Building Physics and the Built Environment

A retrospective on research driven innovation toward more sustainable building stock

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Introduction

This article is intended as a small retrospective onto research in and on the built environment and the role of the built heritage in view of the challenges of today. Needless to say, such an article is of rather general nature and will not be able to *save the world*, however, the author is on the one hand interested in formulating some lateral thoughts onto the built environment and the environmental discussion, thus triggering discussions based on some general references and some specific projects on the other side. In the first section, the terminology of sustainability, resilience, and some other terms as well as their relationship with the built environment is discussed. Moreover, some characteristics of the evaluation of the built environment in view of recent challenges of mankind are mentioned. Subsequently, some recent projects the author gains knowledge about and/or has been involved into are discussed and their potential impact toward a better "performance" of the built environment is critically assessed. Finally the author tries to conclude with some final thoughts.

Sustainability, Resilience, and the built environment? Is there any relation?

A set of definitions has been used in past decades and recent years to describe the complex nature of ways of life more compatible than the current practice and also regarding the reaction on the ongoing climate crisis. Thereby, the terms of efficiency and sufficiency, sustainability, and resilience often can be found in literature and everday's debates. Efficiency regularly describes a concept that is aimed to reach a good ratio of reached target level of an effort with a minimum of resources. In a broader sense, definitions such as "Efficiency is thus not a goal in itself. It is not something we want for its own sake, but rather because it helps us attain more of the things we value." can be found (Stone 2012). In terms of building performance, efficiency is regularly connected with ideas of delivering a certain desired performance, e.g. comfortable indoor conditions within a residential unit, or sufficient lighting levels on a workplace, by a minimum of consumed energy. While in principle desirable, the question remains, what happens with the difference between efficient states and non-

efficient states. Many studies found that this delta, even if desired, sometimes leads to rebound effects or even contradictory behaviour. A famous example is the over-extentive ventilation after thermal retrofit, which cuts short the savings. A more extreme example is, if saved money of efficiency measures than is re-invested in a stronger, fuel-burning car, or additional holiday flights. As such, efficiency needs to be looked upon in a holistic manner. Given that stakeholder that implement efficiency measures and benefiters might be different stakeholders, it shall not be assumed that people automatically transfer efficiency into environmental friendly behaviour. Sufficiency is a supplementary and at the same time complementary concept to efficiency. Rather than technically improving systems, such as efficiency measures often do (e.g. adding insulation to a wall, replacing a HVAC-system by another, more “efficient” one), sufficiency is looking at certain target values / thresholds which should not be exceeded. A famous example is from Switzerland, and is known as the 2000 Watt society. Based on the global average energy usage of 2000 Watt, as was calculated in the beginning of the 1990ies, this principle targeted a comfortable, but limited energy use per person (Zürich, n.d.). Sustainability might be the oldest of this terms, as it can be traced back to a publication of 1713, which is named *Sylvicultura Oeconomica* and dealt with sustainable horticulture. In principle, sustainability means to keep the consumption of resources at a level that allows systems to regenerate and not to be used up. A lot of scientific effort from different disciplines has been conducted in the past years to figure out definitions and approaches that are sustainable and allow for a more sustainable lifestyle. An important publication has been published by Jeffrey Sachs in 2015 with *The age of sustainable development* (Sachs 2015). Resilience has become more popular in recent years, as a concept of management of crisis and disbalanced situations. However, the pure technical approach of engineering resilience has been improved by ecological and evolutionary resilience in recent years. *Technical or engineering resilience* regularly is defined as the ability of a system to return to an equilibrium or steady-state after a disturbance. Technical resilience regularly considers one equilibrium as given, thus one can say it is a rather linear approach. In contrast, *ecological resilience* is understood as the level of disturbance a system can absorb, before a (permanent) change of the systems structure can be observed. The concept of one sole equilibrium is questioned in here, the existence of different equilibria is considered possible in this approach. Evolutionary resilience questions the aspect of equilibria in general, and considers systems by nature to be dynamic and adapt the concept of system resilience.

In view of upcoming challenges, such as impact of climate change, urban heat island effects and densification of cities, these concepts could be used for target definition of the performance of the built cultural heritage (hereby meant as the “overall existing city matrix” consisting of the built heritage). Needless to say, if we focus onto the upkeep of the existing building stock, all of the mentioned concepts are important for any discourse onto the existing building stock and its performance. The following three aspects shall illustrate the complex relation between Building and Human Ecology and the built environment:

(i) The evaluation of buildings is – today – often based on energy performance indicators, such as heating demand and cooling demand. These KPIs regularly relate to specific, rather short time frames, such as days, months, or heating seasons. What is often forgotten is the environmental footprint of existing building structure, which is – given the long time span these structures remain – by far better than any performance of today’s real estate developments that regularly focus on

a usage time of 30 years or even less. Regularly the evaluation of buildings and building components is not considering these longevity of structures, leading to significant worse evaluation results of existing buildings. Moreover, given the degree of complexity in planning of today's buildings, the in part planned obsolescence of materials and technical equipment, the general high level of technical equipment of the buildings, and the rapid and continuous technological advance of building equipment, it can be assumed that the environmental impact of retrofit, demolition and new constructions will never be competitive to the older building stock. As already indicated, these aspects are barely considered in today's evaluation of the building stock.

