Industrial Energy Efficient Retrofitting of Resident Buildings in Cold Climates

D5.4
Guidelines to End-users/Tenants

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Executive Summary

In this deliverable, the possibilities and challenges that arise when trying to influence end-users energy behaviour, is evaluated and analysed. The report contains different methods possible to influence tenants and also give recommendations and experiences from a contractor's point of view.

Retrofitting a residential building presents the opportunity to greatly improve not only the buildings' energy performance but also to influence the tenants' energy awareness and make them more interested in their personal energy use and consumption. With increasing energy performance of buildings the end-users energy behaviour becomes more important when considering the overall energy use of the building and its inhabitants. The use of domestic hot water and electricity is something the tenants can greatly influence and this raises the importance of trying to influence the end-users and making them more aware of their personal energy use. Measures to reduce energy consumption and the cost of heating of domestic hot water have a direct impact on the ecologic footprint of a building.

A framework for evaluating and visualising tenants' energy behaviour and awareness was developed and implemented by a tenant questionnaire. The indicators covered by the questionnaire were evaluated for all E2ReBuild demonstrations and the qualities related to energy behaviour are presented in this deliverable.

The last part of this report presents a method for handling of tenants' complaints. The proposed methodology covers all aspects of a retrofit process, from the design phase, through the construction works and until the commissioning of the building and end of construction work. The methodology not only deals with handling of tenants' complaints but also offers an opportunity to minimize complaints and to improve the experience of the retrofit process for the tenants.

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1.1 Key Questions

- What possibilities do you have to influence tenants' energy behaviour?
- What are the experiences from a contractors' point of view?
- What are the experiences from the end-user evaluation on the energy behaviour of E2ReBuild tenants? What can be learned?
- How can a methodology for handling and minimising tenants' complaints be introduced and implemented in a retrofit process?

2 Methods to Influence End-user Energy Behaviour

2.1 Introduction

The core challenge within energy-efficient retrofitting within housing is that technical and structural improvements of the building and its technique are not enough to reach highly set national and European targets on reduced energy consumption.

Why? The change to energy-efficient building technologies and improved thermal envelopes supports reduced losses and less consumption, but the impact of the occupants as end-users, who will live in the retrofitted buildings and take use of all the infrastructure and technical equipment, needs to be thoroughly considered. Their "behaviour patterns" will not undergo a "renovation" and their household appliances will not be substituted at once by new energy-efficient devices. It has even to be assumed that a "Rebound"[1] effect may occur in some times and the expected savings turn vice-versa.

2.1.1 Challenges

Recent research and to a growing, but still limited, extent also industry and practice are starting to incorporate behavioural aspects and relating it to energy consumption.

Studies show that energy consumption is strongly depending on users behaviour and users behaviour differ for a broad variety of reasons – the consumption even in identical homes may vary to a factor two ([5]; p.5);

Targeting behavioural aspects in general and behavioural change specifically is a highly complex matter to both study and generate policy suggestions for. All behaviour is context bound, in both time and space, socially and culturally. Within the framework of energy consumption behavioural studies, using empirical data from actual end-users, show that there are several factors which can be generalised about regarding both behavioural patterns and willingness to change. Although the studies within this field are continually growing, preliminary results targeting electric household energy use point to great differences within the framework of age, gender, income levels, attitudes and culture ([19]); each powering and reproducing the individual energy consumption behaviour. Regarding willingness to change, there is still a great need for further research. Conducted studies show that for example women tend to be more eager to change their behaviour, in relation to men, and often take the role of actor of change within their household.

The most challenging aspect seems to be the abstractness of energy consumption. It is far away from consumer goods – it is invisible. It supports a certain quality of conditioned indoor climate[2] and it is connected to our every day's activities like cooking, listening to music, using the computers, household cleaning, washing clothes, keeping goods cold and providing light. Also the consumption is linked with the installation of the heating or ventilation system[3], buying the (electric) appliance and the following use (frequency and duration). It needs a lot of behavioural modifications to saving electric energy. The difficulties for energy saving is found in the invisibility of the electric energy use and the different activities connected behind. It is necessary to be supplied to maintain the mutual life-style, but whether the supply chain before nor the differentiation for what it is needed are a matter of big concern. Electricity and the linked consumption is a *"low interest"* product. *"[…] sustainable*

[1] The "rebound" effect is the extent of the energy saving produced by an efficiency investment that is taken back by consumers in the form of higher consumption, either in the form of more hours of use or a higher quality of energy service. Source: http://www.eoearth.org/article/Rebound_effect

[2] In principle the temperature condition is addressed hereby, but indoor air quality by hygienic required air change rates and humidity control of ventilation plants are further aspects.

[3] Installation of heating and/or ventilation system is in most cases out of the users influence – and therefore not treated within this paper. Despite it has to be noted that the pressure coming from the market (from the occupants' side) may support owners to set more importance on energy-efficient and sustainable building services.

electricity consumption can therefore not easily become an element of life-style." ([7]; p. 1874). While buying organic food or building energy efficient buildings is a matter of life-style the awareness of saving electric energy is less visible and attractive.

Preliminary results from interviews with end-users from E2ReBuild demonstrations (Halmstad, Voiron and Oulu) underline the abstract nature of energy consumption. In conducted verbal interviews and through written questionnaires there is a general consensus regarding the positive aspects of reducing ones energy consumption, and also the possibility to do so, but the way to go about doing this is more complex and hard to relate to actual behavioural change. The technical aspects are easier to grasp and often using low energy lighting equipment is mentioned as examples of how to lower the household energy consumption. The motivation for change is often related to the reduced costs on the electricity bill, although some tenants also mention more broad environmental reasons such as taking part in reducing the use of resources and contributing to a more sustainable future.

"The starting point, and also a key message of MECHanisms[4], is the need for a more contextualized understanding of energy end-users. We have tried to take the critical points raised by sociologists of energy use serious. They have been critical of the dominant techno-economic and psychological approaches to promoting energy conservation. They argue that a focus merely on individual behaviour obscures the fact that individual choice is limited by the way cities, energy supply systems, housing designs and products are configured. From the end-users' perspective, energy use is largely a side effect of other activities like living, raising a family and working. Much of our energy use is habitual and many energy-use habits are further consolidated as conventions, i.e. socially shared expectations about appropriate practices. Finally, policymakers and the institutional system are often sending ordinary energy users 'mixed messages'. This is a very challenging environment for project managers trying to change end-users' energy behaviour." ([1]; p. 44)

Due to the low interest of end-users, the variety of connected products, activities and habitats and of different social groups there is no homogeneous strategy for promoting energy saving measures.

The invisible support of every day's activities provides the perception of self-evidence and less anticipation of control the consumption. This is supported by the yet common way of billing by offsetting with previous periods or estimations.

2.1.2 Requirements on European Level

In 2007 the EU set the objective of saving 20% of the EU's energy consumption compared to projections for 2020 through increasing energy efficiency. The reduction of primary energy consumption shall contribute to prevent climate change and mitigate the emission of CO2 and other greenhouse gases.

According to the Directive 2006/32/EC human activities attributed to the energy sector cause as much as 78 % of the Community greenhouse gas emissions. ([12]; (2)) Furthermore residential and tertiary sectors combined contribute to 37% of the EU's final energy use (2007: 25% for residential, 12% for tertiary sector), underlining the importance of that sector when discussing the reduction of primary energy consumption. Both sectors are mentioned together because they are served by *"buildings where energy is predominantly used for buildings' space and water heating, cooling and cooking (i.e. 78% of total needs for service sector and 88% for residential in 2007[5]). The rest of the energy consumption is to be attributed to the use of electric appliances and lighting.*

[4] "MECHanisms" is one tool developed in the Changing Behaviour project. [1]
[5] Source: DG ENER statistics. Cooking cannot be separated from the data set.

The potential for cost-effective energy savings for the two sectors is currently estimated at 21%[6]. Some of it (or 13.4%)[7] will possibly be realized with the current policies but still the two sectors offer the biggest savings potential from the final energy sectors". ([11]; p. 9-10)

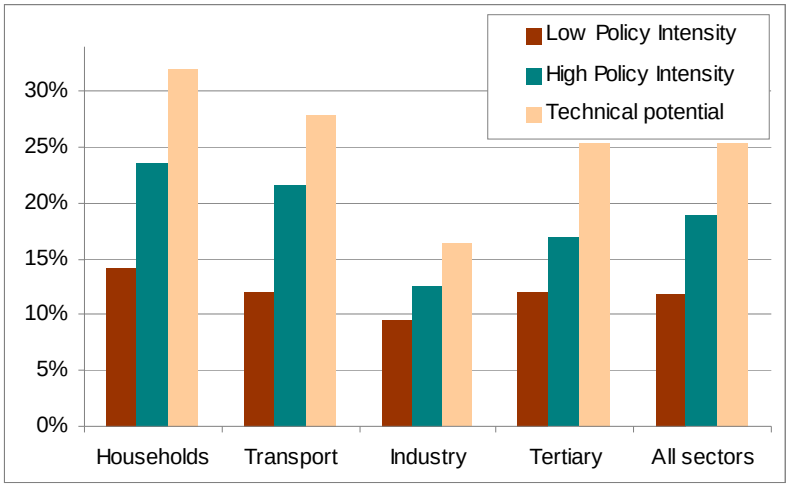

Figure 1: Final energy savings potential in EU 27 in 2020 (Source: EEA 2011)

Current projections of the development of primary energy use for the EU show a reduction in the consumption in 2020 of only 9% compared to 2007, meaning the EU needs to double their efforts to reach the target. ([11]; p. 21).

