CITIES
Centre for IT Intelligent Energy Systems

smart-cities-centre.org CITIES_Centre cities-innovation-center

AALBORG UNIVERSITY
DENMARK

DTU

Time Constants and Clustering of Building

BY JAUME PALMER REAL[1], CHRISTOFFER RASMUSSEN[1], KENNETH LEERBECK[1], RONGLING LI[2], OLE MICHAEL JENSEN[3], KIM B. WITTCHEN[3] and HENRIK MADSEN[1]

[1] DTU Compute, Technical University of Denmark, Lyngby, Denmark
[2] DTU Byg, Technical University of Denmark, Lyngby, Denmark
[3] Department of the Built Environment, University of Aalborg, Aalborg,Denmark

Published December 2020

Access to complete document
https://doi.org/10.1016/j.enbuild.2020.110530

Introduction

Buildings account for a large portion of the total energy consumption and they might serve as a significant thermal storage capacity that can be advantageous for the future energy grid. To utilise this capacity, it is necessary to characterise the thermal dynamics in buildings. Existing methods often rely on data that is difficult to measure, or models that are case-specific. Thus, it is necessary to find new methods that are more general to be applicable to a larger share of the building stock.

Idea

At night, many variables that add noise to our building models are negligible or directly zero (e.g. solar radiation and occupant activity).

Moreover, when a building uses a *nigh-setback* strategy, the heating is turned off during night hours. In such periods the indoor temperature decays freely.

Then, this decay trend is characteristic from the particular building and can be used as a fingerprint that described heat loss dynamics of the building.

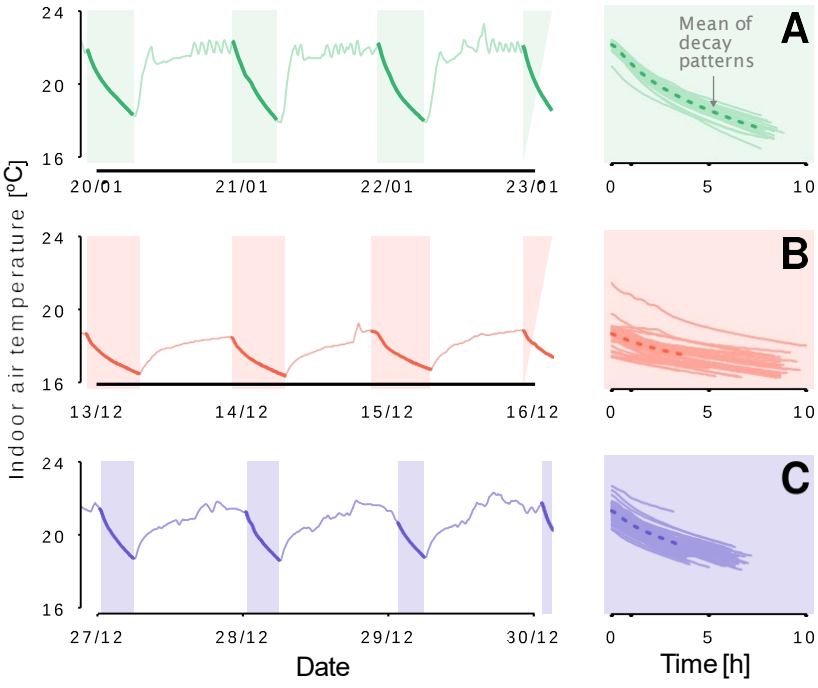

Figure 1. Example of three captured decay patterns for three example buildings: A, B, C

Solution approach

We propose a data-driven method to characterise thermostatically controlled buildings. The method uses Hidden Markov Models to select night data periods with a steady decay of the indoor temperature. Afterwards, a linear model is fitted using the selected night-time data.

Based on this linear system, it is possible to compute two time- constant parameters that characterise the heat-loss dynamics of the building. With these two parameters (τ_1, τ_2) it is possible to cluster and categorise buildings according to their thermal response.

This method uses scarce data that is often easy to measure. Thus, it can be scaled to compare the potential of buildings as thermal storage units.

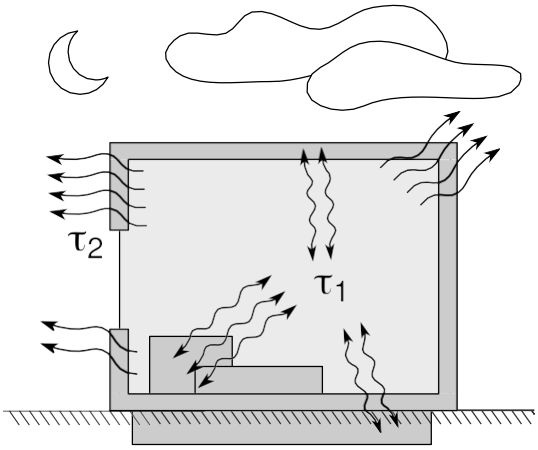

Figure 2. Schematic of the two main heat-loss dynamics inside of a building

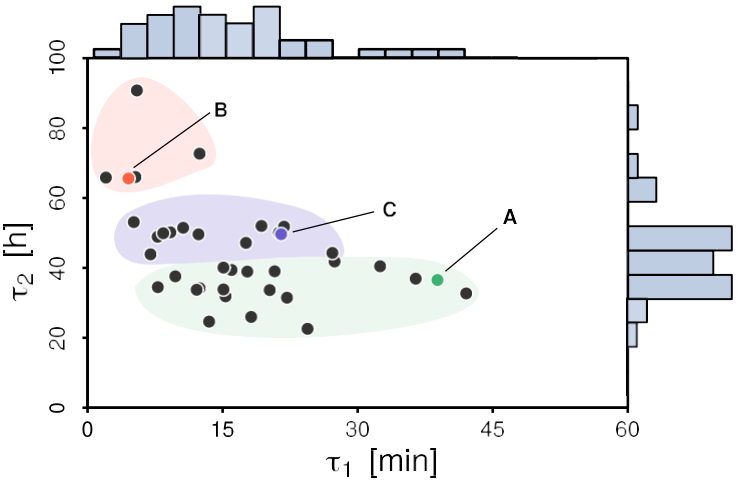

Figure 3. Map of the two time constants for 39 different danish residential buildings

Conclusion

- The results show that it is possible to gain insight about the dynamic thermal response of buildings using accessibe limited data
- The obtained characteristics help assessing the potential of a particular building as a flexible thermal storage unit
- This method requires limited resources, it can be used easily for large-scale screenings of buildings to compare their thermal response

Contact

Jaume Palmer Real (jpre@dtu.dk) is a PhD student at DTU Compute
Christoffer Rasmussen (chrras@dtu.dk) is a PostDoc at DTU Compute
Kenneth Leerbeck (kenle@dtu.dk) is a Research Assistant at DTU Compute
Rongling Li (liron@byg.dtu.dk) is an Associate Professor at DTU Byg
Ole Michael Jensen (omrj@build.aau.dk) is a Senior Researcher at the Department of Built Environment at the University of Aalborg
Kim B. Wittchen (kiwi@build.aau.dk) is a Senior Researcher at the Department of Built Environment at the University of Aalborg
Henrik Madsen (hmad@dtu.dk) is a Professor and Section Head at DTU Compute
Acknowledgments: Innovation Fund Denmark. Grant DSF 1305-00027B