Tenant involvement in renovation for low energy performance

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Abstract: *The general goal of tenant involvement is to ensure that retrofitting projects are successful not only from a technical point of view but also from a social perspective. When possible, strategies should be included to reward users for energy efficient behaviour. Energy monitoring and feedback are tools in support of energy savings. But how do users use these tools and what is the effect? In this paper chosen strategies in three pilot projects within the EU (FP7) BEEM-UP project, were accounted for together with previous studies of metering and feedback systems. The results were based on interviews, discussion among the project partners, measurement data and a literature study. The conclusions were that there are great variations in households' consumption levels which shows a potential for energy savings where the introduction of individual metering and feedback systems are examples of supportive methods even though the anticipated savings might not always be realized.*

Key words: ***Multi-family housing, energy efficiency, energy savings, monitoring and feedback, individual metering, user behaviour***

Introduction

Approximately 40% of the EU's total final energy use (i.e. delivered energy) stems from residential and commercial buildings, responsible for 36% of the EU's total CO_2 emissions. Hence, it is important that the building sector takes its responsibility to reduce its energy use. Implementing technical energy efficiency measures in our homes is of great significance. However, in order to exploit the full potential of reducing the energy use, we need to broaden our view and complement technology development with user perspective and behavioural questions. The energy related behaviour influence to a great extent the gap between the potential and actual energy efficient levels [1]. Of importance is to apply strategies to influence the behaviour of end-users – the tenants.

The work has been carried out within the BEEM-UP project[1], which is an EU project in the Seventh Framework Programme (FP7). The aim of the project is to retrofit existing buildings so that the energy consumption is drastically reduced with a specific goal of reducing the space heating by 75%. The project includes long-term commitment to energy savings and stimulates the owners of the estate to monitor the energy performance and to give feedback on energy use to the tenants also after the retrofitting has been completed. The project follows the processes in three demonstration projects, namely Cotentin Falguière in Paris (F), Van der

[1] BEEM-UP stands for Building Energy Efficiency for Massive market Uptake, see www.beem-up.eu.

Lelijstraat in Delft (NL) and Brogården in Alingsås (SE). This paper reports on previous studies of monitoring and feedback systems in relation to energy saving behaviour, as well as chosen strategies in the three pilot projects. Methods used were interviews with tenants in Delft after the retrofit, participation in the pilot application of new tools for monitoring and feedback systems in Delft and Paris, analysis of measurement data from consumptions in Alingsås and literature studies on the effects of these applications, as well as discussion among the partners involved in the BEEM-UP project.

Households' energy use - Individual metering and visualisation and feedback

The residents of a building influence to a great deal the household electricity and the hot water usage. They also influence the energy for heating to some degree by choice of indoor temperature and window airing habits. To increase the visibility of households' energy usage is one energy efficiency measure a housing owner can implement.

Individual metering and billing usually means that each tenant's consumption of electricity, gas, heating/cooling and domestic hot water is metered and paid for by the individual. Each resident takes economic responsibility for its own consumption [2]. This is also a matter of fairness; that you actually pay for what you consume. Metering the electricity consumption is standard in most countries, but metering heating (or gas/oil), including domestic hot water, varies from country to country. By June 2014 the EU Directive on energy efficiency [3] shall be implemented in member states. It states that metering of the consumptions by end-users must become standard in 2016 in order to reach the European Union's energy target to improve the energy efficiency by 20% by 2020 [4]. However, there are different experiences on the actual energy savings of individual metering, and especially in regards to heating (e.g. [2]). Berndtsson [5] investigated a number of Swedish projects and found savings of 10 - 20% on heating and 15 - 30% on domestic hot water, although there were great variations between households. A large German study, conclude that experiences from previous studies indicate that savings for heating is potentially 20% or even higher [6]. However, it has also been noticed that savings for heating were not obvious [7] and in later follow-ups, even the expected savings of domestic hot water were not gained [8]. Nevertheless, it is of interest that many studies show that the total water consumption is higher (per person) for apartments than for single-family houses were you to a greater extent pay your own bill [8].