Therefore *"a need for improved energy end-use efficiency" is necessary "as there is relatively limited scope for any other influence on energy supply and distribution conditions in the short to medium term, either through the building of new capacity or through the improvement of transmission and distribution"*. ([12]; (1))

For this reason within the European Union the recognition has risen that for reducing electricity consumption and saving electric energy at the short to medium term perspective, the focus needs to shift moreover on the cost-effective side and thus on "soft" measures, predominantly targeting on changing end-users behaviour. Based on a number of studies[8], cost-effective potential exists in all final energy demand sectors. A difference should be made between technical potentials - best available technology irrelevant of costs - and cost-effective potential. ([11]; p. 8)

The intention of focussing towards changing end-users behaviour is mirrored in the correlating articles *within the Directive 2006/32/EC of the European Union, expressing the importance of feedback:*

Article 13 (1)"Member States shall ensure that [...] final customers [...] are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use."

Article 13 (2) "Member States shall ensure that, where appropriate, billing [...] is based on actual energy consumption, and is presented in clear and understandable terms. Appropriate information shall be made available with the bill to provide final customers with a comprehensive account of current energy costs. Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption."

[6] Study on Energy Savings Potentials in EU Member States, Candidate Countries and EEA countries, Fraunhofer ISI from 2009, for example
[7] Ibid.
[8] For example "Pathways to low-carbon Economy, Version 2 of the Global Greenhouse Gas Abatement Cost Curve", McKinsey&Company, 2009 and "Energy Savings 2020: How to triple the impact of energy saving policies in Europe" Ecofys and Fraunhofer ISI, 2010

Article 13 (3)"Member States shall ensure that [...] following information is made available to final customers in clear and understandable terms [...]:

(a) current actual prices and actual consumption of energy;

(b) comparisons of the final customer's current energy consumption with consumption for the same period in the previous year, preferably in graphic form;

(c) [...]comparisons with an average normalised or benchmarked user of energy in the same user category;

(d) contact information for consumers' organisations, energy agencies or similar bodies[...].

For sure the implementation is by now far behind the technical progress and the required standards. Some member states already started actions (Denmark – informative active bill, Sweden – actual consumption reading) – but a statement of the EC [16] on the impact of measures shows the gap. The pressure to reduce energy consumption not only from the technical but also from the methodical point of view is still emphasised.

2.2 Methods

A lot of concerns nowadays are targeted to technical solutions and methods such as demand-side management – but as recognized by the EC the solely technical approach leads neither to cost-effective solutions nor has the potential to reach the 2020 targets. Hence the focus has additionally to be set on the methodical side to further develop improved methods to change energy use behaviour patterns. In the past 40 years a lot of theoretical work on the psychological side has been done and a few studies provided findings out of practice. But due to small scale samples within those historic studies and not-correlating survey conditions for studying a lot of gaps for research on useful methods ([7]; p.1881-1882) could be identified.

More recent, European wide research programmes, like the *Changing Behaviour* project [1][9] provide a good insight of the best practices of demand-side management of the past 10 years ([1]; p.23).

One main finding – obviously – is the "*neither homogenous nor static*" behaviour of end-users. Too many different motivations *("calculated self-interest, altruistic, rules of appropriateness, etc.")* and social-institutional framework conditions determine the logic of re-action of end-users. So motivation and mobilisation has to address issues on different levels. The main failures done hereby are: *"[…] providing cheaper information, new institutions, and incentives"* ([1]; p.27).

Chosen methods have to be differentiated with reference to different levels of target group and the impact they should trigger:

- Engaging the community
- Influencing habitual behaviour of individual end-users
- Influencing investment behaviour

While within the Changing behaviour project the last issue "influencing investment behaviour" is addressed to investors of energy-efficient housing, this is as well as behaviour that could be initiated by end-users.

In order to evaluate the impact of different "*pieces of advice*" provided to different target groups (the community itself and the individual user especially) a ranking on the influence and relevant pre-

[9] The project "Changing Behaviour" was performed within the Seventh Framework Programme of the European Commission Jan. 2008 – Dec. 2010; [1]

conditions of possible actions was conducted among the researches and practitioners in the project Changing behaviour. Results can be found in the abstract of two tables (see Table 1 and 2).

Table 1: Engaging the community

See also Table 5.2 taken over from Report D13 - Changing Behaviour, 2010; p. 31

"Advice"	**Own experience, Rating**	**When is it good advice?**
Engage stakeholders	3.6	When end-users are very dependent on stakeholders; requires real win-win situations and alignment of stakeholder interests.
Use peer-to-peer communications	3.4	In most situations, especially when the target group is fairly homogeneous and trusts each other. Sometimes it may be difficult to do this in practice or to monitor whether the message gets through.
Make sure everyone 'does their bit'	3.2	Especially for long-term and large interventions, when achievements can really be monitored (not just rhetoric).
Use social support and social pressure	2.9	Requires good understanding of social dynamics – who influences whom? May be difficult to manage in practice.

* 4 = very positive / 1 = totally negative

Table 2: Influencing individual habitual behaviour

See also Table 5.3 taken over from Report D13 - Changing Behaviour, 2010; p. 32

"Advice"	**Own experience, Rating**	**When is it good advice?**
Assess susceptibility to change	3.4	When funding bodies offer flexibility to start with easy things, when the target group is not too diverse.
Create awareness of habits	3.4	When used with care: people may find it insulting if an outsider tells them they are "doing it wrong".
Give feedback	3.4	When people have the opportunity to change their behaviour, and the information is not too overloading.
Use rational appeals	3.4	Once you have people signed up for your project. When the rational argument is sufficiently dramatic.
Use emotional appeals	3.2	When backed by facts. Not easy to use for people with a technical background.
Build on ongoing change processes	3.0	May be useful in some situations, but ongoing change situations can also be stressful.
Competitions	3.0	When rules are fair, when groups of people (not individuals) compete with each other. Danger of dissatisfaction, might not promote long-term change.
Change the users' environment	2.9	When the target group is willing to change. But prompts, for example, can lose value with familiarity and can be annoying.
Use commitment and goal-setting	2.4	When goals are clear, agreed on in society and measurable and when frequent feedback is available.

* 4 = very positive / 1 = totally negative

These tables demonstrate very clearly the importance of understanding the target-group of end-users and of differentiating the group beyond their social and local context. The entire situation has to be reflected very carefully and it has to be considered how the needs correlate with project objectives.

While the importance of both levels (to address community by broad awareness campaigns and to set actions to influence the individual habit behaviour) is obvious – the further focus for the E2ReBuild approach is set on methods on the individual level, that could be addressed by building owner or housing association. Nevertheless the demand to public entities to realize awareness campaigns should be expressed insistently by the actors involved in building and housing management – but they are encouraged to support as well as to contribute to such campaigns!

2.2.1 The Feedback Method

Why feedback is generally assumed to be an effective way to influence user's behaviour? Basically feedback is psychologically spoken an intervention that interrupts the normal order of things ([5]; p. 6). While individuals are more or less supposed to follow acquired habits they can be motivated by reward or punishment. Hence positive or negative intervention provides measureable effects on behaviour, primarily on a short-term basis.

Basically feedback is defined according to the Oxford dictionary as

"Information about reactions to a product, a person`s performance of a task, etc. which is used as basis for improvement."[10]

The crucial point identified was the "invisibility" of energy consumption. Feedback on energy consumption provides information on a person`s activities and use of appliances.

