Reflection

Automate user behavior to reduce energy demand and improve indoor air quality of residential buildings

10-05-2019

Name student:	Thomas Koenes
Student number:	4648110
Telephone number:	0653664972
Private e-mail address:	Koenes.thomas@gmail.com

Studio	
Name:	AR3B025 Sustainable Design Graduation
Topic:	Circular Building Products
Main tutor:	Marcel Bilow
	Regina Bokel

In 2013, national agreements have been made to stimulate a healthy and sustainable growth of the Dutch society and economy. Agreement has been made that all buildings need an average energy label A by 2030 (Sociaal-Economische Raad, 2013). However, the calculated energy savings for all energy labels do not correspond with the actual energy savings. Calculating the energy saving potential of a building is difficulty to determine due to unknown air infiltration and user behavioral characteristics (Majcen & Itard, 2014). The occupants, not buildings, are the primary energy consumers because they behave proactively and perform energy related tasks in order to seek comfortable personal conditions (Hong, Yan, D'Oca, & Chen, 2016). These indoor conditions are reached by operating the thermostat, opening windows, mechanical ventilation and much more. Unfortunately, these systems can be misused by a user due to ignorance, user error or negligence. The effect of user behavior on the heat loss and indoor air quality becomes greater when buildings become more air tight, have a more complex ventilation system or higher insulation value (Jack, Loveday, Allinson, & Lomas, 2015). Thus, it is important to accurately simulate user behavior in order to accurately predict energy consumption, but it is more important to educate or assist a user to behave sustainable.

In which way can a new system effectively assist users to reduce the energy demand for heating and cooling of a residential building, while creating a safer and more comfortable indoor air quality?

The general aim of this research is to advance the knowledge base on ways of saving energy and increase indoor air quality by addressing user behavior characteristic with an automated building product. This study could offer alternative options for energy saving methods and thereby contribute to the current efforts in sustainable design research. By providing knowledge on thermal loss due to user behavior, occupants can implement such strategies to create more comfort while reducing their energy consumption. The ambitions of my proposal is creating a working prototype that makes decisions based on indoor parameters, via an algorithm that is substantiated by literature, simulations and calculations.

This concept focuses on reducing the thermal loss due to the increase of the air change rate resulting from window operation. The additional energy consumption due to window operation during heating season can be significant, but is difficult to quantify. Ventilation and window opening characteristics become more important due to renovation trends favoring air tight buildings. These high performing and air tight buildings can lead to an indoor accumulation of air pollutants and high humidity's, which can cause multiple health symptoms. Indoor air pollutants encompasses multiple fumes and particulate matter sizes, which need to be taken into consideration while designing a product for indoor comfort. This was one of the first obstacle while researching this topic. I wanted to include every type of pollutants that could be found in the indoor environment, but this created a situation that was a bit overwhelming. After discussing with both of my mentors, we settled for measuring the indoor environment on CO2 and PM10 concentrations These pollutants are commonly used indicators for indoor air quality. These parameters for indoor air quality needed to be measured with sensors, which posed a lot of difficulties. Mixed and contradicting information on these sensors can be found. Especially the CO2 sensors gave a lot of difficulties, due to the multiple measuring techniques that are used to measure CO2 concentrations. In the end, five different CO2 sensors were used for the prototype, all with different codes, which took more time than was planned. The final prototype is installed in the PDlab where it was used for testing its cooling and air cleaning potentials. The creation of this prototype relied on companies that wanted to sponsor this project, which created some difficulties and rethinking of my design. My first ambitions were too high, I wanted to replace the current windows used in the PDlab with TipTronic window frames from Schuco. But after months of discussing, this seemed impossible which forced me into creating a different prototype. The final prototype is made in collaboration with AXA home security and Netatmo.

The used research approach could be improved, but every form of research has its obstacles that, in retrospect, maybe could have been avoided. Being over ambitious is part of being a student, that sometimes needs a little guidance from a tutor. In the end, I created what I wanted to create. The prototype that is installed in the PDlab works as intended, it lowers energy consumption due to thermal loss and can guarantee a safe indoor CO2 concentration.

The final system is designed for residential buildings that are constructed before 1975, because of the lack of regulations on ventilation capacities and the low energy awareness during the time of construction. A larger renovation can become financially more interesting when installing this ventilation system, due to the large financial incentives which are associated with a CO2 driven ventilation system. Therefore, the proposed system can form a catalyst for occupants to invest in a larger intervention, accelerating the energy transitions and hopefully reach the Dutch goals and ambitions to make all buildings an average energy label A by 2030 (Sociaal-Economische Raad, 2013), with a more desired and predicted energy consumption.

REFERENCES

Hong, T., Yan, D., D'Oca, S., & Chen, C.-f. (2016). *Ten questions concerning occupant behavior in buildings: The bigpicture.* Berkeley: Building and Environment.

Jack, R., Loveday, D., Allinson, D., & Lomas, K. (2015). *Quantifying the Effect of Window Opening on the Measured Heat Loss of a Test House.* Leicestershire: Leeds Beckett.

Majcen, D., & Itard, L. (2014). *Relatie tussen energielabel, werkelijk energiegebruik en CO2-uitstoot van Amsterdamse corporatiewoningen.* Delft: Rekenkamer Metropool Amsterdam.

Sociaal-Economische Raad. (2013). *Energieakkoord voor duurzame groei.* Den haag: Sdu Uitgevers.