In modern society, energy is very much a commodity that people are more or less unaware of. It is in many cases just delivered to our homes. By visualising the use of energy, people can be made aware of their own impact while providing them with an opportunity to change their behaviour. Visualisation of energy consumption in housing has been evaluated, for example in [9-14]. It has been shown that real-time metering and displaying support tenants' awareness of their electricity consumption. However, it has also been shown that it is difficult to keep the interest for energy visualisation alive at home [13, 15].

Feedback is linked to visualisation and there are many different kinds of direct and indirect feedback, such as in-house display devices, online information systems and informative billing. A number of different studies on feedback have been performed - an overview can e.g. be found in [12]. Individual field projects show a variety of results. A number of old and new studies on different types of feedback on energy consumption, some together with other behaviour changing tools, show that savings ranges from 8-27% [16]. More commonly referred figures ranges from 5-12% [17]. Other studies show none or small positive effect compared to reference cases [17-19]. Also Fischer [9] provides an overview of studies on feedback on electricity use. As an example, savings of up to a third of the electricity consumption have been measured when dormitory residents were exposed to real-time visual feedback and different incentives [20]. Finally, to fill the gap of evaluations of long-term results of home energy management systems (HEMS) a recent study by van Dam [21] discovered an initial peak in savings, that would fall back after some time. The average energy savings after some time were about 7%.

Chosen strategies and experiences in BEEM-UP pilot projects

The building of the Paris pilot project constitutes 87 apartments built in the 1950s and are owned by ICF Novedis. The energy feedback system used in the building is integrated in a videophone service that is also used as door opener, and as a communication channel between the housing owner Novedis and the tenants. On a display, data on daily consumption as well as on accumulated consumption is available. There are data on electricity, heating and hot water consumption which could be compared with previous days, weeks, months or years. There is direct feedback by figures (in Wh) and “smileys” to strengthen the message of more or less consumption compared to the previous time period. There have been discussions about showing indoor and outdoor temperatures but these have not been implemented yet. An external company was introducing the videophone and energy feedback service to the tenants by arranging workshops giving instructions as well as highlighting energy saving possibilities. The equipment is very new and a first evaluation will follow in about four months. There is no known previous evaluation of this particular design.

In the Dutch pilot project there are 28 attached houses and 80 apartments, which were built in the 1950s and are owned by Woonbron. A smart display is being used, working as a programmable thermostat and presenting real time and historical energy data and information about outdoor and indoor temperatures, heat and power consumption as well as information on the weather forecast. Comparisons can be made with historical data as well as with averages of the neighbourhood. The service comes from the energy company and the house owner is facilitating the first two years of use. During 31 interviews in Delft, that were carried out one year after the installations of the displays, some tenants indicated that insight in the power consumption had impact on the purchase of energy efficient lamps, on more selective use of the electric laundry dryer, defrosting of freezer and early replacement of refrigerator.

The four set points of the thermostat function of the system were often used as an improved manual thermostat. In the first weeks after installation the tenants tended to check the historical energy data and also the power consumption quite often and they indicated a high learning curve. Then the activity tended to drop, depending on the level of interest in energy issues. The interviews indicated different reasons causing the fading interest. Some reached the end of a positive learning period, some were disappointed in the effect of their efforts to save energy and some had played enough with the new gadget and lost interest. An average positive effect on energy consumption has been reached, however. Further lessons learnt regarding the system were that the more reliable, transparent and understandable the feedback was, the more the user would take notice of the information. Also, these new systems were not (yet) robust enough and breakdowns with poor repair have caused that some tenants were either disappointed or did not even bother any more.