In literature ([5]; p.3) it could be found in studies in the 1970s that *"[…] clear feedback is a necessary element in learning how to control fuel use more effectively over a long period of time and that instantaneous direct feedback in combination with frequent, accurate billing is needed as a basis for sustained demand reduction. Thus feedback is useful on its own, as self-teaching tool."* ([5]; p.3)

2.2.1.1 Methods to Give Feedback

Ways and models to change environmental relevant behaviour were developed in various environmental psychological projects ([7]; p. 1974) – two main streams can be identified:

- To influence a person`s habits by stimulating more sustainable behaviours
- To raise a person`s consciousness on environmental impacts and demonstrate own contributions to it

Both can be supported by the means of feedback to consumers on their own consumption – to make it more "tangible". It was seen in different studies that improved feedback may lead to reduction of consumption up to 20%. This range is very ambitious; a lot of studies provide the range of 5-12% ([7]; p. 1877). But, as many papers emphasize, results depend vitally on how the feedback is provided to consumers.

Basically two different types of feedback can be identified:

- Indirect feedback: via billing; in case of frequent and accurate billing the householder is assumed to get a much better understanding of the heating load at different times over the year;
  Savings are assumed to range between 0-10%; including e.g. following systems of feedback:
  - Online billing with incorporated analysis and advice for end-users, no figures on savings available in studies

[10] http://oxforddictionaries.com/definition/feedback?q=feedback

- Feedback letter: additional information regarding electricity bill, simultaneously sent but in separate envelope, including most important information at first glance - partly in graphics - and saving tips

- Direct feedback: via meter, display monitor or signal lights; in case of instantaneous and clearly visible or accessible display it may give the end-user adequate information on the different end-uses. So the accumulation of the different energy-consuming activities or appliances is more understandable. Saving are assumed to range between 5-15%, but it has to be considered that the installation of these kind of meters is rather expensive compared to the feedback via billing. Signal lights might point out, if e.g. the heating starts to work or inside/ outdoor temperature heats up/cools beyond a certain level. Including e.g. following systems of feedback:
  - Pay-as-you-go systems (tested in North America and Northern Ireland) with savings around 10-20%
  - Time-of-day pricing will be an option for a better distributed energy load over the day in order to avoid peak loads; Studies showed rather a shift of load than a significant impact on savings.

2.2.1.2 Persistence of Feedback Methods

The main question to be asked is further on the persistence of the effect. At which time-point is it possible to speak that end-user behaviour was influenced sustainable? Psychologists call the effect intrinsic – new behaviour patterns come up. From experience it seems to last about 3 months ([5]; p.4) until a new habit can be formed, but the longer feedback is continued the higher the chance that it is kept and that further changes (other efficiency measures) are initiated.

Factors influencing the effectiveness of feedback:

- General context (social, educational, historical framework)
- Scale and timing of feedback (indirect feedback after certain periods or up-to-date instantaneous feedback)
- Synergies between feedback and other forms of underlining information/ influence: it is difficult to separate implications (all studies up to now were too small-scaled to give relevant findings); generally it is assumed that additional advice can help to change behaviours in a sustain manner, but in case of incentives to save energy the effect fades away when incentives are taken away ([5]; p.4
  Timing, time-frame and frequency determines the effect whether it is a long-term perspective of energy-saving including other following efficiency measures (via accurate billing) or it is change of activity patterns by moment-to-moment-feedback (displays, monitors).

2.2.2 The Training Strategy

The “Intelligent metering” project focused on a considerable training programme and training material for building users and occupants in order to achieve significant changes in end-user behaviour [8]. The training included mechanisms for enabling, engaging and incentivising the building users. It started with the project launch, followed by a poster campaign, individual and small group discussion on the base of best practice and good housekeeping guides and large group presentations and training sessions for all building users. The range of training resources included good practice guides, good housekeeping information, case studies, posters and stickers, WWF educational material and a list of internet sites with relevant training resources.

This approach might be only partly recommendable due to the more educational, instructive and to some extends even mandatory character of the training programme.

2.2.3 Information Policy within Early Stages of Retrofit

The IEA SHC Task 37 "Advanced housing renovation with solar and conservation" focused mainly on a broader market adoption of advanced and holistic renovation strategies. [3] [4]. The occupants' participation was identified as a key for successful implementation – that includes as well the further operation phase. Options on how to influence user`s behaviour were not addressed particularly, nonetheless the increase of social interactions is favoured as a key factor for successful renovation. Coincidently identification with the residential area, the understanding of the renovation background contributes to the behavioural pattern afterwards. Therefore it is recommended, certain essential themes, should be communicated in very early stages by information and awareness campaigns already during the design and renovation phase for the housing.

"In addition, involving the occupants and explaining their responsibility with regard to the proper operation of the various systems and/or techniques integrated in the housing also makes it easier to require occupants to control their consumption and to verify maintenance of the systems installed. For this reason, information on the various systems and/or techniques integrated in the housing unit and their correct usage should be given as soon as the housing is occupied. It is also advantageous to offer occupants a guide for the use of the housing, as soon as they enter it, and to give them the particulars of a contact person should they need more technical information." ([4]; Sheet 003)

2.2.4 Participatory Aspects, Possible Window of Opportunity within a Retrofit

As mentioned above the involvement of occupants might prove an important asset in generating changed behaviour patterns. In relation to the EC-initiated Concerto projected it is further stated that: *"Householders, as potential users are often unaware of practices and technologies available, often sticking to old energy inefficient habits. In both refurbishment and new construction activities, it is therefore important to inform and train residents to change their behaviour either through dedicated counselling activities or through participation in feedback activities on their energy consumption."*([20]; p. 12)

It is however important to note the risk of occupants feeling forced into involuntary "training mode", making them less inclined to take part, or at least doing so with a potential to actually change their behaviour. To label it training is a rather top-down normative approach which is probably not the right way to go.

Studies have further shown the need for feedback and participation from the perspective of occupants handling the higher level of technical system in low energy buildings and apartments:

"The results indicate that the low-energy profile of a building had a limited influence on the decision to rent the apartment, however residents were generally proud to live in environmentally friendly buildings. Moreover, tenants also suggested that living in the energy-efficient buildings increased their environmental awareness, making their behaviour more environmentally friendly. Residents of low-energy houses gave better rating for indoor climate than that in conventional houses, which suggests higher satisfaction with the product; however, tenant feedback identified some problems with ventilation system and space heating. Findings indicate that there is no significant difference in operation and management of low-energy buildings, however information and communication activities are absolutely crucial in successful management of low-energy buildings." ([21]; p. 18)

In more general terms recent research emphasize how participation can bring added values in terms of increased involvement at the local level and positive behavioural change.

"The capacity of citizens to contribute to tackling social challenges and problems is mostly untapped. Current models for encouraging citizens to participate in civic life are geared around citizens

influencing decision making or service delivery, rather than individually or collectively making change themselves." ([22]); p. 3)

"For the hard to become habit, we need social reinforcement, for the habit to become easy we need to shape our habitats accordingly — places to practice and people to teach us or work with ([23]; 27).

Participation, between tenants, and between tenants and stakeholders in a retrofit has the potential to build knowledge sharing and creating a forum for social reinforcement through which behavioural changes might be an outcome, alongside a possible strengthening of local social capital.

2.3 Recommendations for Implementation and Testing from the E2ReBuild Demo Projects

One main core target group that has an influence on end-users behaviour are so-called *"energy-intermediates"*. These are individuals or organisations (private or public) on various national or international levels focusing on climate change, energy saving, sustainability, etc. that implement and manage demand-side management projects. The *"energy intermediates"* are in contrast to researchers and practitioners who are mainly targeted with an Action Research (AR) approach – based on the close cooperation between researchers and practitioners to develop an improved understanding. The implementation is done by means of research needs that are embedded in the reality of the demo projects ([1]; p.6); Hence the approach is based in theory but needs the strong collaboration and interdependence between researchers, clients and practitioners ([1]; p. 12).

This project could abstract some main rules to be considered for Action Research (AR) like on one side *"a strong theoretical foundation for the practical work, e.g. through case study analysis, […] to avoid results that are 'too academic' to be applied in practice."* It is recommended *"learning to speak each other language"* ([1]; p. 9). Further on the results that are aimed to be achieved have to serve both – researchers and practitioners.

The approach of AR is based on a reflective learning – so the process is to understand how things are going and to improve the own ways of working throughout the project. *"AR is used to help implement solutions to real world issues, as well as to identify and clarify issues and problems* ([1]; p. 13).

The key for AR is meant to be a sufficient project communication in different ways ([1]; p.9).

One of the objectives within the E2ReBuild WP 5 is the development of means influencing end-users behaviour. So the AR approach was appropriate: A good foundation was developed by literature review of already accomplished studies and pilot projects and the analysis of questionnaires within E2ReBuild demo projects. The draft hypothesis on how to influence end-users is integrated in the work of Task 5.2 and can be assessed therein by intermediaries and practitioners.

