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The influence of occupants' behaviour on energy consumption investigated in 290 identical dwellings and in 35 apartments

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1 Introduction

Occupants who have the possibility to control their indoor environment have been found to be more satisfied and suffer fewer building related symptoms than occupants who are exposed to environments of which they have no control [Paciuk, 1989, Toftum, 2009]. Consequently, giving the occupants possibilities to interact with building controls will result in better building performance in terms of occupant satisfaction. However, occupant behaviour varies significantly between individuals which may result in variations in the energy consumption of buildings. Andersen et al. (2007) conducted a simulation study with the aim of quantifying the effects of different behaviour patterns on the energy consumption in buildings. They defined energy saving and energy wasting behaviour patterns and found that differences in occupant behaviour might lead to ratios of more than 3 between the highest and lowest energy consumption. The differences found here occurred at identical thermal comfort ranges and occupancy patterns, suggesting that the differences in the real world might be even larger.

Andersen (2009) found that occupants' patterns of window opening and heating set-point preferences seemed to be stable within a dwelling but varied greatly between dwellings. It was assumed that the stable patterns of use would lead to a stable pattern of heating consumption within the dwellings but a variation within dwellings.

In this paper, I have analysed two sets of data with two different aims: Heating consumption data from 290 identical townhouses was investigated with the aim of estimating the influence of occupants' behaviour. Furthermore, 11 years of heating consumption data from 35 apartments was analysed with the aim of investigating the relative stability heating consumption within each dwelling.

2 Methods

The first set of data consisted of four years of heating consumption data from 290 identical townhouses, collected via the annual heating bills.

The houses were located in Albertslund, a suburb of Copenhagen. The measured values included space heating and heating for hot water consumption.

179 of the houses were east/west oriented with the largest windows facing west, while the remaining 111 houses were north/south oriented, with the largest windows facing south. 118 of the houses were located at the end of the 'row' and had an extra wall (gable) facing the external. The remaining 172 were located between other houses. All the end houses' consumption was corrected by subtracting the average difference between end- and middle houses (15.9 kWh/m²) from their consumption. A similar attempt was made to correct the data for differences in orientation. However, no statistical significant differences were found between consumption data from the two orientations.

The data was obtained in anonymous form without information about the inhabitants.

The second set of data was obtained from a single building containing 35 apartments, located in the centre of Copenhagen. This dataset consisted of 11 years of heat consumption in each apartment. The heat consumption was measured using heat consumption allocators on each radiator and did not include heating for hot water consumption. The data included names of the tenants and information about periods where tenants had moved in and out.

To investigate relative stability of the consumption patterns, a comparison was made between 'movers' and 'stayers'. A 'stayer' was defined as an apartment, where the tenant stayed the same (no one moved in or out) during a period of two consecutive heating seasons. A 'mover' was defined as an apartment where the tenants moved out and new tenants moved in. The apartments were ranked according to their heating consumption. For each heating season, it was investigated if any apartments had changed rank and if so how many ranks they had moved. A comparison of rank changes was done between movers and stayers. This was done to test the assumption of stable consumption patterns, which would result in a lower rank movement amongst the stayers that amongst the movers.

3 Results and Discussion

The heating consumption from the 290 identical townhouses ranged from 9.7 kWh/m² to 197 kWh/m², resulting in a ratio between highest and lowest consumption of 20. Since the houses were identical, the differences must be a result of differences in occupancy and differences in the occupants' behaviour.

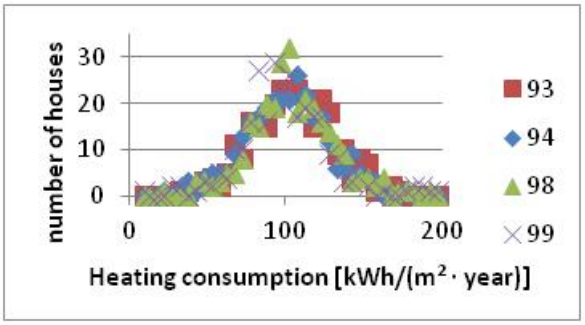

Figure 1: Distribution of heating consumption from 290 identical houses.

The heating consumption from the 290 houses was remarkably stable over the four years. However, since the data was anonymous it was not possible to investigate the stability of the heating consumption of a single house, based on this data. This was possible using the data from the 35 apartments.

Figure 2 shows the distribution of the apartments rank movements from one heating season to another.

Most of the apartments moved less than 10 ranks (up or down) between two consecutive heating seasons (35 of 48 movers and 259 of 302 stayers). The movers had a statistical significant greater standard deviation than the stayers did (one sided F-test). This provides evidence that the apartments' consumption patterns were more stable in the cases where the tenants did not move than where new tenants moved into the apartment.

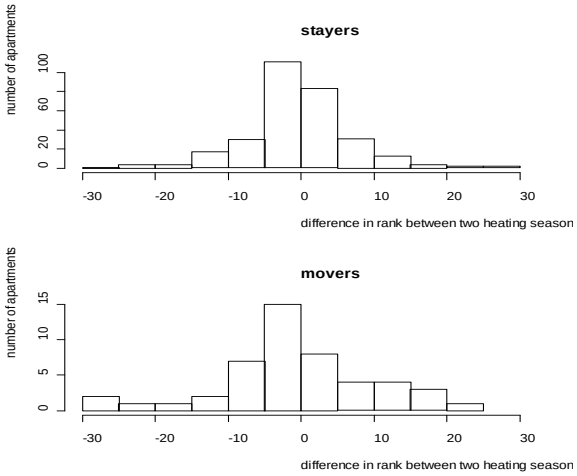

Figure 2: distribution of changes of ranks of the 35 single apartments from one heating season to another.

4 Conclusions

The largest variation between heating consumption in 290 identical houses was 20 to 1. Since the houses are identical, the variation was a result of different patterns of use.

35 apartments were ranked according to their heating consumption. Apartments where the tenants moved had a higher change of rank than apartments where the tenants stayed the same, indicating that the behaviour of the occupants had a significant influence on the energy consumption in the building.

5 References

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