Korea. He has extensive research assessment experience, including two stints on the UK Government's research reviews and as deputy Chair of the Hong Kong Research Assessment Panel 2014. He is currently on the UK Green Building Council *Healthy Homes* task group.

Koen Steemers heads a team of 14 researchers in the *Behaviour and Building Performance* (BBP) Centre. He coordinates the MPhil course in Architecture and Urban Studies and supervises PhD students. He has produced over 200 publications (with over 4000 citations), including 10 books ranging in subject matter from *Sustainable Urban and Architectural Design* (2006) to *Daylight Design of Buildings* (2002).

See opposite page for an abstract of Koen Steemers's keynote lecture. This lecture has been recorded and can be viewed **online**.

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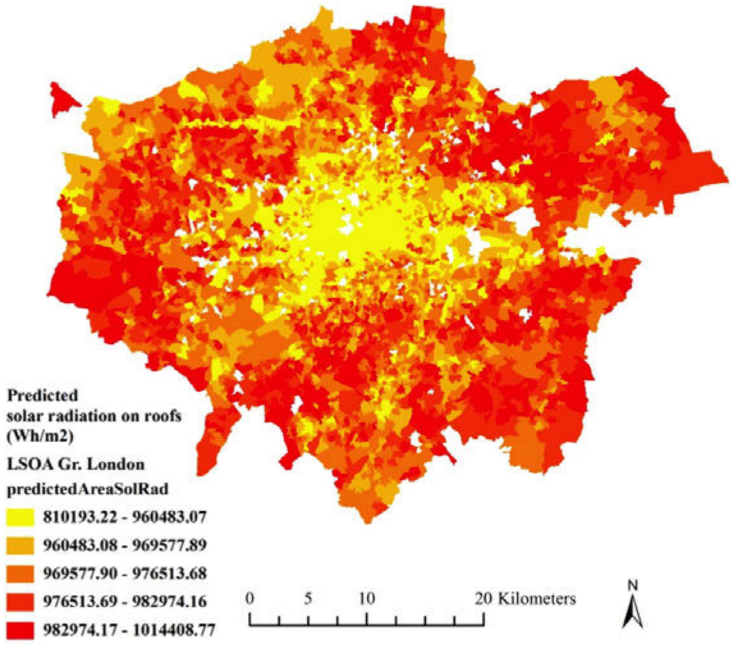
right:
The map illustrates the distribution of the predicted values for roof solar renewable energy potential in London.The results show that ca. 70% of the solar potential for both roof and façade areas can be explained by a combination of urban form descriptors. Using spatial data and a GIS platform, these descriptors are relatively easy and quick to compute, which makes this approach a good contender for rapid analysis of urban solar potential at the neighbourhood and city scales.
From: J.J. Sarralde, D.J. Quinn, D. Wiesmann, K. Steemers, (2015), 'Solar Energy and Urban Morphology', *Renewable Energy*.

below:
Variable heights and spacing at a high density (FAR=7.2) achieves the same sky view factor (SVF=0.3) as a regular array at one-fifth of the density (FAR=1.44).
From: V. Cheng, K. Steemers, et al. 'Urban Form, Density and Solar Potential', *PLEA 2006*



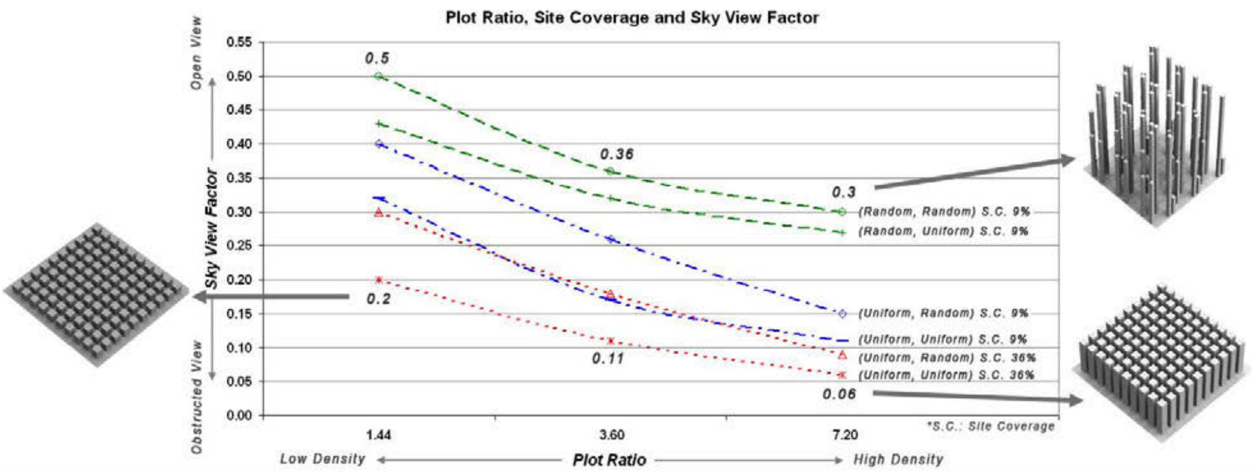
**'Urban Form and Energy:
Systems Thinking and Environmental Diversity'**

Through the lens of 'systems thinking' (the theme of SBE16 Zurich) this presentation explored the environmental performance of urban form. It reviewed analytical techniques ranging from simplified strategies to integrated simulation. Although simple rules have been influential, they are often too simplistic to reveal complex, real-world, interconnected or diverse strategies. More sophisticated and dynamic analysis of urban form, particularly in relation to energy performance and outdoor comfort, has revealed the value of environmental diversity. In place of thinking about optimal solutions, the notion of spatial and temporal diversity improves environmental performance. This is demonstrated through the analysis of urban form where diverse designs outperform regular urban arrays in terms of energy use and outdoor comfort. Finally, using a systematic integrated modelling approach that assess urban form with respect to socio-economic, land use, transport and building design was presented.