The Do`s and Don`ts listed for energy intermediaries ([1]; p.7) within the Changing Behaviour project show very similar common bases and are targeted to the relation between end-users and the intermediaries: Success factors are to understand (the end-users), to work together with the relevant stakeholders, to be flexible (to adapt the project work according to new knowledge gained within the project progress). The main additional challenge for intermediaries is the communication that can only be influenced by one side – the intermediary him/herself! There will be less effort put in from the end-users side in case of insufficient or wrong communication. So it is necessary to know the communication channels, behaviours and social networks of the end-users. The power of social networks has to be considered at any time of addressing end-users. Social support or pressure of networks may influence the reaction and behaviour of users.

How to give feedback to the demos?

- Based on actual consumption (instead of offsetting, estimations, etc.): End-users feel a sense of control and – in case the feedback is delivered with the energy bill – they feel well-informed by the energy-supplier.
- The labelling has to be clear; Labels and technical terms should be explained.
- The components of the pricing have to be clear
- Graphic presentations should support information on data: pie-charts for breakdowns, comparisons with other households with horizontal bar-charts, comparisons with previous periods with vertical bar-charts.

2.3.1 Aspects Determining Feedback

In order to suggest feasible feedback methods for the E2ReBuild demo projects it is recommended not only to select a tool from the technological side; it is moreover important to understand which feedback method may influence which groups within the national context the most. Even within one country it has to be distinguished by applying a tool that users may not be all from the same educational level and technical interest. Therefore the focus should be on more simple and easy to realize systems to forward broader market development in near future instead of difficult and complex tools.

The fundamental aspects found in literature determining feedback to end-users include:

- Frequency: It was seen in many studies that is helpful, but not sufficient enough for its own
- Duration: Long-term projects are assumed to contribute to habit transformation
- Content: Consumption and costs are in most successful cases combined, but information on actual consumption is a crucial point.
- Breakdown: The effect of breaking down cannot be reliable found in the studies, but a lot of successful projects applied detailed appliance-or room-related data. Reported periods should be shorter than a month (continuously, daily load curves, proportion of night/day consumption in case of cheaper night time etc.)
- Medium and mode of presentation: Simple but not simplistic, a combination of text, diagrams and tables are better than a single-format approach, no additional documents recommended. The supply with multiple options of feedback for end-users allows a better adaptation to an end-user's individual preferences. If it is possible by means of computerized feedback. The choices may range from time-periods, comparison, additional information, environmental impact, etc. But such solutions are highly related to the technological and not a "cost-effective" approach.
- Comparisons: Two main approaches may be identified: The comparison with own previous periods (historic) or the comparison among others or with an average household (normative). It was recognized that normative comparison leads on one hand to reductions of high users, but on the other side it stimulates low users ("things are going not so bad") to upgrade a little bit (increased comfort feeling).
- Additional information: Very few studies provide useful information, more or less it might be rather difficult – on one side not to "overload" end-users and on the other side to meet needs of specific, highly interested target-groups.
- Timing of feedback from a global and broader scope:
  For example one pilot project within the Changing behaviour project started renovation discussion under the effects of the worldwide economic crisis. ([1]; p. 43). People were more reluctant to invest in renovation.

- Feedback loops
  It is necessary to learn to receive and provide feedback. ([1]; p. 66). This statement can be confirmed by the experience of an Austrian monitoring project of the entire "Building of Tomorrow" projects[11]. Tenants claimed lacking feedback on the out coming of elaborate tenants' questionnaires (conducted before and after renovation) – the findings of the questionnaires were not communicated back to them.
- Tailoring feedback
  It is difficult to transfer an instrument from the theoretical context to practical implementation ([1]; p. 44). Additionally it has to be considered that any demo is different from the other, not only from the country-specific and national framework but also from the tenants living there. The misleading perception "one-size-fits-all" ([1]; p. 69) should not mix up with the request to apply the same principles for all demos.

2.3.2 Contribution to "European Open Research Questions"

With reference to different international papers [7] the national or country-specific background is a determining aspect for how to give feedback. Not every finding can be deducted to all countries worldwide, even within Europe there are differences. While consumers in some nations, for example Hungary, are not interested in information exceeding price and amount – they are more interested to have secured supply, others are interested in the comparison with other households (like Japanese) or in the comparison with their own previous consumption (like Swedish).[12] Even easy-to-understand-information may be understood in different ways: A graphic design with the representation of the data points with small houses was tested in the US and in Norway. While the ranking in the US was very high, the Norway did not like the "childish" design.

A lot research gaps that have been identified in various papers can be met by the E2ReBuild project therefore:

- The sample sizes were up to now too small. What is needed – are large-N studies with reliable data, combined with survey data on motivation, preference regarding feedback and types of action to be taken. It is vitally needed that after sub-grouping the samples a sound number of representative households.
- Which feedback stimulates energy-savings the most?
- Feedback given within which time-frame is most effective?
- Comparative studies among different countries/nations. The cultural and national differences as well as preferences for how to get feedback may be interesting. The "one-fits-it-all" approach will not be possible even in Europe.

[11] Tenants of monitored demonstration buildings claimed lacking feedback on the out comings of the monitoring and elaborate socio-scientific evaluation (questionnaires conducted after renovation) – the findings of the were not communicated back to them. [2]
[12] See Fischer, 2007; p. 1881

2.3.3 Suggested Feedback Methods within E2ReBuild Project

Figure 2: Measuring appliance (Source: Geier)

Based on findings out of literature and own reflections five feedback methods have been defined, appearing appropriate and feasible to be tested within E2ReBuild demo projects. The suggested methods can be adopted on its own or as combination of different approaches. In order to achieve a sufficient cost-value ratio the feedback methods might be allocated within one building/ housing estate (e.g. 90% of households “Real data billing”, 10 % of households “Detailed Monitoring”), taking into account that “Detailed monitoring” seems a rather cost-intensive approach.

The suggested feedback methods (two indirect and three direct methods) are as follows:

1. *“Real data” billing*: billing based on actual consumption; incorporated analysis, easy to understand; most important information at first glance supported by graphic illustrations; comparisons to the same period of the previous year and average usages of other end-users.
2. *Feedback letter*: including additional information and analysis regarding the bill; sent simultaneously with electricity bill, but extra document; information easy to understand, most important information at first glance supported by graphic illustrations; comparisons to the same period of the previous year and average usages of other end-users; including saving advices for end-users.
3. *Smart metering system*: keypad display in room of end-users choice; billing based on actual consumption, are read remotely, send the reading information electronically (optional via post); instantaneous feedback, clearly visible or accessible display, may give the end-user adequate information (e.g. consumption in kWh, costs, CO2 emission, per hour, in total, predicted, compared to average usages of other end-users).
4. *Detailed Monitoring*: "Smart Home" solutions based on home automation (bus-systems); instantaneous appliance-specific feedback possible via extra display in room of end-users choice or computer, providing detailed appliance-, type of use- or time of usage-specific information (including consumption in kWh, costs, CO2 emission, per hour/day/week/year, real-time power usage and price reporting); individual and comprehensive end-user evaluations possible.

5. *"Energy meetings"* as a forum for sharing knowledge and generating participatory behavioural change by enabling contact between tenants and stakeholders (social reinforcement); including information, training and counselling activities (e.g. handling of new technology and appliances); could be established either web-based or as an annual meeting/ group discussion organized by the housing association (more informal, complemented with coffee and cake..); as additional component end-users could build up teams (established by comparability) and compare/discuss their self-read meter figures of energy consumption - social factor and commitment as incentivising key element. These meetings could also take part during a retrofit process as a means to share knowledge on presumptive technical solutions, their use and their functionality, between for example tenants, facility care takers and technical entrepreneurs.