The whole housing area of Swedish project includes 299 apartments built in the 1970s and are owned by Alingsåshem. One of the main changes for the tenants related to the energy use after the completion of the renovation was that the hot water consumption and household electricity was individually measured for each apartment. Before the renovation both these consumptions were included in the rent. The common electricity and heating is measured per house. To clarify this formerly "invisible" cost is usually not done without any concern from the tenants and for that reason workshops were held in Brogården prior to the installations. It is a complex matter to compare the situation before and after the installation of the individual metering system. A number of energy efficiency measures were done within the renovation, such as the installation of energy efficient appliances as well as water saving fixtures. In one of the houses (18 apartments), an average decrease of 15% was achieved for the domestic hot water; the corresponding figure for all electricity (i.e. common and domestic electricity together) was 38%. In addition, more detailed measurements have been made in this house after the renovation, during a period of just over a year so far. The annual household electricity was measured to 21 kWh/m^2 (heated area). This is lower than a typical Swedish value, of 30 kWh/m^2 (heated

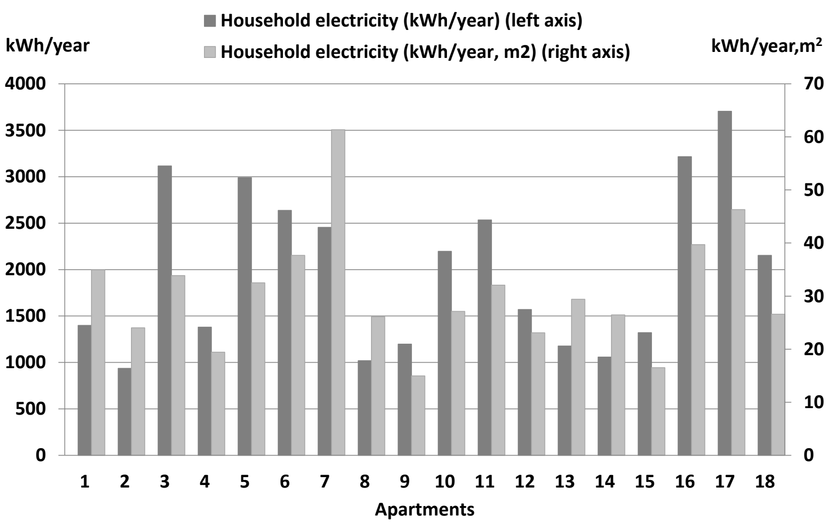

Figure 1 Annual household electricity in 18 apartments in Swedish pilot project. Presented as consumption per year (left axis) as well as consumption per year and rental area (right axis).

area) [8]. Corresponding value for the domestic hot water was 23 kWh/m^2 (heated area) – typical value is 25 kWh/m^2 (heated area) [8]. Great variations in consumption were found between the 18 apartments, Figure 1 and 2. The largest domestic electricity was 3705 kWh/year and the lowest was 937 kWh/year, with a mean consumption of 2003 kWh/year. When the heated area of the apartments were considered one of the smaller apartments had the highest consumption with 61 kWh/year,m^2 and one of the larger apartments had the lowest consumption with 15 kWh/year,m^2. The coefficient of variation[2] was 44% (kWh/year) respectively 36% (kWh/year, m^2).

The largest hot water consumption was 115 m^3/year and the lowest was 4 m^3/year, which is an extremely low consumption. The mean consumption was 38 m^3/year. Corresponding figures for when the heated area of the apartments were considered were 1.45 m^3/year,m^2 and 0.05 m^3/year,m^2, with an average of 0.54 m^3/year,m^2. The coefficient of variation was 78% (kWh/year) respectively 70% (kWh/year,m^2). No consideration has been taken to presence at home during the measurement period. It can be added that there was no strong correlation between the household electricity consumption and the domestic hot water consumption (the coefficients of determination, R^2, was 0.39).