The approach is to test current and future development scenarios (e.g. compact form versus sprawl) over the longer term and to identify the relative energy consequences. Key results are:

- At an aggregate and regional level, urban scenarios have a modest relative impact on energy.
- The scenarios change the spatial distribution of energy demand which has implications for energy supply (e.g. compact form - CHP, ground source systems and networks; versus sprawl - solar and wind).
- The uptake of retrofit technologies, occupant behaviour and expectation, and the rate of new-build have a large impact on energy demand for all scenarios.

'Systems thinking' reveals complex and diverse strategies regarding: a) social v. technical solutions, b) individual behaviour v. urban systems, and c) static v. dynamic characteristics. Such richness of systems thinking can be explicitly embraced for sustainable urban design.



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Peter Edwards
Singapore-ETH Centre for Global Environmental Sustainability

Peter Edwards took the natural science tripos at Cambridge University, specializing in botany, and graduated in 1970. In 1973 he obtained his Ph.D. degree, also from Cambridge, for a thesis entitled *Nutrient cycling in a New Guinea montane forest*. He was a lecturer/senior lecturer in ecology at the University of Southampton, England, from 1973-1993. Since 1993 he has been professor of plant ecology at the Swiss Federal Institute of Technology (ETH), where he has also served as chairman of the Department of Environmental Systems Science.

Peter Edwards has always had a strong interest in the application of science and technology for better policy. He was a founder and first executive secretary of the Institute for Ecology and Environmental Management, a professional organization for environmental practitioners. At ETH he was faculty coordinator and member of the executive board of the Alliance for Global Sustainability, a research partnership between several leading universities.

He is author of around 300 refereed scientific papers and author/editor of several books covering a wide range of environmental topics including ecosystem processes, insect–plant interactions, environmental management and biodiversity. His recent research has focused particularly on large-scale processes in terrestrial ecosystems, including interactions between large herbivores and vegetation, the dynamics of vegetation on the flood plains of large rivers, and the role of biodiversity in agricultural landscapes.

See opposite page for an abstract of Peter Edwards's keynote lecture. This lecture has been recorded and can be viewed **online**.

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right:
Aerial view of the Ciliwung River in Jakarta, Indonesia.

below:
Visualization tools in 'Value Lab Asia' at the Singapore-ETH Centre.

'Future Cities Laboratory: Innovative Research for Sustainable Cities'
Asia's urban population will grow by more than one billion people by 2050. ETH's Future Cities Laboratory (FCL), which forms part of the Singapore-ETH Centre, was established to provide knowledge and ideas to make these rapidly growing cities more sustainable and resilient. This lecture presented examples of the kinds of problem-oriented research undertaken at FCL, and the challenges of putting new knowledge into practice.

One FCL study set out to quantify the materials used to transform Singapore into a modern city, and examined the environmental and other impacts. In total, some 2000 million m^3 of material were required for land reclamation, which was obtained by importing sand from other countries, topping of hills in Singapore and dredging.

A second study developed a new approach to urban river rehabilitation. The river studied was the heavily polluted Ciliwung River in Jakarta, which floods regularly, causing untold misery to residents. The multi-disciplinary research team used a combination of hydrologic, hydrodynamic and 3-D landscape modelling to assess the consequences of potential interventions in the urban landscape. Working closely with stakeholders, they developed design scenarios aimed at restoring the riparian ecosystems and improving the quality of life for local communities.

A third example focused on the extensive areas around many Asian cities where urban and agricultural forms of land use coexist (a settlement form known as *desakota*, which can easily develop into an extended urban sprawl). The aim of this project was to develop new forms of urban design that provide the benefits and quality of an urban life-style while preserving agricultural communities.

An important part of the 'glue' holding these projects together are the superb facilities provided by the 'Value Lab Asia' for modelling and presenting 3-D and more-dimensional data. These provide not only an essential research tool, but also a means for translating research into solutions that practitioners can use. We argue that this kind of transdisciplinary research, engaging stakeholders at all stages of the prcoess, will be essential for achieving a sustainable urban future.

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Chrisna du Plessis
University of Pretoria

Chrisna du Plessis is a Professor in the School for the Built Environment, University of Pretoria, South Africa. She was formerly Principal Researcher at Council for Scientific and Industrial Research (CSIR) Built Environment in Pretoria, South Africa. Her work focuses on sustainable human settlement and the application of sustainability science in the built environment.

Chrisna du Plessis is known for her work on the evaluation of policy and research strategy for sustainable building and construction in developing countries, and is currently concentrating on urban sustainability science at both theoretical and technical levels. Her main expertise is the development of trans-disciplinary research and development programs that follow a complex systems approach to the development of human settlements as sustainable social-ecological systems.

She studied architecture at the University of Pretoria, South Africa, obtained a PhD in Urban Sustainability from the University of Salford, UK, and was awarded an honorary doctorate in technology from Chalmers University of Technology in Gothenburg.

Chrisna du Plessis represented South Africa in the Earth Charter drafting and consultation process and contributed to several national and international policy and strategy initiatives on sustainable settlements. She was lead author of the United Nations Environment Program's *Agenda 21 for Sustainable Construction in Developing Countries* and is Theme Coordinator: Sustainable Construction for the International Council on Research and Innovation in Building and Construction.

See opposite page for an abstract of Chrisna du Plessis's keynote lecture. This lecture has been recorded and can be viewed **online**.