Table 3: Rating of feedback aspects and suggested feedback methods (Source: CCTP)

	Suggested feedback methods					Rating	Source	Rating
	indirect:		*direct:*					
	1. "Real data" billing	**2.** Feedback letter	**3.** Smart meetering system (with communication module)	**4.** Detailed monitoring ("Smart Homes" with bus-system)	**5.** "Energy meetings"	Rating of feedback aspects regarding its relevance for success (according to literature)		(own perception)
Frequency								
- less monthly					X	o	(Fisher 2007, p.1880)	
- monthly	X	X				+	(Fisher 2007, p.1880)	
- more often than monthly			X	X		++	(Fisher 2007, p.1880)	
Duration								
- short term (< 9 months)						o	(Fisher 2007, p.1880)	
- long term (> 9 months)	X	X	X	X	X	+	(Fisher 2007, p.1880)	
Content								
- Information on electricity consumption	X	X	X	X	X	+	(Arvola et al 1994)	
- Information on costs	X		X	X		++	(Arvola et al 1994)	
- Information on environmental impacts					X	o	(Fisher 2007, p.1880)	
Breakdown								
- room-specific				X		+	(Fisher 2007, p.1880)	
- appliance-specific				X		++	(Fisher 2007, p.1880)	
- type of use-specific (eg. heating, lightning etc.)				X		++	(Fisher 2007, p.1880)	
- time of the day-specific			X	X		+	(Dobson and Griffin 1992)	
Medium/ mode of presentation								
- interactive, computerized			X	X		++	(Ueno et al 2005)	
- via internet	X				optional	+	(Bender et al 2006)	
- via post included within electricity bill	optional		optional			+	(Arvola et al 1994)	
- via post as additional paper		X				o	(Roberts and Baker 2003)	
- self meter reading					optional	+	(Fisher 2007)	
- single format (eg. only text)	optional					+	(Roberts and Baker 2003)	
- multiple format (text, diagrams, graphics)	X	X	X	X		++	(Roberts and Baker 2003)	
- meetings/ discussions (social reinforcement)					X	+	(Staats and Haarland 1995)	
Comparisons								
- historical comparisons	X	X	X	X		++	(Fisher 2007, p.1880)	
- normative comparisons		X	X		X	o	(Fisher 2007, p.1880)	
Additional information								
- commitment and goal setting				X	X	+	(McCalley and Midden 2002)	
- energy saving advices		X			X	o	(Wilhite 1997)	
- training/ counselling					X	+	(Di Nucci et al 2010)	
Feedback loops								
		optional		optional	X	+	(Haakana et al. 1997)	
Tailoring feedback								
			X	X	X	+	(Fisher 2007, p.1880)	

Legend:

o	averaged
+	high
++	very high

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3 Methods to Influence End-user Energy Behaviour – Experience from a Contractor's Point of View

3.1 Introduction

In this introductory chapter, the importance of influencing end-user energy behaviour is discussed, with the EU goals and national requirements as starting point. The aim, method and outline of this chapter are presented.

3.1.1 Background

The EU goals and targets for energy savings in the near-term future

In order to achieve the EU goal of a secure, competitive and sustainable energy supply, one of the European Council's strategies is to make efforts to reduce the use of energy. According to Directive 2006/32/EC (Europarl. and the Council, 2006), each member state has been ordered to implement national action plans for how it intends to reach a 9% target of energy savings by 2016, compared with 2008 levels for final customers. The EU "Green Paper" stresses that there is potential for 20% energy savings, compared with 1990 levels, which is intended to be reached by 2020 (EC, 2006). To reach the EU goal of reduced energy use by 20 %, the individual countries will find their own goals and methods to reduce energy use. By June 5 2014, the national directive and regulations for reduction of energy use should be adopted.

Energy efficiency of buildings

The Directive 2002/91/EC on the energy performance of buildings (EPBD, 2003) covers five requirements listed below. It is up to each member state to choose their own method and to define their own energy requirements to fulfil the Directive. The EPBD Directive came into force on the 4th of January 2003 and had to be implemented in each member state at the latest on 4 January 2006.

- A methodology for estimating building energy performance
- Minimum requirements of energy performance for new buildings
- Minimum requirements for energy performance for refurbishment/retrofitting of existing buildings.
- Energy declaration/certification of buildings
- Control of individual boilers and air conditioning systems

National legislation and traditions for energy use vary a lot between different counties. Most counties within Europe have regulations on energy performance for the designed building, but not for the energy performance of the completed building. In Sweden the regulation includes the energy performance of the building in operation, and not only calculated performance.

Near-zero energy buildings

In the Directive 2010/31/EU (Europarl. and the Council, 2010) that aims to increase the share of near-zero energy buildings (Near ZEBs), it is clear that these buildings should have a very high energy performance. The Directive covers new buildings as well as retrofitting and will take effect in 2019 for public buildings and 2021 for other buildings.

The Nordic countries have different approaches to how the Directive will be met, both in terms of ambition and foresight, and if energy requirements will cover estimated or real energy performance. For instance, in Denmark, so-called energy levels have been introduced as building codes for new construction, in which energy requirements are tightened up in the years 2010, 2015 and 2020. This is intended to lead to a reduction of energy use by 75% between the years 2006 and 2020 for new

buildings. The Norwegian government has proposed passive house standard as a requirement for all new buildings by 2015. In Sweden, there is no definition of Near ZEB, but there are ongoing investigations of conditions for more strict energy requirements.

Energy performance related to end-user behaviour

Due to the more strict energy targets in new as well as refurbished buildings, the share of energy use related to end-user behaviour is higher today. This means that the end-user energy behaviour plays an important role to achieve these targets. Therefore, it is important to investigate different actors' preconditions, incentives and opportunities to influence and change end-user energy behaviour.

As mentioned earlier, energy requirements for buildings in Sweden relates to energy performance for buildings in operation, and not to calculated performance. Energy requirements cover use of operation electricity and of heat for hot tap water and space heating, all of which are affected by how the buildings are used. If the client is not satisfied with the energy performance of the building it is up to the contractor to prove that the building performs according to the contract. If the building doesn't fulfil national legislation or project specific agreements, the contractor is economically responsible and may have to pay a fine. Therefore, it is especially important for contractors in Sweden to monitor and evaluate the energy use. It is also a reason to learn about residents' energy behaviour, and how it is possible to influence it.

3.1.2 Objective

This study investigates methods of influencing end-user energy behaviour from a contractor's point of view using experience from NCC. The goal is to identify success factors and critical aspects to consider when choosing methods and systems for different situations and conditions.

3.1.3 Method

The study was carried out by conducting interviews with different representatives for NCC Construction, NCC Housing and NCC Property Development. The interviews are complemented by a brief review of previous work.

3.1.4 Outline

In Chapter 2, preconditions and incentives for different actors in different countries to influence and change end-user energy behaviour are discussed. NCC Construction is used as an example sharing experience from housing projects in Sweden, Finland, Norway, Denmark, Germany, Latvia, Estonia and Russia. In Chapter 3, different examples of methods for different occasions – from marketing to operation of the building – to increase awareness and to encourage end-users to change their behaviour are presented. Success factors and critical aspects are discussed in Chapter 4.

3.2 Different Actors' Preconditions and Incentives

Preconditions and incentives to influence and change energy behaviour depend on many factors, such as types of businesses, contracts and actors, legislation and national requirements, but also on economic, cultural and social factors. In this chapter, we discuss – from a construction company's point of view – the different actors' preconditions and incentives to focus on energy performance and end-user energy behaviour in new building projects as well as in refurbishment projects.

3.2.1 A Contractor's Perspective

NCC Construction builds and refurbishes various types of buildings and is contractor for both internal and external building projects. The internal clients, NCC Housing and NCC Property Development

(PD), develop and sell new building projects. External clients are, for instance, private and public housing companies, housing associations as well as private customers.

An obligation to fulfil energy requirements

The contractor is responsible for the construction of the building according to the demands and criteria specified by the clients. In Sweden, the contractor's obligations also cover fulfilment of the energy requirements, as previously mentioned. If the client is not satisfied with the energy performance of the building, it is up to the contractor to prove that the building performs according to the contract. If the building does not fulfil the national energy requirements and project-specific agreement, the contractor is responsible and has to pay a fine. During the last few years, NCC has worked hard to monitor and collect measured data in all NCC projects. For more information, see Chapter 3.3.3.

NCC Construction provides information about the technical equipment and instructs the operational managers when the building is transferred from the control of the contractor to the client; for more information, see Chapters 3.3.2 and 3.3.6. However, NCC Construction does not have any information about the effects of behaviour on energy performance, unless part of the contract.

Traditional contracts leave no margins for extra incentives

Normally, a contractor's business is to meet the requirements according to the tender at the lowest cost possible. This is often a necessity to win tenders. The client specifies the ambition level for the project. In design-bid-build contracts, the contractor will not be able to focus on behavioural aspects more than using statistical data. Design-build contracts usually allow for limited analyses.

Partnering projects

The partnering concept is used for both refurbishment projects and new buildings. It means that the client and contractor act together and share responsibility and make decisions together. Under these conditions it is easier to work with environmental issues, for example adding information campaigns, energy displays, etc. For instance, partnering can be used as a design and decision tool to determine the energy and cost solutions best suited to the client as well as how this can contribute to a more optimised retrofit project in regards to energy efficiency and cost optimisation (Burke, 2013).

Sustainable renovation projects

In a sustainable renovation project, several retrofit solutions and their associated costs are proposed and calculated by NCC Construction for the client ranging from the minimum required work to ensure that the building is functional (highest energy use), to best solution using a combination of new technology and new control systems. The cost calculations also take into account how the measures would finance themselves through lower operation costs and what time frame this could be expected.

The proposed solutions have limitations defined by the customer in advance. Each calculation also shows how the specific retrofit could be financed over time. In the E2ReBuild demonstration building Giganten 1 & 7 in Halmstad, the most aggressive savings package was chosen (Burke, 2013).