(ii) Given the upcoming challenges pertaining to climate change and urban heat islands, the existing building stock often profits from its large mass of constituent walls and elements. However, the increased necessity for shading devices and greenery will change the way we have to deal with the built heritage. For instance, the Viennese *Gründerzeit* residential building stock does regularly not encompass shading devices on the building exterior. The alternative of energy consuming A/C units is – due to the energy and emission impacts - neither an option, nor an opportunity, as these units even increase the issues they should mitigate.

(iii) Building regulations and building-related standards demand not only efficiency in the operation of buildings, but also require specific adaptations in the usability. The major examples hereby are fire safety and aspects of Universal Design. Without doubt, the consideration of safety and risk assessment are of importance, but shall not lead to exaggerating modification necessities. Current guidelines (e.g. the OIB-guidelines in Austria, OIB 2019) thus provide different levels of minimal requirements that differ between new buildings and retrofit of buildings.

Research and Development in the domain of performance improvement of the sensible building stock should, given the complex nature of upcoming challenges, performance goals and aspects of preserving of cultural heritage, explore technologies and approaches that can foster these in-part contradictory goals.

Examples of research projects with impact on both heritage preservation and performance improvement

Past and ongoing research projects, conducted at the Research Unit of Building Physics and Building Ecology included projects pertaining to the improvement of the thermal performance of building envelopes. Examples of such projects were the impact assessment of aerogel plasters (project AGelFa, compare Schuss et al. 2017), which could act as thermally insulating alternative for articulated facades and viable way to supplement gaps in facades. Similarly, the thermal improvement of traditional casement windows as conducted in the projects VIG-SYS-RENO and VAMOS (see nachhaltigwirtschaften n.d.) could offer new ideas for thermal improvement of windows resulting in "repair" instead of "replacement". However each and any improvement of the thermal envelope might be rather useless, if no knowledge about the correct behaviour of occupants exists at the operators, and on the other side occupants do not operate buildings accordingly. As such, any research in the domain requires the consideration of Occupancy and Human factors (compare Mahdavi et al. 2021). Moreover, user-centered research and development has to consider the necessities of the people with special demands. As an example, in the project ViDeA (Maringer et al. 2019), we explored the

contrast perception of people with visual impairments, and the requirements toward visual environments in buildings. While the adaptation of lighting conditions might be easily done in most of the existing buildings without severe changes of the buildings, this is not necessarily true for adaptations for people with mobility impairments, leading to conflicts between universal design aspects and maintenance of original shapes of affected existing buildings. So called “Crazy Ideas”, such as the occupant centred delivery of radiative heating and cooling might also offer new approaches for energy savings (compare Sommer 2020).

Conclusions

The present contribution in very short words outlined the close connection between typical concepts of environmental friendly development, the existing buildings stock, and energy- and environmental-impact related research and development in the domain of the heritage-relevant building preservation.

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References

Carlowitz, H.C. (1713): Silvacultura Oeconomica.

Davoudi S., Shaw K. , Haider L.J. , Quinlan A.E., Peterson G.D. , Wilkinson C. , Fünfgeld H., McEvoy D. , Porter L. (2012) Resilience: A Bridging Concept or a Dead End? “Reframing” Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan Urban Resilience: What Does it Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note, Planning Theory & Practice, 13:2, 299-333, DOI: 10.1080/14649357.2012.677124

Mahdavi a., Berger C., Amin H. et al. (2021) The Role of Occupants in Buildings´ Energy Performance Gap: Myth or Reality?;Sustainability, 13 (2021).

Maringer, M., Wolosiuk D., Hauck N., Pont U., Vogelauer C.,Fürst E., Buser F., Mahdavi A.: (2019) "Toward visual accessibility in the built environment: The ViDeA Project"; Applied Mechanics and Materials (invited), Special Volume: Energy Saving and Environmentally Friendly Technologies - Concepts of Sustainable Buildings (2016), 428; 829 - 835.

Nachhaltigwirtschaften (n.d.) Endreports of the projects VIG-SYS-RENO and VAMOS, www.nachhaltigwirtschaften.at

OIB 2019: Richtlinien des österreichischen Instituts für Bautechnik, www.oib.or.at

Sachs, J. (2015): The age of sustainable development. Columbia University Press.

Schuss M., Mahdavi A., Pont U., Sustr C., Aien S., Ghazi Wakili K., Stahl T.: "Strukturierte Aerogelputze"; in: "Bauphysik-Kalender 2017", 1; N.A. Fouad (ed.); Ernst & Sohn. Verlag für Architektur und technische Wissenschaften Berlin, Berlin, 2017, (invited), 153 - 175.

Sommer, B., Pont, U. (2020) Prüfung bauphysikalisch und energetisch innovativer Gebäudekonzepte auf ihre Machbarkeit unter Monitoring und Evaluierung eines Mock-Ups. Schriftenreihe 29/2020, BMK; https://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe-2020-29-eva.pdf

Zürich (n.d.): Unterwegs zur 2000-Watt-Gesellschaft - Wie Zürich zu einem nachhaltigen Umgang mit Energie kommt; available via: https://www.umwelt.graz.at/cms/dokumente/10260085_6740671/cbdec255/LAY-2kw-heft%20Z%C3%BCrich.pdf