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'Thriving in the Symbiocene: A Message of Hope'
We are living through the end of the world as we knew it. Everything that has been familiar about our planet and our world is changing and we will need to change with this, or become extinct. This is not a bad thing. In the breaking down of old systems, we have been given an opportunity to change. And the biggest change we need to make is in the stories we tell ourselves. We can remain stuck in old stories of separation and denial, or start telling new stories of collaboration, cooperation and symbiosis in which humans are restored to their natural place as members of the community of life whose purpose is to create an abundant and thriving future in which all species can flourish for all time. We can do this if we do more than slow down the degeneration of our systems, and start working on developing regenerative systems that can adapt and transform to meet the unknown conditions of our future world. If we understand that what needs to be sustained is the functional integrity of the global social-ecological system; and what needs to be developed is the adaptive capacity and evolutionary potential of this system. If we shift the basis of our relationship with planetary systems and other members of the web of life, including other humans, from exploitation to adding value, doing more good, instead of less bad. If we shift to improving and enriching our relationships with each other, with nature, with our neighbours and future generations; focusing on contributing, adding to and giving back.

As designers and engineers our role is to become the matchmaker, mediator and facilitator of the dialogue; the narrator constructing the story of a different future; and the mentor leading the stakeholder team to another way of being. But to do this, we need to start with self, becoming impeccable warriors who come to the table with a soft and open heart, with compassion for the fears and failures of ourselves and others, yet fierce in our determination to create a better future.

left:
Lecture by Chrisna du Plessis,
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Serge Salat
Urban Morphology and Complex Systems Institute, Paris

Serge Salat is an urban planner, a scientist in the science of complexity, an art historian and an internationally recognized architect/artist. He is the founder and President of the Urban Morphology and Complex Systems Institute based in Paris.

Serge Salat has been seminal in applying the science of complexity to cities. He has authored more than 20 books on art and architecture, as well as more than one hundred publications and communications. He has opened the way in introducing physics far away from the equilibrium, fractals, as well as network analysis and complexity science to a better understanding of cities.

He is a practicing architect and city planner and advises international organizations such as United Nations, The World Bank, AFD (French Agency for Development) and CDC (Caisse des Dépôts et Consignations), on strategic transitions of urbanization in particular in China, where he brings a unique integration of scientific skills, economic, financial and governance competence with his experience of designer of large scale projects to advise on national policies as well as on specific projects. He is one of the authors of the Fifth IPCC assessment report.

Born in 1956, he graduated from École Polytechnique with a master of mathematics and physics (Paris, 1979), from Institut d'Études Politiques (Paris, 1982), and from École Nationale d'Administration (Paris, 1984). He obtained a Ph.D. in Economics (Université Paris IX Dauphine, 1979–82); a Ph.D. in Architecture (École d'Architecture de Paris La Villette, 1989); and a Ph.D. in History and Civilizations (EHESS, Paris, 2010).

See opposite page for an abstract of Serge Salat's keynote lecture. This lecture has been recorded and can be viewed **online**.

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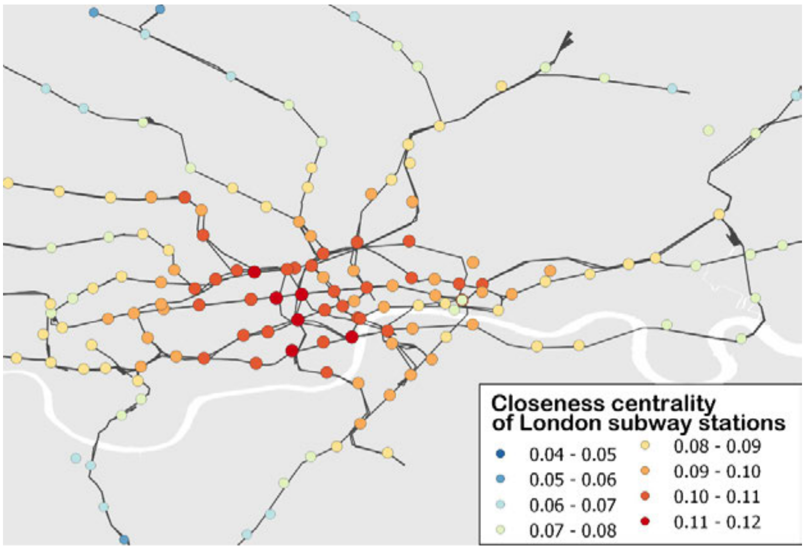
right:
London subway closeness centrality map of subway stations (topological distance in the network of a given station to all the others).

below:
Greater London jobs density peaks at 150.000 jobs per km² in the City of London and is aligned with transit accessibility.

London Gross Value Added per km² ranked from the most economically productive urban land to the less productive shows an inverse power law where 20% of London urban land produces 67 % of the city's GDP.

Images © Urban Morphology and Complex Systems Institute.

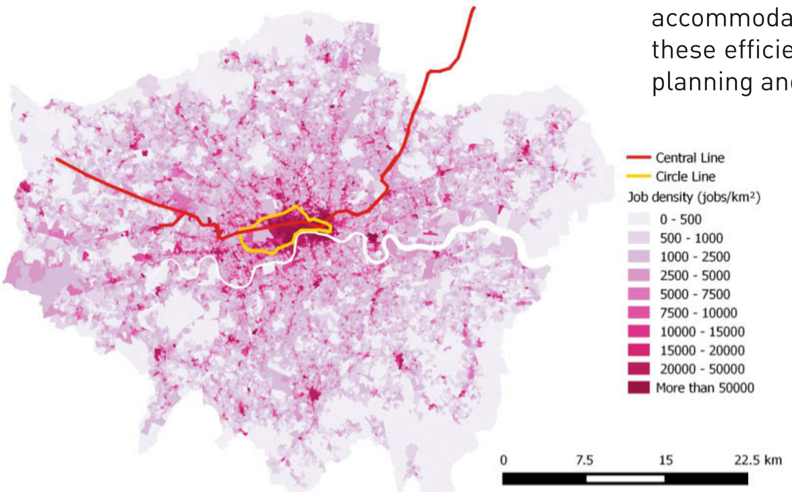


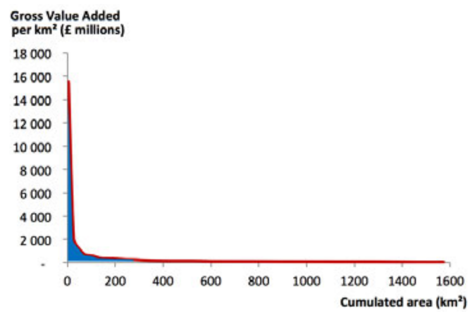
'Systems Thinking for Integrated Sustainable Urban Planning'

Systems thinking and integrated spatial planning are key for achieving resource efficiency. Articulated densification and strategic intensification of cities reduces the need for resources while increasing economic growth and social inclusiveness through enhanced access to jobs opportunities.