Sustainable tenders – proposals for sustainable choices

For all larger tenders, NCC sees a possibility of giving the client proposals for green choices. Therefore NCC works with sustainable side tenders suggesting improvements for the environment. NCC offers services such as classifying buildings in accordance with certifications, such as BREEAM, LEED, Green building, Miljöbyggnad[13] and SVANEN[14], passive house standard etc. The side tenders

[13] For more information about Miljöbyggnad, see http://www.sgbc.se/certifieringssystem/miljoebyggnad.
[14] For more information about SVANEN, see http://www.svanen.se/en/.

may also include energy solutions based on renewable energy and other additional commitments adjusted for the specific building's preconditions.

A sustainable side tender is an opportunity for the client to make a better choice for the environment. Obviously, sustainable side tenders can include information campaigns as well as energy visualisation.

Demonstration projects in research and development

Apart from energy issues in tenders and contracts, behavioural aspects in energy use has been the subject for several research and development projects using NCCs projects as demonstrations. The E2ReBuild EU-project and the refurbishment of Giganten 1 & 7 is one of these examples. Another example is the refurbishment project of Giganten 6, in the same neighbourhood, which is a demonstration project within LÅGAN Program for buildings with very low energy use (Swedish Construction Federation, the Swedish Energy Agency, Region Västra Götaland, Formas).

The passive house residential area in Vallda Heberg is also evaluated in detail with regards to energy performance, indoor climate and energy system solutions within a LÅGAN demonstration project. NCC is building the first Swedish passive house for sub-arctic climate in Kiruna, which will also be evaluated within a demonstration project financed by the Swedish Energy Agency and NCC Construction.

3.2.2 Internal Clients' Perspectives

NCC Housing develops and sells new residential houses, mainly for private consumers, and NCC PD develops and sells commercial buildings. They are responsible for everything from the concept and purchase of land to selling the completed residential area or commercial property.

Certifications of buildings

Both NCC Housing and NCC PD work with the certification of buildings, which is a way to improve a building's performance in many aspects of sustainability. The number of certified buildings has increased tremendously over the past years; only in Sweden the number of buildings with the certification "Miljöbyggnad" has gone from just a few till over 800 in less than two years (SGBC, 2014). The demand for BREEAM certifications has also increased. Up to November 2013, NCC Construction has built over 100 of buildings certified by Miljöbyggnad, BREEAM, LEED and SVANEN.

All detached houses and apartment buildings developed by NCC Housing will be certified according to Miljöbyggnad at the level "Silver" or higher. Within this environmental classification system, there is an obligation to collect information about all the materials in Building Product Declarations (BPD). NCC Housing also offers certifications of single family houses with SVANEN. According to SVANEN, there is an obligation to install equipment for individual monitoring of hot tap water and space heating in households.

All of NCC PD's commercial properties will be certified by BREEAM at the level "Very good" or higher. This means an obligation to inform tenants and operational managers about the functions in the building. NCC PD has developed their own building user guide templates for tenants and for operational managers (in Swedish). A BPD is optional in BREEAM, but is required in all projects developed by NCC PD.

Climate Declaration

NCC Housing has also worked with Climate Declarations of buildings as a way of communicating energy use and impacts on climate change to customers. The declaration gives a picture of the climate change impact for the different stages of the life cycle of the building, not only the climate change impact associated with the energy use of the building. Climate Declaration as well as Climate Compensation can also be part of Sustainable Tenders.

Green Lease

For all properties that NCC PD develops, a Green Lease will be signed. This means, for instance, that the tenants and the property owners are committed to distribute information about the building's energy performance annually and to develop an action plan with activities to reduce the use of energy.

Information campaigns, individual billing and energy visualisation

Some years ago, NCC Housing and PD developed the web tool *Green Living-Green Working* that informs tenants in an interactive way how climate-friendly behaviour saves energy and money. The *Green Living-Green Working* tool is available at NCC's homepage, and has mainly been used at trade fairs.

NCC Housing informs their customers about end-user energy behaviour in all NCC countries, by organising meetings or by providing a building user guide/brochure, or both. NCC PD also has their own building user guides with instructions for tenants and operational managers, see Chapter 3.3.2. They have also started to organise inspiration meetings for tenants in office buildings.

As mentioned earlier, NCC has started to monitor energy use in all projects – at least on an aggregated level. Detailed energy monitoring is a precondition in countries which apply individual billing, as in Germany, Russia, Lithuanian and Latvia. In SVANEN-projects, there is also an obligation to install equipment for monitoring electricity, hot tap water and space heating.

Energy visualisation is not yet a standard in NCC Housing and PD's projects. However, NCC Housing has tested a number of different energy visualisation systems, see Chapter 3.3.5, and NCC PD is looking for a product that suits their needs.

3.2.3 External Client's Perspective

External clients can be private and public housing companies, housing associations as well as private customers. Obviously, their preconditions and incentives to focus on energy performance and end-user energy behaviour differ.

Marketing, branding and insurance against high operation costs

For property developers, energy efficiency measures and environmental certifications can be a way of marketing quality and branding the company at the same time as it increases the value of the building and thereby also the price when selling the building. For real estate owners as well as for private customers more ambitious energy efficiency measures can also reduce the risk of high operation costs of the building in the future.

Landlord/tenant dilemma

For landlords the classical landlord/tenant dilemma is a great barrier to overcome in order to make investments in energy efficiency measures. The European Council of Real Estate Professionals and the International Union of Property Owners defines the landlord/tenant dilemma as follows.

> ***"Landlords and tenants both have an interest in the energy performance of buildings; however, their interests are not always the same. Requirements concerning levels of energy efficiency continue to increase, but the question remains, who will pay for this work and who will benefit from the saving in energy costs? There is a problem with split incentives which includes what we highlight here as the landlord/tenant dilemma." Source: CEPI and UIPI (2010)***

Ástmarsson et al. (2013) have investigated if tools like energy performance contracting and energy labelling can help to solve the landlord/tenant dilemma. The authors point out that the principal/agent problems can only be overcome with a package solution. In the Danish national context, they suggest a combination of legislative changes, financial incentives and better dissemination of information.

3.2.4 An End-user Perspective

Energy performance related to end-user behaviour is a national and cultural question. In countries where it is a tradition to pay for your own energy costs, as in Germany, Russia, Estonia and Latvia, energy issues has historically got more attention. In the Baltic countries, each household pays for their individual energy use, not only for electricity and hot tap water, but also for space heating. From 2013, all NCC Housings projects in Russia also have this opportunity. This means that when customers buy a new flat, they accept that some flats need more space heating and have higher operation costs than others dependent on location in the building. Residents of a low-energy building have lower energy costs and are less vulnerable for increased energy prices.

In both Estonia and Latvia, and especially in Latvia, residents have stated that the cost of energy is substantial in relation to their income. In these countries, a lower energy cost is an obvious incentive to move into a newly built home.

In countries where energy prices are still too low to be an effective driver in residents' behaviour, environmental threats, like climate change, may be a stronger argument for more energy-efficient behaviour, than money saved.

3.3 Methods to Influence Energy Behaviour

In this chapter, we will present examples of methods – used or discussed in NCC projects – to increase awareness and to encourage end-users to more energy-efficient energy behaviour. These cover different methods for different occasions – from marketing situations to operation of the buildings.

3.3.1 Interactive Web Tool Green Living

Increasing interest and awareness of energy and environmental issues in marketing can be done in many different ways. NCC's tool Green Living was one of the first interactive web tools developed in Sweden that informs residents about their responsibility and, in an interactive way, shows how climate-friendly living saves energy and money. The users can quickly and easily find out more about how they can cut their energy use and carbon dioxide emissions and how they can cut their energy costs by different actions, see the description below and Figure 3. The tool has mainly been used at trade fairs and the interactive tool is also available at NCC's homepage (http://www.ncc.se/sv/Boende/GreenLiving/).

In NCC Housing's selling material customers are informed about measures taken to make the building energy efficient and they can get tips on what they can do to live more energy efficiently. They are also given the recommendation to visit the website and read more about simple steps they can do to cut energy use, emissions and energy costs using Green Living.

"In our efforts to reduce our environmental impact, we at NCC work consistently to develop buildings that are as energy-efficient as possible. But it's not just about how we build them. Because the biggest amount of energy a building uses during its lifetime is used by those of you who live in the building. What you do in your everyday lives counts.

So, to help you save even more energy, we have developed GREEN LIVING – a new tool on our website in which you can quickly and easily find out more about how you can cut your energy consumption and carbon dioxide emissions. You can also save a lot of money.

