Long term owner commitment to energy savings

BEEM-UP

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BEEM-UP
Building Energy Efficiency for Massive market UPtake

Integrated Project
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Demonstration of Energy Efficiency through Retrofitting of Buildings

Deliverable D3.6: Long term owner commitment to energy savings

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PP	Restricted to other programme participants (including the Commission Services)	
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Deliverable description

This report is part of the work carried out within the BEEM-UP project in Task 3.5 concerning energy behaviour and especially feedback about energy consumption towards the tenants. The overall goal with the tenant involvement in the BEEM-UP project is to ensure that retrofitting projects are successful also from a social point of view and to encourage energy saving behaviour by the tenants.

Long-term commitment of the building owner towards the tenants applies to the energy awareness of the users and continued attention tot energy savings, also through behaviour. The cornerstone of long term commitment is energy feedback by for instance management technology installed in the renovated houses, e.g. reading electricity, gas and water meters, smart meters and home energy management systems. Feedback on actual use of electricity and heat or gas is needed to enable the tenants to adjust their behaviour and to be aware of further energy saving potential.

The case studies of the BEEM-UP projects are the three demonstration buildings retrofitted under the project framework
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- Cotentin Falguière in Paris, France (ICF Novedis is the building owner)
- Van der Lelijstraat in Delft, the Netherlands (Woonbron is the building owner)
- Brogården in Alingsås, Sweden (Alingsåshem is the building owner).

Relation to other activities in the BEEM-UP project

Task 3.5 has a close link with WP5 dedicated to tenants' involvement for energy savings and an action in WP5 is to evaluate the indoor comfort and energy related user behaviour. The information from task 3.5 may feed the deliverable D5.6 (tenants' preferences in relation to their living environment).

Contribution of partners

This document is based on information from the three pilot sites. The building owners (Alingsåshem, Woonbron and ICF Novedis) provided information about energy monitoring and feedback. The building owners gave their feedback about the ways in which the owner is dedicated to reduce the energy consumption through behaviour of users, for instance through incentives to influence energy awareness or energy saving behaviour.

BEEM-UP Partners Involved are Alingsåshem, ISA, Nobatek, ICF Novedis, Woonbron, OTB and SP. OTB of Delft University led the task, collected information and in addition conducted interviews and made a short video about the use of the home energy management system in the pilot site in Delft (http://youtube/pMUggJQLNZM).

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Chapter 1. Introduction

1.1 Overall objectives

The objective of the BEEM-UP Project is to realise substantial energy savings in renovation of dwellings and to promote large-scale market uptake of successful strategies. To make the renovation strategies ready for large-scale uptake they must be economically feasible, practically applicable and socially acceptable. To discuss and realise this, energy performance has been evaluated in different contexts: monitored output, performance testing, evaluation of user satisfaction and behaviour, and evaluation of processes. This deliverable is about the relation between monitoring and user behaviour, with a focus on feedback systems that give the users insight in energy consumption. The role of the owner as long term promoter of energy efficiency is an important topic.

The objective of Task 3.5 is to develop a model for long-term monitoring and commitment of the building owners towards the tenants to make feedback on energy consumption possible. Long term owner commitment refers to the application of energy management technology, e.g. remote reading of electricity, hot water and heat (gas), and optimized control including feedback of energy performance to the tenants. The proposition is that energy feedback systems contribute to 0 - 25 % reduction of heating energy, depending on the change in metering and cost accounting through the renovation. Individual metering and billing of domestic hot water has shown more than 25% and up to 50% of reduction compared to non-metered and non-individually billed solutions. The impact of specific measures on user behaviour can be great. For future market uptake it is important to find out which measures actually work and how its effect can be improved.

The second objective of Task 3.5 is to support a social atmosphere in a neighbourhood that allows good communication about quality performance before, during and after the renovation. After the renovation means; good maintenance and complaint handling and supporting social interaction to maintain a good living condition for the users. Performance quality is more than technical performance of installations; it includes good use of the environment and positive social interaction in a neighbourhood.

In many energy saving projects, we see a discrepancy between what was calculated and actually measured as energy consumption. The calculations refer to a standardized demand pattern and household size, while the actual occupancy pattern can be different. More effects than improvement of energy performance must be taken into account. The change in indoor comfort is obvious and this will have effect on the energy consumption. For instance, if it was difficult to heat up bedrooms during the cold season before the renovation, it is easy after the renovation, permitting better use of all spaces in the house. But this may lead to higher energy consumption. Another example is that the hot water comfort will increase when a small 12 kW heater is exchanged for a 24 kW heater, meaning that instead of 2,5 -3 dm^3/minute of hot water in the shower, now 6 dm^3/minute is available. The rebound effect can be expressed as the difference between the actual savings compared to the expected savings. For example, installing additional thermal insulation might only increase the indoor temperature without gaining any energy savings and the hot water system might provide more water per minute which will increase the comfort and energy consumption, while the efficiency of hot water production may be much better.

This deliverable gives attention to modern home energy management systems that are being applied in Delft and Paris. The application of innovative new systems provides an important opportunity to collect experiences.

The objective of this task is to develop a constructive link between the following items:

-The need to involve building owners in the real performances including comfort during the use phase of the housing. This need is reinforced by the increase in the buildings' technical sophistication and by the high increase in performance levels to be reached in refurbished buildings. Monitoring technology can support performance evaluation. The availability of cost-effective energy monitoring technologies (monitoring, data transfer system for the residential area, user interfaces) makes it easier to execute.

-Delivering a "performance and comfort" service towards the tenants and simultaneously motivating and assisting tenants in adapting an energy conscious behaviour.

-Establish continued dedication of owners and users to social sustainable quality.

This is why this document offers insight into all the requirements identified for each pilot site by each building owner and suggests a model that will feed these requirements with updated information on the basis of the current and future technical offer in this domain.

1.2 Points of interest

Software and hardware: Attention to all the available technologies: wireless communication, real time access, multiple interfaces, web and smartphone services. Discussion has been observed on ownership, updates, periodic (monthly) cost and one-time costs for equipment and services, compatibility with other hardware, restriction for users (for instance service exclusive by a specific energy supplier).

Role of home owner: policy toward energy monitoring and giving feedback to tenants, dealing with modernization of the systems, dealing with questions or complaints and with breakdown of systems (who does the help desk and technical service) and finally support for positive interaction with and in the neighbourhood.

Responses of the tenants will be dealt with in the post-occupancy evaluation. Points of interest are: tenants' involvement, the frequency of reading energy data and feedback information (frequency of opening the internet site, or taking notes or reading hardcopy information), the long-term effect on energy awareness and behaviour. How to respond to and motivate different household/response types?