Scientific evidence derived from cross analysis of dozens of cities shows that resource efficient urban forms create cities that are more competitive, with lower transport and housing costs, with high quality neighborhoods, with lower infrastructure costs and lower CO_2 emissions, cities that are resilient to natural hazards. Doubling jobs density increases by 5 to 10% economic productivity; e.g. 60% of New York office space is on 9 km² (1% of NYC land area). Enhanced access and mobility lowers transport and housing cost: e.g. in Hong Kong, 83% of jobs are within 1 km of mass transit; in USA, residents near Transit Oriented Development (TOD) stations spend 37% of income on transport and housing against 51% for other people.

These resilient and efficient cities share common features of self-organized complex systems. They are networks of relations from which locations emerge. They have no characteristic scale but show wide variations of sizes, densities, concentrations, strengths of connections (e.g. volume of commuting flows in transit lines), and centralities in their subway networks across urban space. Ubiquitous power laws order the frequency of sizes, densities, connectedness, and, in some cases, centralities with common exponents across different cities that are referred in physics as universality classes. For example, the frequency of plots of a given size follows in NY, Paris, Hong Kong a power law of exponent – 0.5. The size of parks also follows power laws in Paris, NY, Rome, Barcelona. GDP creation is highly concentrated following a Pareto principle where 20% of the urban land produces 80% of the city GDP (e.g. London, Zhengzhou). Jobs densities are highly concentrated with a hierarchy exponent of the power law of -1, e.g. 1.5 million jobs in 15 km² in London and NYC. A long term vision of the city shape, and highly granular planning with wide variations of FARs at small block scale, like in NYC and Singapore, completed by flexibility to accommodate market changes, allows shaping these efficient city forms with a delicate balance of planning and market.





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Jens Feddern
Siemens Building Technologies

Jens Feddern is heading the Center of Competence Building Performance and Sustainability for South and West Europe. This organisation is acting as a service provider with the specific knowledge and experiences in the different regions and is assuring the proper risk management especially for energy efficiency and modernization projects.

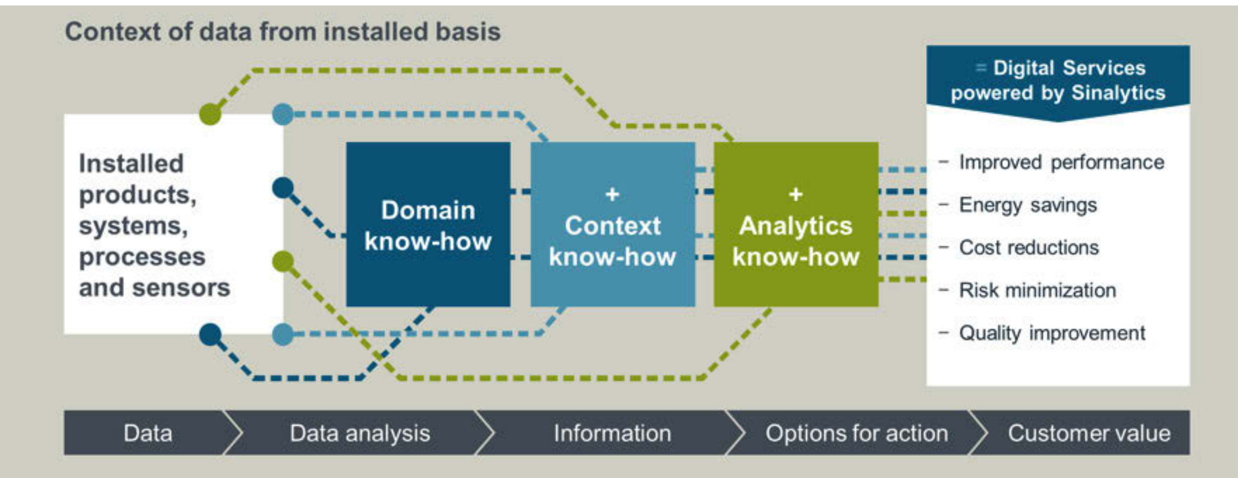
He holds a degree in electrical engineering and executive master in business studies. Jens Feddern has been working for Siemens since about 16 years in various functions in product development, business development and global account management with a specific track record of more than 10 years in the life science industry.

See opposite page for an abstract of Jens Feddern's keynote lecture. This lecture has been recorded and can be viewed **online**.

below:
Digitalisation in buildings – how to transform data inform data into meaningful information and into customer value.

opposite page:
Comprehensive data analytics for optimisation tasks – detect the potential and supervise the results.

The path to maximise building performance – holistic view on the entire building infrastructure and beyond.