If you live in one of our newly-built homes, right from the outset you can look forward to a level of energy consumption that is at least 20 per cent below legal requirements. In passive houses it is halved. With GREEN LIVING you can further cut back on your energy consumption. That makes a difference – to both your wallet and the environment.

The reduced climate impact is the result of various climate-friendly measures that you select in a virtual NCC home. For example, if you switch off the lights in a room when you're not there you can save SEK 296 and reduce your carbon dioxide emissions by 42 kilos. Every year. Feel free to come in and have a go!"

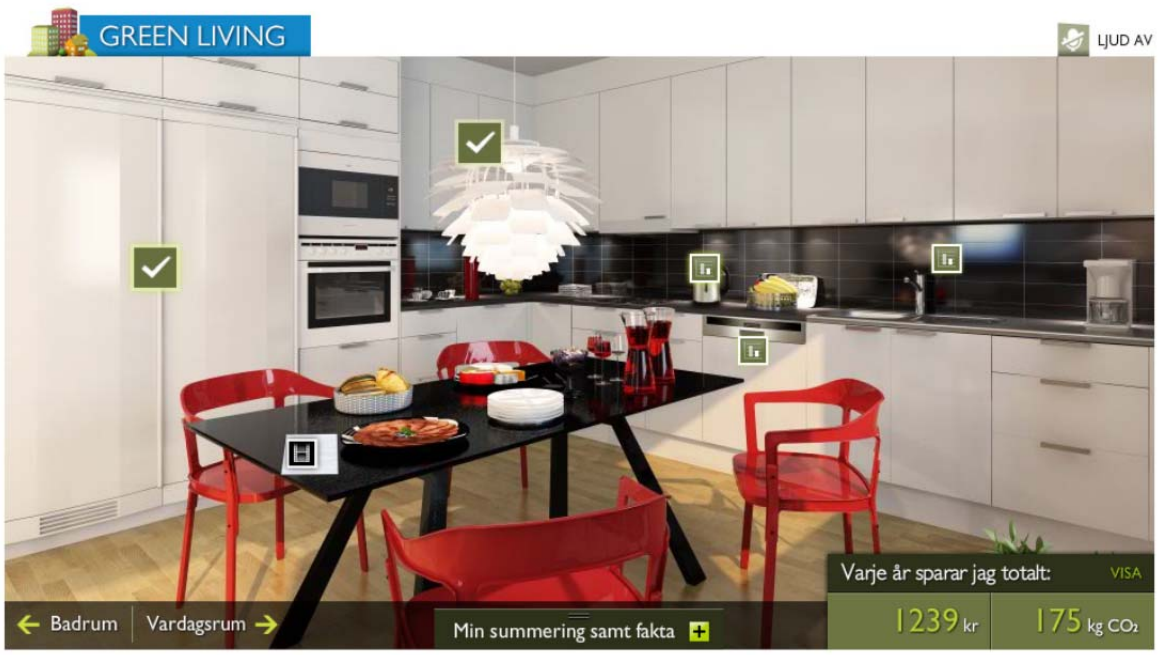


Figure 3: Green Living – an interactive web tool that has been developed by NCC Housing

There is also a corresponding web tool for office buildings, Green Working, which also informs tenants how climate-friendly working saves energy and money. The interface for Green Living – Green Working is only available in Swedish, and these tools are not up-to-date and need further development.

There are also other interactive web tools developed by third parties. One example is an initiative from the Swedish Energy Agency, Nature Conservation and SABO - the Swedish Association of Public Housing Companies (SABO, 2014). An interactive web tool has been developed that, apart from presenting advice for energy savings, presents the user's energy profile based on a web questionnaire.

An interactive tool, such as Green Living, can be used to increase interest and awareness about energy behaviour at trade fairs, selling meetings, information meetings about refurbishment projects and energy inspiration meetings.

3.3.2 Building User Guides and Information Meetings

NCC Construction always provides a maintenance and service folder containing instructions/manuals for the technical equipment in the building. Six hours of education is included in the standard contract. NCC educates/instructs the customers' operational managers when the building is transferred from the control of the building firm to the contractor. Sometimes, the education is held on a few occasions.

Often, the clients have their own building user guides with information to tenants and operational managers about indoor comfort, energy and environmental performance and tips about ways to improve energy performance. NCC Housing informs their customers about end-user energy behaviour in all NCC countries, by organising meetings or by providing a building user guide/brochure, or both. NCC PD also has their own building user guides with instructions for tenants and operational managers. They have also started to organise inspiration meeting for tenants in office buildings.

3.3.2.1 Lessons in Living (NCC Asumisen koulu) – An Example from NCC Finland

This text is taken from a memo of an interview on 14.10.2013 with Ilkka Alvoittu, Project Development Manager, NCC Construction Finland, held by Simon le Roux, Aalto University (le Roux, 2013).

'Lessons in living' (NCC Asumisen koulu) is a residents' training concept that has been used for ten years in Finland and by NCC for four years. The training material is broad and is based on decades of experience and pioneering research development in Finland for an environmental approach to user-oriented building services, indoor air quality, energy efficient heating solutions, water saving, ecology and life-cycle thinking.

The training material and content used was developed originally at Enertek Oy in collaboration by HVAC engineers Veijo Matilainen, VTT Research Professor Miimu Airaksinen, Ilkka Alvoittu, and Ilkka's father Lauri Alvoittu. Enertek was later purchased by Optiplan, owned by NCC Finland group.

NCC Housing School is currently arranged for all of NCC Finland's own housing development projects, and may in the future be expanded to NCC Partnering projects. The 'Lessons in living' are also used for NCC commercial premises such as office buildings. It is currently not used in refurbishment projects but it is possible to adapt the teaching material for refurbishment, and develop a similar training process appropriate to refurbishment, with attention to communicating the risks of disturbances to residents, and explaining the refurbishment process.

The training procedure

The training procedure is targeted at residents buying a new apartment in a typical new build housing corporation in the Finnish market. The training is held approximately three months after building work has been completed and the buyers have taken occupancy, in conjunction with the transfer of administration meeting, in which the building is transferred from the control of the building firm to the shareholders. During the construction stage, the housing company is typically administered by the building firm or developer.

Before the training at the shareholders' meeting, the residents will have already taken occupancy and inspected their new apartments, and are ready to receive the new information. The apartment will have been handed over to the buyer after the building had been approved for use by authorities, and the buyer has had the opportunity to inspect the apartment. At the handover of the apartment the owners receive initial information about the apartment and installed equipment, but this is not the real focus of the Housing School. If residents need individual help in using their new home or appliances, it is recommended that they get free advice, for example from the Martha Finnish home economics organization.

An important starting part of the training is to affirm the resident's decision to make a significant investment in a new apartment, and install pride in their new home by commenting and praising the architecture of the building. This raises the perceived value of the building. The focus of the presentation is on supporting the well-being of the new residents. The training is not intended as individual user guidance, but rather about understanding building characteristics.

The experience in NCC has been that many claims for defects are based on misunderstandings about the characteristics, features and behaviour of a building, which may differ from the residents' previous homes, and since residents do not necessarily understand how a building performs, they may misuse it, or be frustrated by the way the building behaves. Based on experience with anecdotal evidence, it is possible to explain many of the typical problems new residents have, and pre-empt possible claims for defects.

The nature of complaints is that residents may find it difficult to admit that they did not understand the reason for some issue that they found annoying, and are unwilling to back down without losing face. Of course it is also true that the construction company does not always communicate well to residents. If the construction company is reluctant to admit their own mistakes and blame subcontractors rather than taking responsibility for disturbances or taking action to rectify a problem, the complaints or claims process may escalate into a potential confrontation.

The housing school aims to avoid common misunderstandings by explaining building physics, indoor climate, building equipment and services, and by making good environmental behaviour a shared value. The message is that environmental thinking is a virtue, and social pressure is used to encourage positive behaviour change.

Currently there is only one session at the shareholders' meeting 3 months after apartments hand over. Ilkka proposed that there could be another meeting at the time of the one-year inspection, when notifications of defects are gathered from all buyers of apartments. The one-year inspection is held after a period of 12–15 months, i.e. approximately one year of occupancy. This would also be a potentially good time to follow up residents training, with deeper insights into the maintenance and operation of the building during different seasons.

It is important to explain to shareholders about the need for regular maintenance and upkeep of the building, and issues of life cycle in anticipating future repairs, so that residents do not have unrealistic expectations of durability and maintenance-free living in a new apartment building. There is experience from the past, showing how the poor scheduling of repairs can shorten the building service life, reduce user comfort and affect the occupants' quality of live.