1.3 Outline

Chapter 2 includes the description of the monitoring and feedback systems that have been installed in the three pilot sites, and explains the role of home-owners. It also presents experiences in the three pilot projects with promoting of awareness of users about energy saving. This forms the basis for the development of long-term commitment models in Chapter 3. Chapter 4 presents a framework, which can be used as a model. Conclusions and recommendations are also given.

Chapter 2. Monitoring and feedback in the pilot projects

2.1. Introduction

Monitoring is the collection of data related to energy ambitions, first of all to allow evaluation of the performance of technologies. Information from monitoring systems and feedback on energy use is an important way in the learning process of the providers of systems as well as for the housing owner and the tenants. As a consequence the tenants may adapt their energy related behaviours. Monitoring is relevant for knowledge transfer of the energy performance of our buildings within EU's construction and housing sector. Further, the BEEM-UP project has a specific goal of "massive market uptake", where monitoring plays an important role in illustrating the energy performance in dissemination activities.

Monitoring has an effect in itself as well: feedback for the persons involved will influence the perceptions and even actual behaviour, which in turn influences the outcome of the monitoring. Most measures of the renovation are intended to save energy; others will demand more energy, because the users deliberately use more services or appliances, even when it increases the energy consumption. The more user friendly the feedback is, the easier it will be to understand the impact of energy using functions such as heating, cooling, bathing, lighting, laundry drying, computing, watching television, gaming etc. This attention to energy aspects is a value in itself because better insight in the effect of temperature set-points and use of appliances, of buying new products and being asked to support new energy saving measures can have effect on decisions.

The big difference between monitoring and feedback on energy use is the time frame of feedback: monitoring/metering gives a result every year or sometimes every month, while feedback comes more frequently and often when the user wants it and looks into it. The following technologies can be seen in practice:

1. Manually reading meters and calculating the consumption over the previous period.
2. Annual information of consumption and other cost for the users, for billing (yearly final consumption plus service cost and taxes).
3. Periodical information on level of consumption, for instance each month, as extra service (smart meters plus remote reading).
4. Tele-monitoring by providers in order to control the performance of technical systems, including optimization of its performance.
5. Energy data on demand, whenever the customer wants it (smart meters and access service) through smart phone, pc (internet) or videophone.
6. Systems that provide consumption data and extra information, such as real time power uptake, comparisons with data from the neighbourhood or with energy consumption targets and weather data (these are the home energy management systems or HEMS).

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, with the incentive to save money through

energy saving behavior. 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) varies from country to country. By June 2014 the EU Directive on energy efficiency shall be implemented in member states. It states that metering and individual billing of the consumptions by end-users must become standard in 2016 and will contribute to reaching the European Union's energy target to improve the energy efficiency by 20 % by 2020 (Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC). Many experiences on the effect of individual metering of heat versus cost distribution on the basis of rooms or surface area show savings of 15%-20%

(http://www.managenergy.net/lib/documents/874/original_ME_NWE_AarhusNov13_03_Felsmann_BillingWorkshop.pdf?1385050251. Also, studies show savings of at least 15% after individual metering and billing of the electricity use (Fischer 2008). More savings can be reached when users did not pay for the energy before the renovation, because it was included in the rent and users did not get information on the cost for the energy consumption.

By visualising the use of energy, people can be made aware of their impact while an opportunity to change behaviour may be possible. There are many different tools for feedback, such as in-house display devices, online information systems and informative billing. A literature study (Darby S. 2006, 2010) on documented effects brings the conclusion that the best feedback is computer based with multiple options for feedback (energy, money, comparison with historical data and with the neighbourhood), and contains interactive elements that engage the household, provides device-specific energy consumption and also provides high resolution feedback (daily or more often). Further, the feedback should be longitudinal, be measured rather than estimated, and designed with consideration for its usability and interactions with its user. The study leads to the positive conclusion that long-term feedback helps to create new habits.

The long term commitment of home owners to energy monitoring refers not to the standard application of metering systems, but to an extra step of energy management technology, e.g. remote reading of electricity, hot water and heat (gas), and optimized control including feedback of energy performance to the tenants. Provided that the users have option to control the consumption, we speak of home energy management systems, meaning that the tenant can access real time data and history whenever wanted and also that the energy consumption can be influenced.

2.2. Systems in pilot site Brogården, Alingsås (Sweden).

The whole housing area of Brogården includes 300 apartments built in the 1970s and owned by Alingsåshem. Before the refurbishment, both hot water and heating were included in the rent and no individual metering was ever done. In the area of Brogården the household electricity use was also included in the rent. Since everything was collective and the bills paid by the housing owner Alingsåshem, it was impossible to see how much energy the individual household was consuming. Since the entire energy supply was based on a model with collective use, it would have been too complicated and expensive to put up meters before the refurbishment.

The renovation has improved the performance to the Passive House Standard. Passive houses require a minimum of heating, only a few days a year when a pre-heating of the incoming air is necessary. Individual cost accounting of this heat was not useful. In all the refurbished apartments the domestic hot water is monitored individually now. It is also possible to see the hot water consumption of the house as a whole (which might be relevant in the houses that have a laundry room that can be used by all the tenants). And each apartment has an individual electricity meter.

During the BEEM-UP project extra meters were installed in four apartments (in a house with a total of 16 apartments). These meters collected data about the indoor climate and the levels of carbon dioxide as well as the energy consumption. These monitoring results, even in a few apartments, have led to the insight that the heat recovery system did not work as planned. Measures were taken to improve the performance, which led to the predicted performance and to more energy savings.

The change to individual metering and billing is an essential step towards awareness of one's own consumption and offers an opportunity to influence one's energy bill. However, to clarify this formerly "invisible" cost is usually not done without any concern from the tenants. To prepare tenants for the potential shock from confrontation with actual energy cost, "awareness" workshops were held in Brogården. The situation before and after the installation of individual metering on domestic electricity and hot water is difficult to compare. A number of energy efficiency measures were simultaneously taken, such as installation of energy efficient appliances and water saving fixtures. In one of the houses (18 apartments), an average decrease of 19 % was achieved for the domestic hot water; the corresponding figure for all electricity (i.e. common and domestic electricity together) was 17 %.

In addition, more detailed measurements were made in this house after the renovation, during a period of just over a year so far. The monitored annual household electricity use was 31 kWh/m^2 (heated area). This is a typical Swedish value. Corresponding value for the domestic hot water is 25 kWh/m^2. Great variations in consumption for each of the 18 apartments can be seen in Figure 2.

