BRIDGING THE BUILDING PERFORMANCE GAP

Tools for Reliable Energy Performance Characterisation of Buildings

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Introduction

The European households accounts for 25 % of the total energy consumption (Fig. 1), where 65 % is used for space heating (Eurostat, 2016). Consequently, a significant part of the greenhouse gas emission. But, equally important, buildings offer great possibilities for large energy savings and reduction of greenhouse gases through renovation. Greenhouse gas reductions that are necessary to reach the European energy strategy goal for 2050—specifically a greenhouse gas reduction of 80-95 % by 2050, compared to 1990.

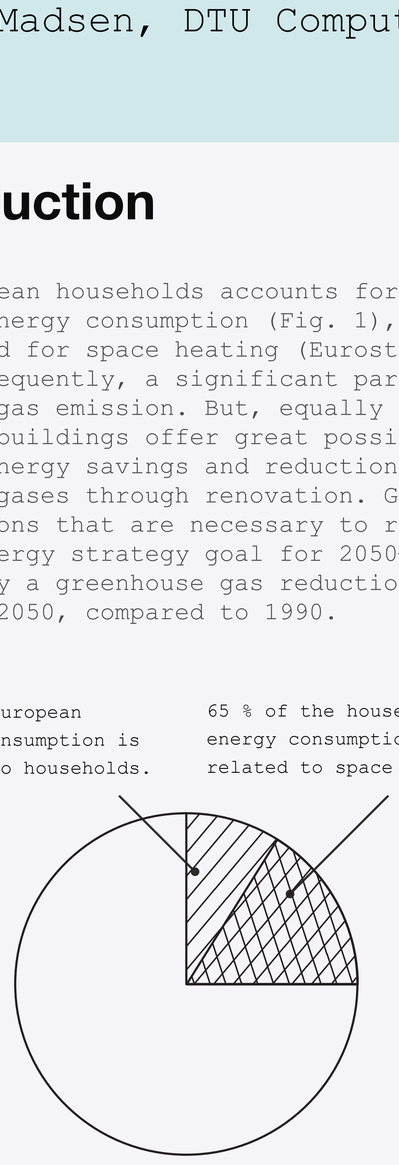

Fig. 1 – Total European energy consumption based on tonnes of oil equivalent.

Talking about energy reduction, the estimated energy consumption for buildings are often underestimated. One study shows that the difference can be as large as 100 % (Brohus *et al.*, 2010) and differences of 300 % are observed between identical buildings (Socolow, 1977; Meier *et al.*, 2010). This discrepancy is partly related to oversimplified assumptions about occupant behaviour in the design phase, and partly to sloppy workmanship in the construction phase. Development of reliable tools for in situ characterisation of the actual energy performance are for that reason of utmost importance. Tools like this can help obtaining tangible energy savings, improved thermal comfort and higher built quality.

Today, there is no operational method or tool that can be used to identify, quantify and analyse the reasons for the discrepancies between expected and resulting energy and indoor climate performance. Consequently, there is missing a possibility to target building improvements and optimise the operation.

The development of tool for reliable energy performance characterisation of buildings is part of the REBUS projects, which concerns energy renovation of apartments from the 60's and 70's. Many of the tools used in REBUS are based on results from the CITIES project.

Approach

The objective of this project is to develop reliable yet simple energy performance characterisation tools, that easily can be put into practice. The main research approaches to reach the goal consists of data splitting, building performance estimation and occupant behaviour trend recognition.

Data Splitting Today, reliable co-heating methods for building envelope test exists for unoccupied buildings. This includes the QUB/e method developed by Saint-Gobain. These methods are fast and work independent of season. Because the building is uninhabitable during the measurement campaign, these methods does not provide information on occupants' effect on energy consumption and thermal comfort.

To characterise building performance and occupant behaviour, measurements are carried out during occupation. Consequently, a method to separate building and occupants' effect on energy consumption and thermal comfort is necessary.

Bacher et al (2016) has earlier succeeded in splitting domestic hot water and space heating consumption by use of kernel distribution estimation. Chen and Liu (2017) has develop a method for outlier detection based on joint estimation of model parameters (Fig. 2). Both methods will be tested.

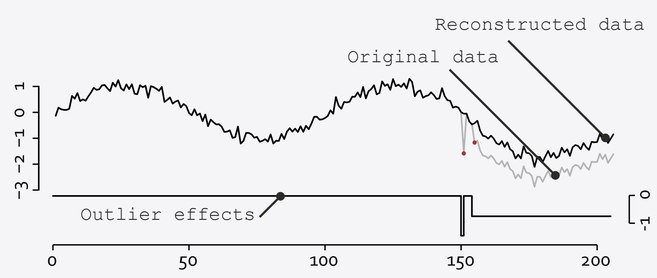

Fig. 2 – Detection of outlier and level shift due to external effects, e.g. occupants' behaviour.

Building Performance Estimation Significant discrepancies between insulation levels of identical designed building components have been observed in studies related to Annex 58. As the actual thermal performance of the walls are hard to quantify by measurements, statistical parameter estimation methods can be used as illustrate in the same Annex (Madsen *et al.*, 2016).

Different performance estimation methods for different detail levels will be tested on data from occupied buildings. This includes autoregressive models with exogenous input (ARX models) and grey-box models.

Occupant Behaviour Trend Recognition Occupants' effect on the energy consumption and the thermal indoor environment is often neglected indirectly due to lack of suitable design tools. As a result, the expected energy consumption is often underestimated.

By isolating the occupants effect via the before mentioned data splitting method, valuable information can be obtained by e.g. consultants and occupants. This being occupants feedback on building use related to energy and indoor climate, and better energy and thermal comfort estimation based on user type for consultants.

Perspective

Wrapped together, the final tool will:

1. feed occupants with suggestions for better building use related to energy and indoor climate,

2. supply consultants with valuable information on occupants' behavioural tendencies based on specific occupant types for better building performance and thermal comfort estimation, and finally

3. provide easy assessment of building performance for contractors and building owners.

4. Identify the most beneficial buildings for renovation projects to maximise the energy efficiency obtained for a given investment.

5. Provide automated guidance on how to improve the individual buildings or apartments.

By educating the occupants in better building use, provide information for better energy and thermal comfort design, and assess the realised building more easily than currently, this project contributes to the REBUS target of reduces the energy consumption after renovation by 50 %.

A known limitation on the method will be that the measurements must be obtained in the heating season, to distinguish thermal dynamics from noise. However, the tool will add higher level of detail to energy performance characterisation than what exist now, as well as gain information on occupant's effect on energy consumption and thermal comfort. Information that otherwise is hard to obtain.

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