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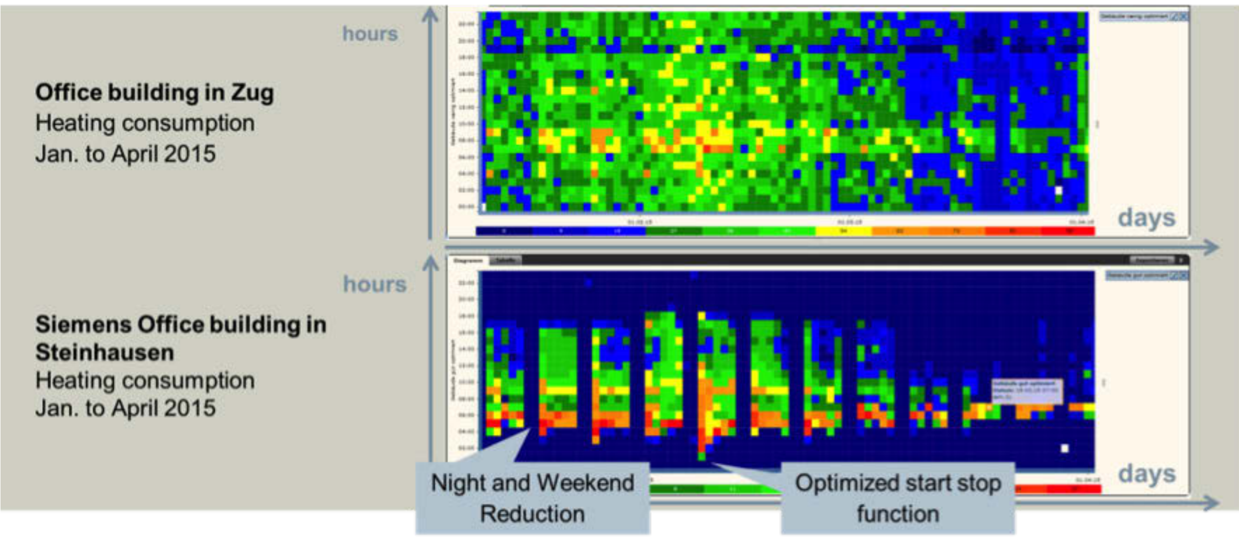


'Expanding Boundaries: Systems Thinking for Building Performance'

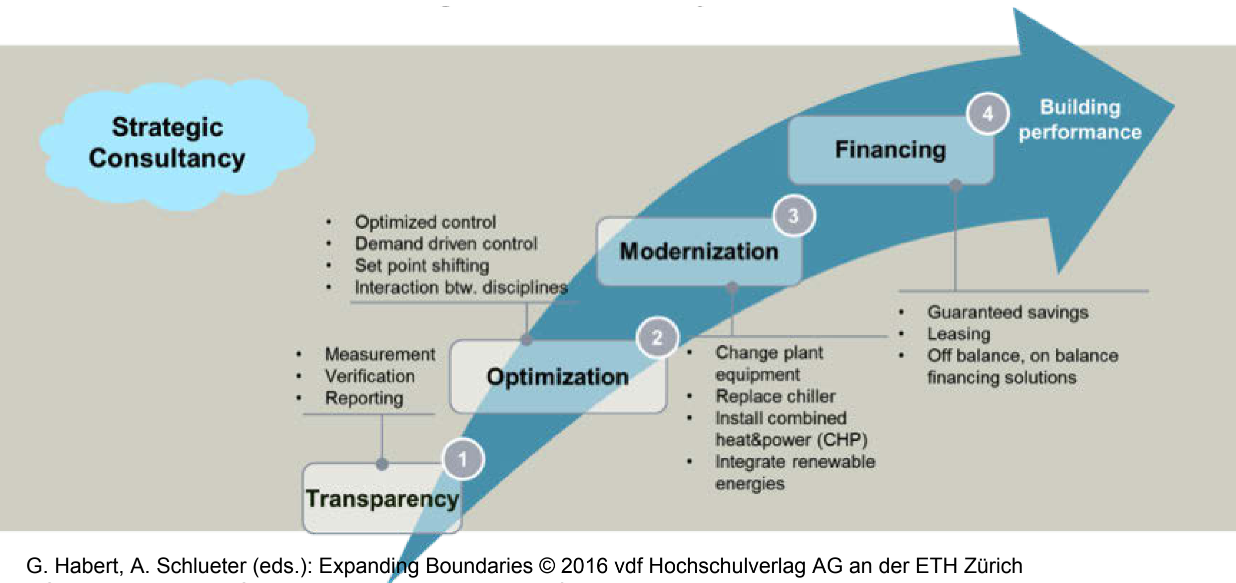
Europe's building stock has a significant modernisation potential, but less than 1% is explored year over year. The key to success is not a one-to-one replacement of equipment that is at the end of the life cycle or even broken, but a holistic analysis and modernisation of the entire building infrastructure whilst considering actual user needs.

80 % of a building's life cycle costs occur during ongoing operation but significant decisions are already made during construction. The planning must rely on numerous assumptions about the future use and operation and technical innovation is increasing while the buildings are getting older.

To get to know exactly the current and future needs comprehensive data collection provides a solid foundation to maximise the building performance during ongoing operation.

Big Data or even better Smart Data provide the foundation for systematic analysis and predictions. This analysis is based on thorough technical understanding, detailed knowledge about the individual application and comprehensive analytic methodologies.

This keynote lecture has shown the Siemens path to maximise building performance from transparency, over opimisation to comprehensive modernisation. The digitalisation in buildings was highlighted and as a consequence the digital transformation of services was explained. Several examples and case studies have demonstrated the successful application in practice.



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04
Panel Discussion

The role of human and technology for a
future sustainable built environment

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Smart Humans or Smart Meters?
The role of human and technology for a future sustainable built environment

Chair:
Niklaus Kohler (em. Prof. KIT)

Participants:
Annette Aumann (City of Zurich)
Chrisna du Plessis (University of Pretoria)
Jens Feddern (Siemens Building Technologies)
Eike Roswag-Klinge
(Ziegert | Roswag | Seiler Architekten Ingenieure)

This discussion brought representatives of science, industry, planning and public administration to the table. While they shared the concern for a sustainable future of the built environment, speakers – based on their respective field – presented varying views on how to achieve it. Following the overall topic of the conference, system synergies despite different approaches as well as the influence of the human factor were discussed. The following questions are linked to the central issue of the discussion:

Can the optimisation of technological systems pave the way to sustainability?
What is the relevance and impact of public policies and guidelines?
Which potential or risk does the increasing digitalisation and infomatisation of both building construction and operation bear?
Finally, what about the human? Is the individual user controling or controled by a technologically intricate and therefore sustainable built environment?

