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INVOLUNTARY REBOUND IN LOW ENERGY BUILDINGS

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1. INTRODUCTION

German standards for energy efficient buildings demand increasing levels of insulation. However, it has been observed that the energy savings achieved are often lower than projected – an effect known as “energy performance gap” (EPG) [1]). The literature attributes this in large part to occupant behaviour. However, occupant behaviour is still not well understood [2]. We address this research gap by analysing the interaction of building characteristics and household behaviour in a case study of low energy buildings. We too observe an EPG, but we conjecture that it is to a larger part an “involuntary rebound”, meaning that the interaction between households and building technology changes in ways unforeseen by the planners and not intended by the households themselves.

2. DATA AND METHODS

We approach this topic mainly from the perspective of sociological practice theory [3]. Within an interdisciplinary team of social scientists and engineers, we study six buildings with eight apartments each, built in 2010 according to German EnEV 2009 standards. The thermodynamic properties of the buildings are described in a detailed report. During the winter months of 2017/18, we conducted 18 qualitative interviews with the residents, focusing on their energy consumption and the respective thermal and ventilation comfort. Data on the energy consumption of the apartments are recorded over the last eight years. Thus, our material comprises building physics and technical installation descriptions, energy consumption data, temperature measurements and window opening times, as well as interview data on the households' habits and evaluations.

3. INVOLUNTARY REBOUND

The conventional assumption of the rebound effect is that consumption increases in reaction to savings achieved through more efficient technology. For example, occupants voluntarily choose a higher room temperature due to more effective insulation and hence lower heating costs. However, the rebound we conceive is partly to be seen as “involuntary”, due to the following observations:

– Unexpected energy consumption mainly occurs during fall and spring months.
– Measured room temperatures even in winter times sometimes reach a maximum of 32°C, well beyond the usual thermal comfort limits [4].

- Reported as well as measured average temperature settings differ between adjacent apartments, ranging from 18° to 25°C. Differences in energy consumption between apartments are even higher.
- Interview partners report different thermal comfort expectations during the day, depending on different practices (watching TV, physical activity, sleeping).
- Interview partners partly report extensive ventilation practices.

Based on these observations, we presume that the involuntary rebound has three independent and combinable causes: 1) Negligence – occupants do not register open windows any more due to reduced draught and the resulting loss of biofeedback [5]. As a consequence occupants might forget to close windows when outside temperatures become cooler. 2) Heat transfer between adjacent apartments may not only result in unfair energy bills [6], but even in overall energy leakage – occupants who prefer a colder indoor climate may ventilate their apartments to get rid of undesired heat transfers from their neighbours. These heat transfers occur when the outside walls produce only weak cooling in relation to the heating inputs from neighbours. This is particularly the case with highly effective insulation of outside walls and when the gradient between inside and outside temperatures is lower (fall, spring, during the afternoon). 3) Asymmetric inertia: Temperature preferences vary during the day and may change rather suddenly. Because room temperatures can be reduced much faster by opening windows than by regulating radiators, occupants may choose to constantly keep thermostat settings at the upper preference limit and to lower temperatures by ventilating.
A detailed analysis of hourly data (currently underway) may help to differentiate between the causes.

4. CONCLUSIONS

If negligence and variant temperature preferences are the causes for involuntary rebound, two sorts of remedies are in reach to reduce the resulting EGP: Against human negligence, artificial intelligence may help to regulate heating valves and window openings in a more efficient way [7]. In the case of varying temperature preferences of occupants, the usually inert modern heating systems could be set to provide only a minimal temperature level, e.g. 18°C. Temperatures above this level could be reached with spatially more differentiating and temporarily faster reacting devices [8].

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