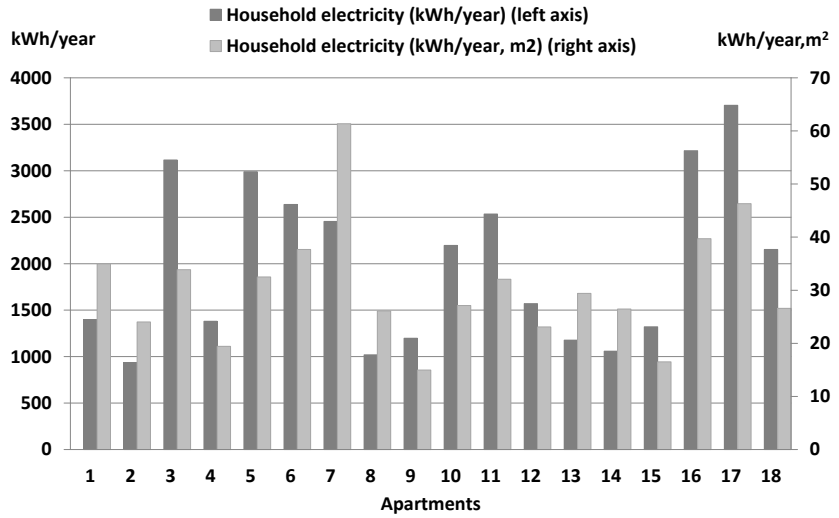

Figure 2 Annual household electricity in 18 apartments in Swedish pilot project. Presented as consumption per year (left axis) as well as consumption per year and rental area (right axis).

The highest domestic electricity use during the measurement period was 3705 kWh/year (apartment 17 of 80 m^2) and the lowest was 937 kWh/year (apartment 2 of 39 m^2). The mean consumption was 2003 kWh/year. When the heated areas of the apartments were considered one of the smaller apartments has the highest consumption with 61 kWh/year·m^2 (apartment 7 of 40 m^2) and one of the larger apartments has the lowest consumption with 15 kWh/year·m^2 (apartment 9 of 80 m^2). The coefficient of variation[1] is 44% (kWh/year) respectively 36% (kWh/year, m^2).

The largest hot water consumption is 115 m^3/year (apartment 11 of 79 m^2) and the lowest was 4 m^3/year (apartment 9 of 80 m^2). The mean consumption was 36 m^3/year. Corresponding figures for when the heated area of the apartments were considered were 1.45 m^3/year·m^2 (apartment 11) and 0.05 m^3/year·m^2 (apartment 9), with an average of 0.54 m^3/year·m^2. The coefficient of variation is 79% (kWh/year) respectively 73% (kWh/year·m^2).

This illustrates the importance of paying for what you actually use: the fairness principle. Also, when users would have information about the average or maybe even about the extremes, it could have even more impact on awareness.

Alingsåshem was keen to introduce meters for the sake of ecological sustainability. To transfer the costs for energy from the company to the tenant also means that the tenants are taking a bigger responsibility, and that some financial responsibility is lifted from the housing owner. All heating is metered for the house as a unit (16 apartments). Today the tenants can see individual warm water consumption on the rent invoice and the electricity consumption on the electricity invoice (and on the internet). Since most of the tenants at Brogården are paying hot water and electricity bills for the first time in their lives, they have been extra careful with their energy consumption since moving into the refurbished flats. Their behaviour is expected to change once the fear of the energy bills has somewhat subsided. Both these systems only provide data for an entire month and both systems present the data with 30 days of delay. For Alingsås the ideal monitoring system would show the tenant's real-time consumption of electricity and hot water, as well as the indoor temperature. They agree that a favoured solution would be a smartphone application and a management service that is delivered by a general market provider, with support from the home owner. In 2014 this option was out of reach.

Community involvement

Alingsåshem is a small organisation with 3800 owned dwellings. The scale allows for good personal contact with tenants. Brogården represents an important part of the housing stock and the renovation process has taken many years. During this period and also because of the relocation of tenants, enormous much work is put into helping tenants and giving assistance to fulfil individual needs. This fact and also the high ambition of the renovation has been rewarding for the housing association and the local authorities, who own the association and feel responsible for it, have been on top of it, both critical and very much in support of the ambitious work. The long term perspective is the key to success. The communication with tenants is also developed with the long term perspective.

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

From the side of the tenant organisation this perspective was too long. The pioneers that helped to get the high ambition accepted went away, the tenant organisation lost its energy and key persons and stopped altogether for the time being. This event is very much a widespread phenomenon, indicating that permanent representation is not of this time. Instead, more open coalitions and actions that involve people is the present situation. Free, dynamic and relying on modern social media is the key to have people meat each other both in digital life and person-to-person. The project has led to discussion about these changes that are also relevant for the housing association to move into and adapt as modern ways of communication, community building and involvement of a neighbourhood in the maintenance of the area and in keeping up the interest in performance quality including energy performance.

Commitment of Alingsåshem

Housing owner Alingsåshem is deeply committed in trying to encourage behaviour change amongst the tenants, in order to facilitate a more sustainable society. The houses are as adapted to energy efficiency as is possible today. Other facilities in the Brogården area – such as houses for sustainable waste disposal, and dedicated spaces for bicycles – also encourage a more sustainable lifestyle.

For the owner Alingsåshem, commitment to long term monitoring relates to keeping the energy consumption on a level that was designed for. A campaign on “mindful” hot water use for bathing could have some effect, but the owner is reluctant in inferring in individual consumption habits. An issue is the involvement of three different providers for electricity, domestic hot water and heat. Right now it seems more plausible that the housing owner is to take the cost of the meters, than it is to encourage the tenants to buy a technical solution themselves. For the heating the tenants lack any pressing incitement to monitor their consumption.

As for community development, the housing association is aware of the opportunities that social media represent and are keen to adapt to the use of communication channels and still combine this with face-to-face meetings, in particular events such as fairs, parties, creative sessions etc. that bring the tenants together. Facilitating this process is important, first because not all tenants have access to modern social media and second to find people who can help in the communication: other promoters or ambassadors will become active for the neighbourhood, after the very valuable but maybe “old school” committees have stopped.

2.3. Systems in pilot site Van der Lelijstraat, Delft (The Netherlands).

The renovation of 108 apartments and semi-detached dwellings in Delft was executed in a collective exercise first, followed by individual measures that the tenants could choose: the so-called free selectives. The collective part included insulation of the envelope, except insulation of floors above crawlspaces. The free selectives are central heating, or a new combined hot water/heater if central heating is already available, a solar domestic hot water system, floor insulation above crawlspaces, a smart electricity meter and a home energy management system (HEMS). For the free selective a rent increase must be accepted. The HEMS is for free. About one third took the selectives measures, but the package differed per occupant, depending on preferences and the dwelling characteristics. Most tenants have ENECO as energy provider, but since the market was opened to competitors, more companies are active in the neighbourhood.