The discussion has been recorded and can be viewed **online**.

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opposite page:
Participants of the panel discussion and signage poster.

right:
Chrisna du Plessis
Eike Roswag-Klinge
Annette Aumann
(top to bottom)

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05

Conference Papers

Distributed Energy Systems and Infrastructure **46**

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SMART REGENERATION OF PUBLIC UTILITY BUILDINGS

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[1] Department of Pianificazione Design Tecnologia dell'Architettura, Sapienza University of Rome, Rome, Italy

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Abstract

Energy renovation is instrumental for reaching the EU 2020 goals and smart districts are integral parts for the development of Smart Cities in the near future. At building scale, every structure runs differently and energy consumption profiles depends not only on climatic locations and technological quality of buildings, but also on occupancy levels and different types of public utility buildings (school, healthcare and homes for the elderly, office, university).

A new smart regeneration approach will represent the central focus beyond a simple technological concept of Smart Building, where the buildings should be seen as part of a larger system of energy networks and whose diffusion within the city could be linked with the concept of urban energy network and physical “nodes”.

Currently, good practices and projects aim to promote the adoption of the key technology and to identify and remove barriers to deployment. Still today, approaches to record non-residential assets in a comparable structure have not been successfully implemented yet and data are fairly poor.

An integrated approach is proficient to reveal the performance of the innovation, its technical requirement, as well as prerequisite required in terms of existing infrastructures, technical expertise, regulatory requirements and financial costs involved.

An ongoing research from the PDTA Dept. is promoting a set of exemplary of public utility buildings and a portfolio of material, industrialized systems, smart and energy equipment solutions to be used in refurbishment projects, in order to stimulate a whole vision of the smart efficient buildings and different scenarios according to the boundaries of a smart district level in Rome Municipality.

Keywords:

Interactive nodes; systemic approach; Building Energy Management Systems; set of technical solutions

1 INTRODUCTION

A large number of studies and surveys at the EU level and Eurostat data show that the existing European building stock requires urgent adaptation to current and future needs. More than 40% of the energy consumption in Europe is due to heating, ventilation and air conditioning and lighting operations within buildings. The non-residential building sector is characterized by a large number of different building types, each with specific functional, morphological and structural characteristics and parameters. In addition, the buildings differ on account of their age, the construction materials used in the corresponding periods and their technical equipment.

In the recent past some approaches have been made to reflect the current situation in terms of available information, but also in terms of finding appropriate ways to structure a non-residential building typology. Due to the poor availability of data so far, there is a great need for further research. Therefore, understanding energy use in the non-residential sector is complex as end-uses such as heating, ventilation, cooling, lighting, IT equipment and appliances vary greatly from one

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building category to another. Utility buildings, according to existing building and construction standards, have to be partly renovated (building envelope, HVAC) approximately every 20 years, and completely retrofitted approximately every 35 years [1]. A large portion of the existing utility building stock in the EU was built after the Second WW and mainly during the 60-ies and 70-ies. The renewal of this stock to meet energy standards and face climate issues – based on more efficient processes and zero or nearly zero emission – represents the next perspective for cities [2]. A sensible management of energy in these buildings can achieve major savings in the energy use (and thus, also cost) and in the reduction of greenhouse emissions.

Nowadays this is no more a vision but a concrete challenge for governments, associations, stakeholders and policy makers at all levels, and represents currently a priority for G20, World Bank and OECD agenda. According to the EPBD (Directive 2010/31/EU), all new buildings shall be nearly zero-energy buildings by the 31st of December 2020, and 2 years earlier for buildings occupied and owned by public authorities. Public authorities should set the example by renovating each year 3 % of central government buildings with insufficient energy performances, as required by the Energy Efficiency Directive (EED, 2012/27/EU). This requirement is complemented by the EED obligation for Member States to put in place longer-term renovation strategies. The implementation of the EPBD is supported by a set of European standards, dealing with the thermal performance of buildings and building components, ventilation, light and lighting, heating systems, building automation, controls and building management.

Buildings could be transformed from purely demand driven electricity consumers to interactive partners with a potential to store thermal energy [3]. The concepts of the Smart City and Smart Grid provide one of the possible solutions that could make historic, consolidated cities more efficient and sustainable, encouraging reflection, ideas, research and projects to regenerate this kind of environment with a focus on smart services [4]. A multi technology perspective, combined with energy management, will make existing energy systems of urban areas more intelligent, where decentralized energy generations and highly interconnected urban infrastructures are in place, buildings become physical interactive nodes of a larger Smart Grid which calls for an upgrade of building models in the direction of Smart Buildings, for a transition from single buildings to Smart Objects [5].

2 METHOD

The goal of this ongoing study is to design a roadmap for the retrofit of the existing public utility building stock, through the analysis of case studies of major significance in terms of building characteristics and period of construction.

According to the World Energy Outlook 2015 this study puts itself forward as a methodological approach to the widespread problems of saving energy, in which the construction sector is a fundamental element. Furthermore, Smart Cities and Communities Initiative highlights the importance of intelligent energy management systems in cities in order to achieve massive reductions of greenhouse gas emissions by 2020, and the integration of renewable energy sources as outlined in the 20-20-20 targets and in the European Energy Roadmap 2050 [6]. The Energy Roadmap 2050 considers that the high "energy efficiency potential in new and existing buildings is key" to reach a sustainable energy future in the EU, contributing significantly to the reduction of energy demand, the security of energy supply and the increase of competitiveness [7]. The Roadmap to a Resource Efficient Europe identifies the buildings among the three key sectors responsible for 70% to 80% of all environmental impacts [8]. In 2011 a survey on buildings' gross floor space in the EU27 revealed that this floor space totals approximately 30,500 sq km. 25% of this floor space are made up by non-residential buildings of which 28% consist of retail buildings, 23% of offices (the largest part are public buildings) and 28% are pure public buildings such as schools 17%, hospitals 7% and sports facilities 4%. The majority of these buildings are not owned by the national governments but by local authorities such as cities, urban communities, Lander, provinces, regions and others. When a Private property represents the ownership entity, usually these local authorities provide a subvention for their construction and maintenance [9]. The development and use of intelligent solutions based on ICT could promote efficiency, connectivity and the integration of urban infrastructures and systems at two distinct levels: building/district - district/city (IEA 2014. Energy Technology Perspectives-ETP). The City of Rome is trying to come into line, culturally and strategically, with European standards of environmental health and energy savings.

