Pathways To the Smart Building Era - A Mixed Method Approach to Understand Building Occupants and Unlock Organizational Bottlenecks to Achieve a Balance Between Thermal Comfort and Energy Efficiency

Abstract:

The use of smart building technology provides massive amount of data and the opportunities seem endless. However, digitalization is a relatively new concept for the real estate industry and how to make the full use of the digital landscape is not yet realized. Therefore, this PhD-thesis aims at providing expertise about how to manage smart building data in common-shared buildings with the goal to reach a balance between thermal comfort and energy efficiency.

Publications:

- *Showcasing the First Steps Towards a Digital Twin for Campus Environments.* September 2022. K Bäcklund, P Lundqvist, M Molinari, P Karlsson. Showcasing the First Steps Towards a Digital Twin for Campus Environments (diva-portal.org)
- *A Meta-Analysis about Building Occupants and Their Impact on Building Energy Use, Differentiating the Energy Saving Potential between Smart versus Conventional buildings.* February 2023. K Bäcklund, P Lundqvist, B Palm, M Molinari. The paper is under submission to: Energies | Special Issue : Thermal Environment and Energy Saving in Buildings (mdpi.com)

Research Projects:

2018: Research project *GDPR and Smart Buildings* funded by Smart Built Environment (Cyril Holm, Jonas Anund Vogel, Marco Molinari, Barbro Fröding and Robin Roy). I wrote a report about the implications on smart building technology, including Undervisningshuset as a case study building. Presentations at seminars and KTH Live-In Lab events.

Final Report: juridik-och-digitaliseringen-av-samhaellsbyggnadssektorn.pdf (smartbuilt.se)

2018: *Multipla testbäddar*. Research project within the concept KTH Live-In Lab (Jonas Anund Vogel). The goal was to establish an open platform to share building data between various buildings (and owners). Facilitations of meetings between key stakeholders; Akademiska Hus, KTH and the provider of HVAC system, Lindinvent. Investigations about how to share data in a compliant and secure way.

190830_Slutrapport Multipla testbäddar.pdf (kth.se)

2019-2022: *Live-In Smart Buildings* funded by Energimyndighetens E2B2 program (Marco Molinari, Davide Rolando). I wrote a Literature Review; *The Use of Feedback as a Nudge to Promote Energy Aware Behaviour* (Not published). I also facilitated a measurement campaign at Draconis student apartments at KTH, testing a web-based app that provided information about perceived indoor comfort from the building occupants.

Cost- and Energy-Efficient Control Systems for Buildings | KTH

Real-time user feedback: monitoring campaign in student apartments | KTH

Background & Way Forward:

Based on key findings from action research within the context of Akademiska Hus and KTH, my PhD-work intend to contribute with new ideas about how to understand and optimize smart building data. The aim is to explore ways to utilize smart building data to lower the climate impact from commercial and common-shared urban buildings and at the same time ascertain an acceptable thermal comfort for the building occupants.

Undervisningshuset at KTH Campus was established in 2018 by Akademiska Hus. It is a gold-rated building by the Swedish Green Building Council and it is equipped with hundreds of sensors and also smart building HVAC system and sensor-steered lighting. Therefore, this building is assessed as a case study building where I aim to investigate the following:

- Map all the technical building systems in Undervisningshuset.
- Based on observations and system-mapping, determine to what extent the building occupant can interact with the smart building systems (HVAC, lighting, other electricity demanding devices).
- Investigate by the means of an interview study if the building occupants know how to interact with the smart building systems? i.e. are these systems user-friendly, designed in an intuitive way?
- Based on the findings from this case study and previous work – elaborate regarding the potential to target building occupant behavior and awareness to reduce total building energy use. The hypothesis is that the potential should be less in a smart building, compared to a building equipped with conventional building technology. It was found in my literature review that there is a gap in research about the relation between smart building occupant behavior and potential building energy savings.

Preliminary results from the case study in Undervisningshuset indicate that although it is a smart and gold-rated building, the indoor comfort is not experienced by the building occupants to be sufficient. The building occupants can adjust indoor temperature through smart thermostats, but this interaction does not work as expected. This is due to design aspects of the smart thermostats, its physical location in the room and pre-defined temperature settings.

Based on these findings, it can be concluded the building operator and the building manager is key actors to achieve an acceptable indoor climate as well as obtaining an energy efficient building. Thus, my aim is to provide insights how digitalization can be adapted in day-to-day life of managing a common-shared building stock. How to operate a smart building optimally, with the building occupant in focus, and how to select and analyze relevant information from the massive amount of sensor data is two key research questions.