ENECO collects data through distant reading of smart meters in four dwellings. Data from other dwellings, if from ENECO customers, is available for analysis by the Delft University on a yearly basis. Collecting data on electricity use on a 15 minute basis from other households with a smart meter seemed promising, but because the meter is owned by a separate company, the privacy issue blocks using data for all smart-metered apartments.

TU-Delft analyses the relationship between household characteristics, indicators on behaviour and energy consumption with the data available. These results are presented in Deliverable 3.8. of the BEEM-UP Project.

Table 1 shows the type of data available for evaluation of the energy consumption. The reference period covers two years and data is used from 31-37 dwellings.

	Reporting period (after refurbishment)			
Available data	**Data available at dwelling level/Building level**	**Acquisition frequency**	**Provider of the data**	**Period of measurement**
Gas consumption	Data available for 31 dwellings having been equipped with solar boiler	Yearly (from May to May)	ENECO	June 2011 – May 2012, June 2012 – May 2013, data for next year available in June 2014
	Data available for other dwellings (37 dwellings)	Yearly	ENECO	June 2011 – May 2012, June 2012 – May 2013, data for next year available in June 2014
	Data available for 4 dwellings	Daily	ENECO	From 01/10/2013 to the end of the project
Electricity consumption (low and high tariffs separately)	Data available for 31 dwellings having been equipped with solar boiler	Yearly (from May to May)	ENECO	June 2011 – May 2012, June 2012 – May 2013, data for next year available in June 2014
	Data available for other dwellings (37 dwellings)	Yearly	ENECO	June 2011 – May 2012, June 2012 – May 2013, data for next year available in June 2014
	Data available for 4 dwellings	Daily	ENECO	From 01/10/2013 to the end of the project

Table 1. Data available for the periods after refurbishment for the site of Delft

The home energy management system of ENECO was installed in 34 apartments. How this home energy management systems works for the tenants is explained in a video edited by E. Hasselaar of OTB.

(http://youtu.be/pMUggJQLNZM).

Figure 3. TOON being explained by the provider.

Figures 4-6: Connection to wireless communication for sensors metering electricity and gas.

Temperature control of central heating

Central heating after renovation and in dwellings built after 1970 is about standard and, in The Netherlands; individual systems have by large taken over collective heat services. The choice between master thermostats and in particular between manual or automated clock thermostats, including the advanced HEMS deserves attention from the perspective of "learning" energy conscious behavior. According to Sonja van Dam, who studied the first pilots with the energy management system TOON at the TU-Delft "HEMS are defined as intermediary products that can visualize, manage and/or monitor the energy use of products or households. They are intended to give households direct and accessible insight into their energy consumption and thus help them to reduce it. This makes them different from smart meters, which are predominantly intended to benefit the gas or electricity supplier and distributor, and generally need a HEMS to give users the intended insight."

HEMS are different from self-learning devices intended to take over active control from the user. However, the connection to smart phones and tablet computers stimulates interaction and more active user control also for the self-learning devices. What energy effect to expect from the different control systems in renovation projects?

Many thermostats show the exact temperature but certain home owners suggest that showing the temperature opens the perception of needing a precise performance and instead opt for a thermostat with a temperature range of 1-5. An on-off thermostat gives direct feedback and the need of active control leads to pro-active behavior: down when going out or one hour before going to bed, no heating while asleep, a little higher when the household tends to sit down in the evening and likes more thermal comfort etc.

A clock thermostat allows pre-selecting certain temperature levels at different times a day and week-day with repetition of the week cycle. This requires a certain study of the user manual and much practice, because no household pattern is stable enough to follow the clock. For many people the adjustment is a problem and the industry admits that almost 80% of the users keep the factory settings, while more comfort as the selling point of the products, not the energy savings. Olivia Guerra Santin of OTB at TU-Delft found that the average temperature set-point with clock thermostats is lower than with manual thermostats, but the heating hours are longer and the clock thermostat ends up with causing higher energy consumption. A popular advice is to not lower the temperature too much while not using the house or at night, because it will take too much energy to reach the comfort level at the desired clock-time. With a manual thermostat the user tends to turn off the heater when away or going to sleep and smaller steps are taken to increase the non-constant comfort temperature. The overall effect of this conduct is energy saving.

TOON, the HEMS applied in the Delft project can give information on:

- Real time power use (electricity) and on the expected daily level of heat consumption;
- Comparison of electricity or natural gas with the previous day, week, month or year;
- The prospect of energy consumption over the coming period, if the same energy behavior would continue, both in energy units (kWh and m3 natural gas for heating) and in Euro's;
- Comparison of energy use with the average in the neighborhood;
- Actual temperature;
- Pre-set period with four set points: away from home, at home, sleeping and comfort;
- Manual adjustment of the preset set points for the actual period.
- Checking the weather forecast (rain showers coming).

This innovative tool has also some drawbacks: not (yet) fail safe, while the comparison with previous data needs time to adjust and improve over time, getting better after one year. Some users have the impression that the comparison with consumption history is not reliable and stop using this function. And during interviews in Delft a number of HEMS were not working, due to poor wireless communication or other technical failures. The maintenance of systems has been poor: heating technicians (the first to come after complaints about the thermostat) miss experience, while after the initial inspection it takes too long for an expert to fix or exchange TOON (if ever someone shows up). Some users then miss the feedback including the incentive to adapt their energy related behavior.

Interviews with users indicate that the real time information on energy consumption is sometimes surprising and gives new insights and may most have effect on behavior. The learning curve is fast and will last a few weeks, but energy minded or cost minded people stay interested in feedback on the household's energy consumption. When being faced with replacement decisions, they are more likely to replace an old refrigerator for A++ type, an old TV set for a LED television, while taking long showers by teenagers may be discouraged on the basis of the energy effect. Quite many use the four pre-set set points of TOON (away/at home/sleeping/comfort) similar to the manual thermostat: lower by selecting "away", higher with "comfort". This feedback is pretty similar to the manual thermostat.

The TOON is a free service for two years, after that period the tenants have to pay a monthly fee of € 4 to € 5. Dam found that the energy saving effect over period of months is around 7%, which is about double of the cost for using it. All interviewed people choose to continue using the HEMS when they have to pay rent for it.