The City of Rome is divided into 19 municipalities (district), each with its own administration and management. The 2nd District (II Municipio) is one with the most relevant urban area to verify the theoretical background of the research as well as to the verification of prerequisites for regeneration strategy choice. The 2nd District evinces a high concentration of structures for basic and university education, advanced research and healthcare services, but also relevant buildings for public and private services and several student housings [10].

According the peculiar concentration of this type of buildings of such strategic functions makes it possible to an effective simulation of the potential effects of a series of interrelated renovation actions, both at a building scale and at local level. The District dimension, the building concentration and a good associative structure and participative characterization of this territory can finally facilitate the involvement of potential users for the growth of the smart community at a district level, increasing the benefits of the social inclusion in each renewal action on buildings.

These buildings are strategic case studies because they are representative for dimensional cubature, for their constructive characteristics and for the chronological distribution of their construction in order to conduct an analysis of substantial statistical significance. An operation carried out on building complexes with similar characteristics will allow us to direct a large part of the interventions on the entire stock, focusing immediately on the causes of the problems of degradation and inefficiency and the most effective lines of action to take.

The recognition of the consistency of the existing building stock and the subsequent selection of the buildings that are representative of general conditions make it possible to compare results and draw from them intervention guidelines that are applicable to almost all of the public utility building stock. Many energy efficient measures and technologies in retrofit processes can be developed to improve building energy performance for the lighting, window, HVAC, insulation system etc. These include replacing/converting LED, CFL and T8 tubes for lighting systems, VFD chiller system, VAV boxes, conversion of hot water boiler etc. for HVAC system, and mechanical systems such as variable flow primary/secondary systems. Smart lighting technology, which is combined smart LED lights and wisdom lamp holders, hardware and software, can bring more than 30% of energy saving in library and school buildings.

Smart, innovative, intelligent and energy-efficient buildings are concepts that have characterized recent academic literature as the recent funded projects under the 7thFP (Joint initiative EeB-PPP). In this context "Smart Buildings" can be defined as attractive for citizens and investors, as based on an alliance between economic innovation, environmental sustainability, social and cultural development and open governance, in line with the European Strategy 2020 and the EERA (European Energy Research Alliance) Joint Program Initiative on Smart cities.

According to a typology approach, the non-residential categories had been firstly defined (12 major categories each including a certain number of specific subtypes, see Table 1), and then the ones with special consideration to the main relevance in the district and/or due to their quantitative relevance were chosen among the others. An analysis of selected buildings from the research initiative shows that in some buildings, there is no distinct daily time profile for the electricity consumed for heating and cooling, whilst in other buildings, night setbacks or fixed operating times lead to very characteristic daily electricity consumption profiles for heating and cooling [11].

Category	**Function**
Education Buildings	Schools, Kindergartens, Universities
Housing for elderly	Residential buildings for the third age
Office and Administration Buildings	Banks, Insurance-buildings, Government buildings, Official buildings
Factory Buildings	Large-scale enterprises, Manufacturing buildings
Workshop Buildings	Craft, Trade
Health Buildings	Hospitals, Polyclinics
Retail and Trade Buildings	Shopping Centre, Food, Non-Food
Warehouses	Central Warehouses, Shipping Depots
Sports Halls	Private, School and College Sports, Indoor Centres
Indoor Swimm. Pools	Leisure Pools, Small Indoor Swimming Pools
Cultural Buildings	Operas, Theatres, Concert Halls, Cinemas, Exhibition Buildings
Accommodation Buildings	Hotels, detached Restaurants

Table 1: Typological categories for non-residential buildings.

Efforts to increase the rate and depth of renovation will stimulate at the same time the market uptake of highly efficient and renewable technologies and construction techniques that can deliver the expected increase of the actual energy performance of buildings.

Different new design approach for building energy management systems (e.g. Modelica) which are an object oriented description language, these methods create a simulation model of the entire building, including the technical equipment, weather and occupancy.

In this context, the typologies for the support of industrialized modular retrofit of existing types of social housing and of existing types of school buildings can serve as a model for the development of a typology handbook for

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industrialized modular retrofit of public utility buildings. Renovating public buildings in the traditional (and thus lengthy) way as used for home dwellings, would mean moving entire user populations for the time of the retrofitting process, which is hardly feasible and certainly very expensive (costs of twice moving and re-housing). For this reason, the vision is to transform the retrofitting construction sector from the current craft and resource-based construction towards an innovative, high-tech, energy efficient industrialized sector. In this project, new retrofit solutions in planning, design, technology, construction, operation and use of buildings are investigated and will be evaluated.

In a modular retrofit system concept, industrialized craftsmen, within a temperate indoor working climate, produce the new facade and roof components in factories, safely and under much better working conditions than at the construction site. The components (modules) are pre-fitted with heating, cooling and ventilation ducts and service ducts for energy and data transport and are then transported to the site and mounted on site with cranes, within a very short period (days instead of weeks / months).

3 RESULTS

The ongoing investigation led to the identification of the dimensional characteristics of a large part of buildings (mainly school buildings), information on electrical and heat consumption over the previous three years, inspections for the examination and direct verification of data, as well as providing a detailed survey and thermographic and thermos physical surveys useful for the characterisation of the building envelope in terms of thermal performance.