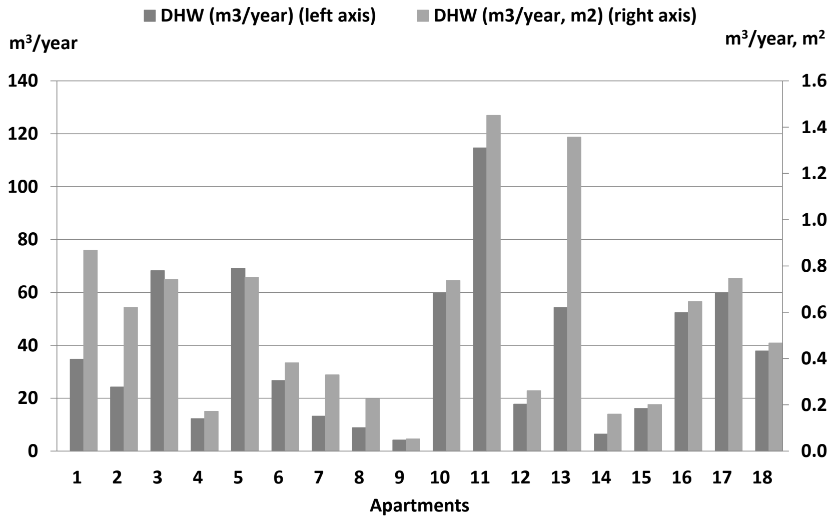

Figure 2 Annual domestic hot water consumption in 18 apartments in Swedish pilot project Presented as consumption per year (left axis) as well as consumption per year and rental area (right axis).

Discussion and Conclusions

This paper highlights some examples of how housing owners can take further steps in energy saving measures and addressing households' energy awareness and usage. The three pilot projects of BEEM-UP have applied somewhat different strategies in this regard. The French pilot project has just recently installed in-home displays where direct, real-time, feedback on consumption is given. Comparisons with historic data is possible and pedagogically presented with easy to understand symbols (the smileys). The displays have just been installed and have not yet been evaluated, but the multi-functionality of the display is believed to increase the prerequisite for usage. In the Dutch project, a home energy management system was used,

[2] Coefficient of variation or relative standard deviation is the standard deviation divided by the mean.

which means not only a display but also the possibility to manage the indoor temperature by programmable thermostats. This turned out to be useful to some people as they could easily pre-set a decrease or an increase in temperature. Average energy savings are reached after the installation. There are both positive and negative experiences of the systems, such as positive effects on some energy related activities, but also the loss of interest and for some even distrust in the data. Breakdowns are of course not helpful in this regard. Long-term commitment is an issue to consider, which confirms results from previous studies. The importance of design and usability is another aspect to regard, which would increase the prerequisite for usage - however it will not mean a guarantee for savings. As all energy consumption was previously included in the rent, the first step in the Swedish pilot project was to start with the introduction of individual metering and billing. It will be of interest to follow the implementation of the EU Directive on energy efficiency in regards to individual metering and the effect – or non-effect – this will have on the households' energy related behaviour. From the previous field studies there seem to be a great potential for savings but the savings cannot automatically be presumed. How the energy usage, and also the energy savings, varies for different households is made apparent in the measurements in the Swedish pilot project. This confirms findings in previous literature [22]. The variations are even larger for the hot water usage. That water consumptions can vary greatly has also been found in previous studies – examples of variations of the total water consumption (hot and cold water) are found in [22]. Another interesting observation is that a low consumption of electricity does not mean a low consumption of DHW. Even though the number of persons is not known in this project, the variations in consumptions indicate that there are some potential for savings. Note that not all aspects of described energy saving tools have been considered, e.g. issues of cost calculations, split incentives, "heat thefts".

To conclude, to decrease the total use of energy in our buildings is a prioritised question where it is necessary that the end-users of the buildings also are involved. There are a potential of decreasing households' energy use - the way to do it is however not completely clear and multi-mode approach might be necessary. Individual metering and employment of feedback systems are examples of how the energy use can become more visible and increase the awareness of people and possibly lead to energy savings. However the expected energy savings might not be realized for a number of reasons. That the data and systems are reliable and robust is a good and necessary start. That the systems have multi-functionality is probably not a disadvantage for the frequency of usage. Just to mention some things. The long-term commitment still seems to be a challenge. In any case, in the end it might be a question of fairness - that we take responsibility for our own consumption of the resources of this earth.

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