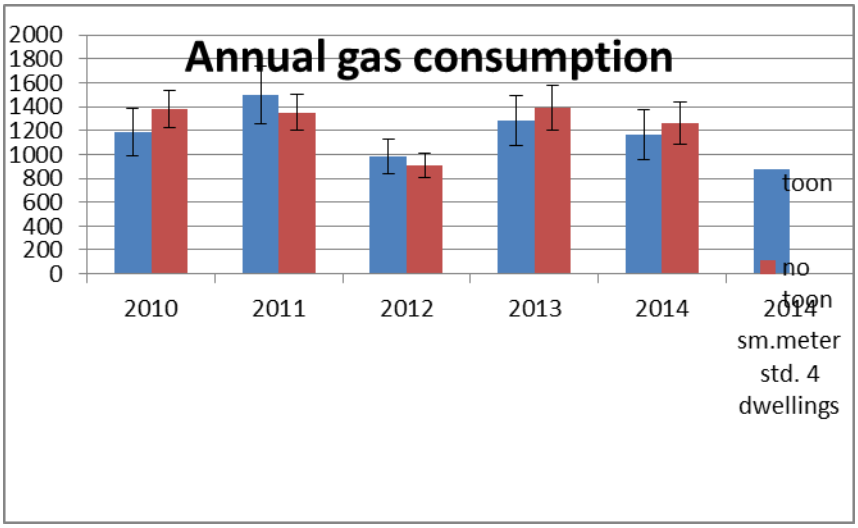

Figure 7. Heating consumptions obtained for the dwellings with and without feedback systems – baseline are the red bars (no TOON)

We see a positive heating energy saving effect of TOON compared to dwellings without this energy management system. TOON was installed in 2013 and selected by the tenants, who before 2013 were less energy efficient than average, while they tend to be more efficient than average after having the home energy management system.

The energy consumption for lighting is minimal based on inspections and interviews. Most households use only three energy efficient lights permanently when it is dark inside. Some have the TV working for more than 10 hours/day. Discussion about high electricity uses indicate that a toy like play-station, a permanently operating pond filter pump, a large freezer and in general a large number of working electrical appliances with stand-by use have an important effect on the total electricity use.

Figure 8. TOON monitor with remote sensors, wireless connection and internet interface

The electricity consumption was low, compared to average Dutch dwellings, while the level hardly changed after the renovation. TOON did not make a difference. The effect of having a solar domestic hot water system and going from a gas heat to a central heating system increased the electricity consumption, due to circulation pumps. The project in Delft had a low heating energy use before the renovation because of installations that provide heating and hot water comfort derived from the 1950's, and with an envelope that did not allow to use the bedrooms in the winter time except for sleeping, because they were difficult to heat up for other functions that need a warm environment. The renovation changed this.

Community development

Dissatisfaction with the poor thermal quality of the envelope brought tenants together in an effort to increase the owners' priority for renovation. The cold winters of 2009 and 2010 caused a strong conviction that improvements were needed. When the initiative for the renovation project was taken and an active group was consulted about the plans, they took a position of having new insulating windows before the next winter, or they would not cooperate in other proposals of the owner. Also the improvement of the envelope would stay without rent increase for the present tenants. This priority for the exchange of windows became like a contract and changed the process in many ways: disconnection of the envelope from installations inside the home and even disconnecting the replacement of windows from insulation of the roof and further measures on the façade. The group of tenants that were involved in the design process and the execution of plans would be active during the few years that this process lasted.

Because of the choice to promote extra measures besides the envelope, it was important to communicate about these "selectives" with all tenants. To promote awareness of the choices and about the energy saving effects, it was important to do more than just written information that probably would not reach all tenants. Meetings were held in the pilothouse to inform visitors and that led to the acquaintance with persons who were enthusiastic about the process and also would be willing to do more for the social interaction in the neighbourhood. A new open group was formed to bring tenants of the neighbourhood together. They organised a start-up party, decorated a large Christmas tree, planted flower bulbs around trees and also collected their energy consumption data, which was compared to other persons in the group. These persons were much aware of the impact of free selective measures and some were the first to use the TOON, take subfloor insulation and a solar thermal system. After the renovation this group was left alone and without an important reason to meet and help, the activities gradually diminished and the group stopped meeting and taking actions. The process was recognised by the owner, but it is not considered the task of the owner to facilitate and actively promote this type of community organisation.

Woonbron is aware of the situation around social interaction in the neighbourhood, but considers TOON the most important service to promote awareness on energy saving issues.

Commitment of Woonbron

Long term commitment of owner Woonbron is effective through the support of TOON after the renovation in the BEEM-UP project. Also, similar to the other owners, Woonbron is dedicated to eco-sustainable improvements of its housing stock and is also aware of the important role of user behaviour. The many social activities in the pilot site and the information campaigns as well as

providing opportunities for interested tenants to lease a solar system, to insulate the floor and to take high efficiency central heating, is on-going for all of Woonbron´s housing stock. Community interaction is facilitated but not initiated nor maintained by the owner.

2.4. Systems in pilot site Cotentin Falguière, Paris (France).

The building of the Paris pilot project constitutes 87 apartments built in the 1950s and owned by ICF Novedis.

In the pre renovation phase the collective heating was monitored per house, not per apartment. The hot water was provided by electrical boilers, which led to high primary energy use. After the renovation each apartment is supplied with heat monitoring that includes domestic hot water from a collective system. According to French regulation monthly consumption figures must be communicated in each dwelling in new buildings.

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 (Figure 6), data on daily consumption as well as on accumulated consumption is available. There is information on electricity, heating and hot water consumption which can be compared with the previous day, week, month or year. There is direct feedback by figures (in Wh) and by “smileys” to strengthen the message of more or less consumption compared to the previous time period. Showing indoor and outdoor temperatures are technically feasible but these have not been implemented yet. An external company is 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 there is no known previous evaluation of this particular design.

To further draw attention to energy saving issues, an “energy kit” has been handed out to the tenants including an energy efficient light bulb, a fridge door magnet with reminder, egg timer for the shower, fridge thermometer and My Planet card game.

Figure 7. Videophone energy monitor showing weekly hating consumption (from Couleurs d’Avenir)

The Synco Living System installed in the dwellings ensures that heating and electrical energy is only used when required. It consists of a central control unit as well as a range of radiofrequency field installation devices for temperature control, automatic metering acquisition, electrical and heating/cooling demand applications. Remote access via internet/smart phone applications is possible.

Figure 8. Synco wireless control on a radiator

A BIOFLUIDES system for energy recovery from grey water was also installed and will be connected to the monitoring system. The data on energy provided as well as recovered energy by the system will be analysed by BEEM-UP Partner NOBATEK.

Community involvement

ICF Novedis has no active involvement in community development. Each building has a housekeeper who is available for assistance to other tenants, but this role is limited and does not include suggestions for the use of appliances or energy saving options. This may develop somehow, because Novedis adopted a sustainability policy in which a more active role for the housekeeper in terms of communication can fit.