Energy management systems will be able to reduce the energy consumption in buildings. This enables informed decisions about the investment and operating costs, energy savings and comfort to be made at an early stage. The use of simulation based verification and optimisation methods dramatically simplifies the complex design process for trades panning energy management.

When planning a retrofit, multiple performance strategies and actions have to be considered. For this reason, a decision support methodology will be used to select the most appropriate retrofit strategy/actions. The simulation-based retrofit design process consists of three phases: (i) Analysis of existing conditions, (ii) Development of retrofit strategies/actions (+evaluation), (iii) Implementation of retrofit strategies/actions.

The specifications for the building management system will also derive from the requirements for the building behaviour defined from the user profiles and the possibilities offered by the building services technology. The states of the building services technology and their temporal development will be described using a so called state machine which responds to changing sensor values in the building and, based on parameterised functions, determines suitable regulating variables for the respective building services technology. These assignments can be changed during simulations across the year in order to optimise the defined quality criteria.

At the same time, the share of renewable energies in a grid of energy-efficient interactive Buildings, with electricity based technologies for heating and cooling (e.g. heat pumps, compression chillers, CHP plants) will contribute to relieving the electricity system and reducing the demand for electrical storages and energy conversion processes by shifting the electricity consumption for heating and cooling temporarily, using technical storages and the mass of the building to store the energy as heat or cold.

This will enable surplus solar and wind power to be used and stored with a high efficiency as heating and cooling energy. Control and energy management concepts will be necessary to ensure that buildings interact favourably with a dynamic power grid and assume a more active role as part of the energy system.

Some important activities are now going to be sufficiently anticipated, in order to ensure the overall energy performance of the buildings and the grid simulations. For these reasons, considerable work on energy performance monitoring, socio-economic studies, E-GIS and software design have to be carried out in parallel, making the renovation project not only a building construction project but also providing a holistic approach to integrate rational use of energy at a neighbourhood scale.

Actually a renovation project at district scale included an important task on the monitoring of the global performances of the buildings such as energy consumption, comfort criteria and quality of renewable energy systems. Monitoring techniques serve to assess the actual and the post-renovation performance of the buildings. Monitoring activities are classified in terms of stakeholders involved, technologies and feedbacks to actors, based on past experiences, in order to provide guidance on the choice of a particular solution.

As no actual standard exists for such large scale monitoring activity, a reflection on the methodologies is needed to highlight the strong/weak points of each of them depending on the initial objectives of the monitoring.

The program represents a unique opportunity of the demonstration project (scale of the project, strong political commitment) to innovate and enhance existing energy policies and practices at local level by: transforming project experience

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into municipal policy, regulation and best practices, thus ensuring immediate replication of the results, proposing evolution for regional and national policies and regulations, making the lessons available to others via the development of policy guidance notes thus facilitating the adoption and use of this innovation by other municipalities and urban planners.

The academic implication of the PDTA Department in the project as promotor proves to be highly beneficial. It provides credibility and legitimacy to the project actions, while taking one step forward the internal reflection regarding the leading role of the university for the development of sustainable urbanism and energy efficiency.

Last but not least, the replicability of this activity also demands a highly mechanization degree since tele-control and monitoring systems advance very quickly.

4 DISCUSSION

The greatest challenge in the renovation market is to find new solutions for an existing situation (built structure and its use). An advanced retrofit strategy aims at establishing a holistic building strategy for the entire, remaining life cycle of the building. The ultimate option in the building strategy is to construct a new building in replacement.

Since the non-residential buildings exist in all communities (e.g. there are more than 370.000 school buildings alone in the EU) the set of technical solutions would be applicable in all cities and regions throughout the EU for all those non-residential buildings that have a structure which allows modular retrofit [12].

The aim of the research program is to evaluate the implications of different critical parameters for reaching the EU2020 energy renovation goals, starting from the lack of a consolidated classification regarding different type of utility buildings such as schools, universities, healthcare and administration buildings [13]. On the other hand, the aim is to overcome also technological and knowledge barriers alongside the transition towards the smart building diffusion, as well as to share the good practices across several national and international contexts. The technology of modular retrofit of existing housing is in full development however the solutions cannot be transposed automatically to utility buildings because of several factors and barriers that impede the diffusion of the industrialized mass retrofit market for utility buildings.

5 CONCLUSIONS

An urgent need for adaptation and transfer of these industrialized technologies towards utility buildings is required and for the creation of the instruments for master planning and stakeholder involvement for adequate retrofit and use of public utility building stock.

The following steps have to be implemented in the future to create a non-residential buildings typology tool:

(i) Create, based on different available sources, database for non-residential buildings
(ii) Analysis of data to build up the typology, relevant tool
(iii) Create final building matrix for defined buildings category

By promoting and thus increasing the use of these smart technologies in the utility building renovation market, demand will rise creating more offer of automated, industrialized production, leading to prices dropping towards or even below the existing price level for traditional renovation.

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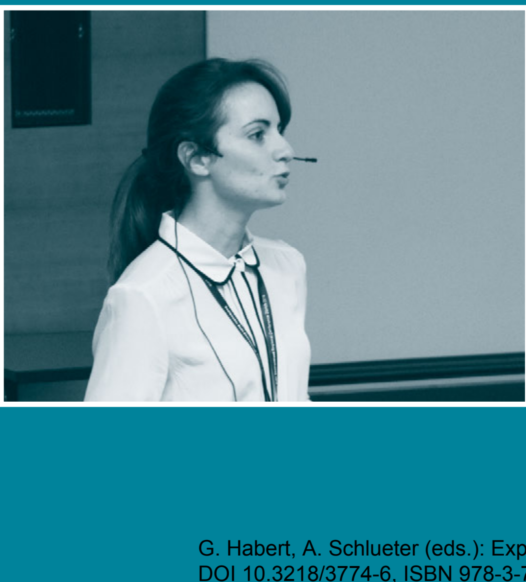

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