During the renovation process, meetings were held and all tenants were interviewed about their needs and to inform them face-to-face about the upcoming renovation. Also, activities were organised around the functions and design of the court at the backside of the building.

Information and guidance on how to ventilate, prevent overheating and use other appliances will be given, both in a meeting and through personal instruction.

After the renovation there is no intention to organise community interaction, meaning that the energy feedback system is the key to long term commitment.

Commitment of ICF Habitat

ICF Habitat developed a sustainability policy for the total stock that includes analysis of energy consumption and focus on improvement of buildings based on the saving potential plus the future market position for rental purposes. The Videophone system is standard business and so will the energy monitor and feedback system be as well: a lasting service to support the tenants in saving energy. ICF Habitat invited a local sustainability organization to be involved in setting up energy related activities for the tenants. The housekeeper in each building has frequent communication with tenants and is in the position to give information on energy related issues. ICF Habitat has stimulated interest in energy topics with small incentives and will continue to raise both knowledge levels and adapted behaviour, to improve the comfort level and low energy consumption..

2.5 Overview of stakeholders for monitoring and feedback

	Energy service	Alingsås	Delft	Paris
		Metered by	**Metered by**	**Metered by**
1	**Common electricity**	energy provider collective (reporting by Alingsåshem)	No common electricity	energy provider collective, monthly report available for ICFNovedis
2	**Domestic electricity**	energy provider individual (reporting by Alingsåshem via energy provider)	Individual metering by Stedin, several electricity providers	energy provider individual
3	**Heating collective**	energy provider, only per house = 16 apartments	--	Heating provider, individual metering
4	**Heating individual gas**	--	Individual metering by Joulz, several gas providers	--
5	**Domestic hot water**	Collective production, individual metering and billing	Individual production	Collective production, individual metering
6	**Feedback system**	--	TOON by major energy provider ENECO and other providers with feedback systems	ICF Novedis includes service in rental contract

Table 2. Monitoring and feedback in pilot sites

Chapter 3. Models of long term commitment to energy savings

3.1. Which models seem promising?

During BEEM-UP meetings, a wide range of activities has been discussed such as campaigns, research and policy development and knowledge transfer on promoting energy ambitions and empowering tenants to get involved. Especially reaching a great extent of tenant involvement is a difficult goal and the culture on tenant involvement is very different per country, as became evident during the partner meeting in Warsaw in June 2014, where options for tenant involvement in Polish renovation projects were discussed. The history of housing policy, the political involvement of citizens, the empowerment actions to get people involved in community actions and also the bottom-up initiatives for the public cause are very different. Lack of trust between the tenants and the owner can be a barrier for cooperation or coproduction and the pilot projects show dedication to building a trustful relationship. Also, many owners tend to follow a technocratic approach, meaning that maintenance and financial issues dominate the discussion about measures and priorities, and the owners are late with asking the tenants what they need or will support. This partly the case in the pilot projects, where the ambition for the energy performance and also the main design elements had a strong maintenance and technical background. Financial restrictions are important, but when a trustful relation is established between owner and tenant, the discussion moves toward the practical issues of renovation and the new quality rather than the willingness to pay. A participative process and individual attention and consideration has however become the key to stimulating support from all tenants for the renovation plans, and finding active involvement of positive and social active tenants is the key to successful energy efficient renovation processes. Besides these active people, the households/tenants who need care and consideration for their personal condition have received much attention. The temporary relocations in the Brogården project have required great efforts, double so much as renovation for the sitting tenants.
In the next paragraphs a number of models of long-term commitment to energy savings, including involvement of tenants, are described, each ending with a conclusion about the feasibility for future market uptake.

3.1.1. Total cost of living guarantee

In the principle of 'total cost of living guarantee' (rent plus the energy bill), the main item is the guarantee for tenants that promises on energy cost reductions will be kept. The tenants are asked to support energy measures and will pay rent for this. In order to raise support the owner gives reliable information on the savings, based on the actual energy consumption and on transparent calculations that the tenants can understand. Also, the energy savings are being monitored and compared to the calculations, providing a basis for either further improvements or financial compensation. The energy company may decrease the cash advances of the energy bill equal to the rent increase. This model is strongly supported by the Dutch National Tenant Association and this model has increased the support level for a number of ambitious projects. However, owners are afraid that the guarantee will

trick the tenants into non-energy conscious behaviour, because the risk that poor behaviour will result in higher energy cost while the financial risk has to be taken by the owner now, due to the fact that the owner gives a guarantee on energy cost, rather than the energy provider. This total cost of living does not solve the split incentive issue: the owner invests and the tenants' profits from lower energy cost. A new Dutch legal development can solve this issue. The idea is to lend owners the option to include energy cost in the monthly payment. This allows investing the energy savings in technical measures, while the tenants keep paying the same cost of living, but have a dwelling with much higher comfort. The effect of this regulation allows owners to raise the renovation ambition to zero-energy bill quality. Rent allowances that are based on the net rent will not change.

Conclusion: application the principle of the total cost of living can have a positive impact on the energy related investments of renovation projects.

3.1.2. Energy campaigns.

The owner has many options to communicate about energy aspects and raise awareness on improvement of energy performance, together with many other performance issues. Many housing associations have organized fairs, workshops, conferences and parties to raise awareness. During the first years of the renovation all the tenants were regularly invited to open houses in the showroom apartment in the area. These open houses were hosted by the housing owner and sometimes contractors or providers would participate. All housing owners are committed to ecological sustainability. That means that a contribution is given to several campaigns concerning energy consumption, some specifically for the residents. Information has been given on how to use the dwelling and climate equipment after the renovation. Community actions have been organized in especially Alingsås and Delft intended to improve the social climate and to involve "green ambassadors" to explain new technologies. The owners are keen on actions to raise energy awareness, for instance through support for the climate street festival (a national campaign in the Netherlands, involving 5000 streets), excursions etc.

Quite a few tenants in Delft and all tenants of the Paris project have received free gift boxes, filled with LED-light bulbs, a shower timer, a stand-by killer and other goodies that have a direct influence on energy consumption, or indirect through raised awareness. Over the last years many housing associations became supporter and member of national campaigns, or regional programs led by green action committees or unions, by government bodies and also by commercial institutions. An important shift in energy priorities can be discovered when evaluating the activities of housing associations during the last decade. However, the financial situation worsened for many housing associations, due to cuts in subsidies or government programs, high taxation and also due to the slow housing market, that makes it more difficult to raise money through selling property.
The traditional representative bodies of tenants seem out-of-date and many housing associations feel the need to adapt new social interaction and community channels to fill the gap that appears when tenant bodies in estates lose their vitality or become static bodies with old representatives that do not appeal to younger tenants. Some are disappointed about the response of tenants: they seem mostly interested in lower cost of living and in better comfort and complaint-free maintenance. However, in discussion with involved housing managers, all give the best chance for the

communications approach: take tenants serious, find the positive and social active people, and organize social events and participative planning processes. This seems a successful way to reach optimised plans, high support and positive willingness to adapt behaviour.

Conclusion: energy campaigns are part of any model of long-term owner commitment.

3.1.3. Green lease

The focus on money makes the financial issue even more important. It is advisable to stay out of long negotiations with tenants in which the financial aspects dominate the communication. One way to move away from financial negotiations is to work company-wide with fixed prices. This can work through lease firms that provide energy saving solutions on the basis of fixed lease prices. In Delft, the energy company ENECO (with its spin-off enterprise Tempus) has made a deal with Woonbron to replace and install high-efficient heaters at fixed rates for the total stock, without bidding on specific projects. When solar systems became available, this product was integrated in this overall lease-agreement as well. Woonbron reduces its investment level through the green lease without limiting the energy ambition. The lease price is somewhat higher than when the housing association would have invested and raised the rent, but the investment would not have been possible and also, the energy savings compensate the tenants for the extra costs.

Conclusion: Green lease is a promising strategy for clearly defined measures, such as heating systems and heaters, solar systems, energy management systems, even for fans and white goods.

3.1.4. Covenants

Agreements between partners to jointly reach high ambitions have been quite successful. Good intentions are not enough; certain conditions have to be met:

- long term connection, to allow relationships and projects to develop and start-up at an early point in a project, allowing lengthy discussion on the process, the ambitions and the desired outcome.
- a consortium with balanced interest, expertise and communicative skills
- financial agreement, best with some financial dependency
- coaching or overall management of the communication and the process
- SMART goals and agreement on how to evaluate the output.

The BEEM-UP consortium and contract can be seen as a successful “covenant”. The cooperation and “deal” between the Swedish tenant association and Alingsåshem can be seen as a covenant for the development of the renovation process of Brogården. Other examples are plenty. A steering group cooperating on the outline for the development of Stadtwerk Lehen in Salzburg, based on the agreement to meet frequently and based on a common document stating the ambitions, is a good example.
The Dutch union of housing associations Aedes, together with the national Dutch Tenant Association Woonbond, the ministry responsible for housing, and other institutions made an “insulation covenant” in the early 1990’s, followed by a “sustainable renovation” covenant in 1998 that resulted

in years of targeted actions to promote energy efficiency and sustainable quality. In 2008 the latest "energy covenant" was agreed upon, mainly with the same partners. The covenants express the desire of central governments to have more energy related actions but without the option to subsidize or legalise this approach. The agreement fills the gap that the central government has in policy instruments and leaves the execution of policy wishes to the market. Despite a great deal of window dressing (in the first period) and "political correctness" that does not reflect real practice (also a form of window dressing) the instrument of covenant is useful and effective, but needs to be combined with other actions , such as campaigns and demonstration projects.

Conclusion: a covenant to work on ambitions with partners in the market is very useful, considering certain conditions. Long term commitment to energy issues could have the form of local covenants between tenant organisations and the home owner.

3.1.5. Monitoring of energy consumption

The objective of monitoring is the execution of a detailed metering program of energy consumption and indoor environment in order to verify the final performance after the renovation. Monitoring is needed to identify discrepancies between forecasted performance and actual results. An energy monitoring system is applied at the three demonstration sites. The projects in Delft and Paris have a home energy management system.

Effect of monitoring and feedback

Traditionally, collective heat and domestic hot water (DHW) services have not been individually monitored and without individual cost control. Energy related costs would be calculated on the basis of the individual surface area, or would be included in the total cost of living and therefore not visible to the individual households. The consequence is lack of cost awareness and for instance temperature control through opening of windows rather than turning down a heater. Adding an individual monitoring and billing system would result in at least 25% energy reduction for heating and up to 50% reduction for domestic hot water (DHW), only because of awareness of costs and for that reason different user behaviour. Nowadays energy monitoring of heat, natural gas and electricity consumption is applied in most buildings, be it with collective or individual installations.

Collective installations of sustainable energy production will go along with detailed monitoring, often at a distance, to facilitate better control and resetting protocols after failure and also to learn from experience how systems perform and can be improved. Remote control is cheaper than site visits after an alarm signal is given. Also we need to consider side effects: lower energy consumption may implicate that technical systems are used for shorter periods of time. This could result in reduction of maintenance cost and a longer life span for the investments.

Energy management is primary an issue for the user and the homeowner, rather than an issue for the provider. The responsibility might shift between the users and the homeowner, depending on the rent contract and energy billing procedure, as well as who owns the installations. There can be different priorities, as we see in the three projects, depending on who owns the technical installations including the energy meters, who does the billing and how important the individual cost accounting is.

In social housing in Sweden collective systems are a general phenomenon and individual monitoring of hot water is not common. The owner often provides laundry machines including dryers and refrigerators, while billing is based on surface area per apartment. Passive House projects with very low heating cost and collective systems do not match with individual metering and billing of heat.

In the Netherlands the collective systems for domestic hot water and for heating have lost popularity, due to the higher energy cost relative to individual heaters. The reasons for higher cost are the constant circulation of water at relatively high temperatures for all apartments, the longer period of heating compared to selective use by individual households, while a backup system and professional maintenance cost relatively much money. Individual systems that allow direct metering and billing are most popular. For large scale waste heat applications and sustainable heat/cold sources such as geothermal sources, collective systems are needed, but the legal system (Warmtewet), the billing system and total cost for the users do not support these systems and for that reason it is difficult to go collective. However, a major improvement has been the application of GJ or kWh meters that monitor all heat that is delivered into one apartment, comparable to the monitoring of natural gas, piped into the apartments for individual heaters.

In the project in Paris the delivery of heat and DHW has changed very much, with much attention to metering and individual billing. Domestic hot water was generated in an electrical boiler, which accounted for large energy consumption. During the renovation individual heating and hot water systems were introduced, including individual metering. This change in heat source plus in billing system will contribute a great deal to the overall energy savings. The bio-gas installation is monitored by the provider to control its performance.

Conclusion: monitoring is an essential strategy for control of the performance and as input for campaigns to keep improving the energy performance.

3.1.6. Home energy management system

A modern approach is the display of individual use on a computer monitor or special display, even on a smart phone. These technologies can be combined with feedback systems, meaning that historical energy consumption data are stored and shown. This facilitates comparison to goals by users and insight into the effect of specific behaviour. The better the feedback, the more a user will take notice of the information.

A problem for the application of monitoring systems is the split incentive dilemma: when the owner invests in the system and the tenants benefit, then financial problems may limit the application. For that reason, home energy management systems may be outsourced to energy suppliers or even videophone-service providers, with billing for the service that is separate from the rent or the services of the owner.

Van Dam (2013) did research on the home energy management system that is applied in Delft and discovered an initial peak in savings that would fall back after some time. Constant promotion and attention is for that reason required. This topic is part of the question: is the owner committed to this service for a long period of time? In her study, the average energy savings after one year were about 7%. Dam (“Smart Energy Management for Households”, 2013) is not very positive about the expectations that HEMS contribute to savings. Narrow technological focus does not work; HEMS can

be part of a long-term and broad focus on energy issues. Dam presents the following conclusion regarding the effect on behavioural change (in § 10.1.6 Conclusions on what design-related strategies may influence the use and effectiveness of home energy management systems (HEMS)):

(quote) *"Household energy consumption is a complex issue. This research found that the role of HEMS in reducing the energy consumption of households is constrained. The assumption that feedback is an effective strategy to reduce the energy consumption of households in general is problematic, at least when feedback is studied or implemented in isolation. It should not be expected that implementing HEMS in households, without any consideration for, amongst others, their design, their usability, the context, accompanying interventions, and family dynamics, will achieve substantial and lasting energy savings for households. …….HEMS should be seen as part of a range of energy conservation strategies, and their implementation".*
And also, commenting on the marketing activities of Microsoft and Google in relation to energy control, that these companies abandoned, she adds: (quote) "*There is a real danger that the erosion of this goal will result in a situation whereby we have merely added yet another piece of technology to our already tech-filled homes. This could lead to an increase in total energy consumption rather than energy reductions…"*.
We will therefor focus on an integrated approach and continued campaign including communication with the tenants. The question remains: what is the long-term commitment of the owners to energy monitoring and feedback, in relation to service to the tenants?

The software and hardware issues are one of the most problematic issues when deciding upon an individual metering and display system. Most meters, that can be put on the wall of the living room for example, are too expensive to be distributed among all the tenants. More inexpensive solutions like smart phone applications mean that half of the tenants will lack the necessary equipment to see the data supplied. If the expensive meters are distributed among the tenants, the questions of connections and software are even more complex.

3.2. Who is providing home energy management systems?

Providing energy management systems is not the core business of the homeowner. A social housing institute (GSWB in Salzburg) explains:

"The Energy feedback systems with monitors or other displays for the public or individual tenants rely on modern technology that will be out-dated in a few years. Keeping the systems up-to-date and also keeping the information and handling of systems up-to-date requires expert knowledge (external consultants) that cost much money. Also, leaving this care to the tenants has not yet proven successful, because of the barriers in using modern technologies. The GSWB want to wait for apps and personal applications through smartphones, instead of relying on building related electronic management systems. The providers of smart phones have a good system to update apps and technologies and users are focussed on new apps. A problem in promoting owner attention is that the effects of home energy management systems is not widely known or proven. However, it is possible that user behaviour could be influenced and could result in reduction in energy consumption at reasonable cost."

Also, the GSWB states that they are very interested in models that work well (Green Solar Cities project, D1.14 by E. Hasselaar).

In the Netherlands the energy agencies compete with home energy management services to attract and keep customers. The monthly fee for the service amounts to €2.95 per month (NUON E-thermostat) to € 3.50 (TOON of ENECO) plus an initial investment of € 150 - 225. The monthly costs are 30-60% of the financial savings (based on results by Dam and user data in the Delft pilot). It means that individual energy monitoring with a feedback system has a positive cost/benefit ratio. Also, making energy cost transparent is also a performance quality of a dwelling.

Conclusion: HEMS is the domain of private commercial providers, with support (where needed) form the homeowner.

3.3. Privacy issue

A smart meter can store data and transmit these data over the grid very easily. The owner of the meter can deliver detailed information with frequent intervals, for instance each 15 minutes.

The privacy issue means that all the consumption data cannot be displayed on the same display or bill for all tenants. It must be possible to provide the data per household (this is time consuming) or to collect the data in a private display, where only the individual tenant has access to it.

In the Netherlands the privacy issue has blocked direct feedback from the provider to the customer, for the simple reason that the smart meter is not owned by the provider, but by the owner of the grid. The grid owner is not allowed to provide clients' information to other companies and is not (yet) interested in providing the service of home energy management systems, except if the grid owner's own smart meters are used. This has blocked direct information about private PV installations through smart meters. TOON collects the data individually and directly to the tenant, while detailed information through the smart meter is only technically available for the owner of the grid, which is not the energy provider ENECO. ENECO is not allowed to deliver the data for research due to privacy reasons. To get access to the data, individual tenants have to give permission.

In Paris a similar privacy issue was resolved regarding the provision of individual energy consumption data through the videophone by special permission for this specific demonstration project.

Chapter 4. Conclusions and recommendations

4.1. Conclusions

Energy ambition requires monitoring and optimisation. For behaviour change, the tenant must receive feedback on the relation between power up-take, temperature levels, showering habits etc. and the energy consumption. Without monitoring, the provider, owner or tenant cannot notice when PV systems or solar thermal systems have broken down. The control of ventilation volumes would require monitoring for that sake as well.

Individual metering and billing is a must-do, except when the cost of metering and billing overshadows the energy cost or there are no possibilities for individual control and saving potential, for instance in collective systems in Passive Houses.

The cost of home energy management is low compared to the savings effect and systems can be applied in almost all apartments, meaning that energy management has the potential to become a standard application. However, the systems will not have the same effect on all tenants and for some the HEMS will have a negative effect on energy savings: certain people are better energy managers than technical systems can achieve.

4.2. Recommendations

Table 3 summarises the best practices of chapter 3. The monitoring, feedback and control items can be combined into services that can result in diversified Home energy management systems (HEMS). Besides these services, the green lease contracts and covenants can add to the long-term commitment. Energy campaigns of many kinds, scale, relation with sustainable quality etc. are indispensable part of any policy to keep energy on the agenda.

ISSUE	BEST PRACTICE
Monitoring	Information electricity consumption
	Information power uptake
	Information outdoor temperature/weather
	Information heat / gas consumption
	Information hot water consumption
Feedback	Compare with neighbour(s)/-hood

ISSUE	BEST PRACTICE
	Compare with target consumption
Control	Control some electrical appliances /lighting
	Control indoor temperature
HEMS	Smartphone app
	Support by home owner
Green Lease	Green Lease of installations, solar thermal systems and PV
Covenants	At national level
	At local level
Campaign	Local plus involvement in national campaigns, green ambassadors, participative planning, social community building activities

Table 3. A model of long-term owner commitment

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