Ilkka also proposed that residents could be invited to a specially arranged site visit event during the construction period to show them the installations and equipment that is later hidden inside the building, such as precast building services elements. All in all there could be series of 4 residents training events: (1) construction site event, (2) personal guidance at the apartment hand-over, (3) stakeholder administration handover meeting, and (4) one year inspection. For refurbishment, instead of the first site event, there could be a presentation onsite to explain how and where the disturbances will take place (dust, noise, access, service interruptions) and how the site management will work to reduce the impact. The intention is to reduce the potential conflicts of interest and to be honest about the trade-offs.

The training material

There is a large amount of training presentation material available (about 150 slides) which can be selected to make a presentation suitable for almost any kind of apartment building. For each event

there are a few introductory slides about the building in question, in order to discuss that particular building's architectural characteristics and orientation (e.g. glass balconies). The tone of the presentation needs to be appropriate to the individual NCC presenter to make it fluent and easy- going, and adjusted to the demographics of the audience.

The residents are given a Living ABC booklet (Asumisen ABC, in Finnish). Indoor climate and user comfort are important issues in the material, to explain different needs, personal preferences and satisfaction (draft, ventilation, surface temperature, humidity, heating and the influence of furnishing). Increasing attention is given to explain how heat recovery mechanical ventilation works, how to save electricity, how to avoid heat losses, how cooking and hot water use impacts on residents energy use, and why it is important to sort waste and recycle.

Experience of the housing school

The experience has been good, resulting in reduced number of claims and complaints, and improved mediation with clients. There is still a need to enlighten NCC's employees, since the construction industry is conservative and common practice is based on years of experience, which may have already become outdated.

Usually less than 50% residents participate. Older residents are more interested and have more time, and participation may go up to 70-80%. The younger generation may be more motivated and interested in the future, since they are more exposed to environmental education. Originally there were some questionnaires made about the training, but the answers were quite uniform, and eventually did not offer new insight. Residents rarely answer completely honestly, and try to give an overly optimistic picture about their behaviour.

The NCC Lessons in Living event at the E2ReBuild demo site in Oulu was held in an apartment at the Virkakatu 8 demo building in spring 9.4.2013. The building was refurbished to a level of new building, so the standard training was used. There were at least 10 people attending, which accounts for a representative majority from 8 apartments. The audience was enthusiastic, which was contributed to by the presence of PSOAS staff at the training event.

The following conclusions were also made based on the E2ReBuild residents' questionnaire.

- Energy prices are still too low to be an effective driver in the residents' behaviour, and it is more effective to use emotional manipulation with added encouragement to save the planet, and praise individual's environmentally virtuous behaviour. First encourage residents to "do the right thing" and then it can be justified and post-rationalised by scientific and economic evidence. Even if the personal economic benefit is small, it still serves to justify a large change based on perceived value.
- Issues about specific technical systems do not come up in general residents discussions since these kinds of technical details are typically of interest to specialists and occasional individuals.
- Issues about well-being, comfort and behaviour are best communicated with stories and hints.
- Safety and satisfaction, and a feeling of connection to the surroundings can be reinforced by praising the good qualities of the new building to the residents. An outside expert is important and their influence adds to the perceived value of the building.
- It is more important to invest time in effective information and communication to clients and residents to avoid conflicts. Residents tolerate more disturbances and more variations in indoor climate when they understand the reasons.

3.3.3 Monitoring Energy Performance

From now on energy performance including space heating, hot tap water and operation electricity, will be monitored on an aggregated level in all NCC projects, using an online web system called MOMENTUM (2014), see Figure 4. By using such a tool, it is possible to get an overview of all projects as well as to evaluate energy performance in separate projects. Using this system, NCC's new projects are automatically monitored and evaluated against current BBR requirements, customer requirements as well as their own internal requirements.

Figure 4: Screen visualising energy use online (Momentum, 2014)

Individual energy monitoring is a precondition in countries which apply individual billing, as in Germany, Russia, Estonia and Latvia. In Sweden, individual monitoring is not standard, but in SVANEN-projects, there is also an obligation to install equipment for more detailed monitoring electricity, hot tap water and space heating.

3.3.4 Individual Billing

Individual billing not only for electricity, but also for heating and hot tap water can be a strong incentive for reduction of energy use, but the residents' economic situation influences the effect of implementing individual billing. In countries where cost of energy is substantial in relation to the resident's income and where individual billing is implemented, as in Latvia and Estonia, there is a stronger awareness about the importance of energy efficient behaviour. NCC Housing's experience from Latvia is that new residential buildings in this country often have lower energy use than the calculated energy use. However, this may cause other problems, such as low indoor temperatures.

The effect of implementing individual billing for hot tap water in Sweden has not been clear. It has been shown that the reduction depends on earlier habits and cannot be measured directly. For newly built apartment blocks in Sweden, the cost for hot tap water does not affect the individual's economy significantly, and residents tend to use as much water as they want, ignoring the cost.

SVEBY standardizes work practice in energy issues for the construction industry in Sweden and develops criterion for end-user energy behaviour. Earlier, SVEBY recommended the assumption that individual billing of hot tap water will reduce the use of hot tap water by 20%, based on measurements. New measurements, made by SABO and HSB, showed that the reduction depends on several factors and sometimes the expected reduction did not even occur, the recommended

calculation criteria of 20% reduced use due to individual billing of hot tap water was removed (SVEBY, 2012).

3.3.5 Visualisation of End-user Energy Behaviour

The popularity and demand for energy visualisation is growing and relatively cheap energy displays and apps are now available for private customers at the market. Energy displays for house hold electricity may cost as little as about 10-20 €.

NCC Housing has tested a number of different energy visualisation systems in different countries. Energy displays have been tested in Sweden and Finland. In Russia, energy visualization combined with visualization of different service functions have been discussed as an opportunity for bigger houses.

In Sweden, the Energy AWARE Clock was tested in ten households within the CLOCKWISE project (Katzeff et al., 2009). NCC has also tested MANODO and ELIQ displays. For more information, see a more detailed description in the section below. In Finland, an energy display has been tested which also displays indoor and outdoor temperatures together with other functions, such as the “home/away” function. In Denmark, two different systems, ISTA and BRUNATA, have been discussed. In these systems, residents can follow their energy use from an app and from a web page.

Today, there are also electricity-meters that measure the overall electricity use in the home and warn you when it reaches a level that is too high. There are also timers or thermostats that automatically turn appliances of. These are already available for private customers at the market.

Visual energy displays

In the CLOCKWISE project, which was a collaboration project between Interactive Institute and NCC, the use of the Energy AWARE Clock (see Figure 5) in ten households in Ursvik, Sweden, between January and March in 2009, was evaluated (Katzeff et al., 2009). The aim of the project was to identify key characteristics in residents’ behaviour in relation to the Energy AWARE Clock.

The results show that the residents have learned about their normal everyday use of electricity and that they have discovered and identified devices that use a lot of electricity. During the three months of the test period, two identified phases were defined: the discovering phase and, later, the confirmation phase.

Results of measurements show a high complexity with many uncertainties, which makes it difficult to draw any strong conclusions. However, despite the prevailing uncertainties, there is an indication that participating households reduced their household electricity use by up to about 10%.

Figure 5: Energy AWARE Clock (Interactive Institute, 2014)

Numerical energy displays

The ELIQ display visualises the total amount and costs of electricity used in your apartment/building, see Figure 6 a) and b). Apart from showing the electricity use momentously as well as the historical use, it also shows a red light if the current electricity use is higher than the normal electricity use. This reminds the residents to be aware of the electricity use connected to activities and electricity-intensive equipment at home. At the company's web page, the users can arrange energy saving challenges with themselves, friends, neighbours and unknown people.

Originally, ELIQ was designed for houses, but it can also be used in many apartment buildings. The interface is in Swedish but there will soon be a multi-language interface available. According to ELIQ themselves, "scientific studies on the use of home energy displays show that a display such as ELIQ at a good spot in the home can help you reduce your electric bill by 10-25% and spare the environment of tonnes of CO_2 emissions".

a) 

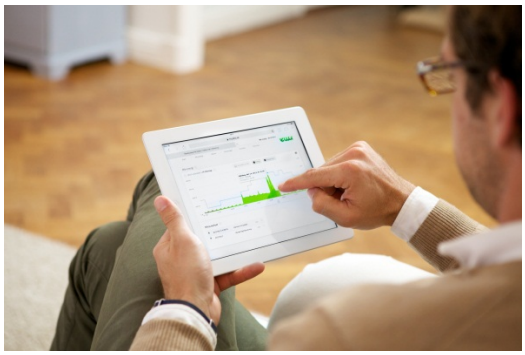
b) 

Figure 6: a) ELIQ Energy display showing the current electricity costs. b) ELIQ online used on a tablet (ELIQ, 2014)

An earlier version of ELIQ's energy displays have been tested in ten (of 75) households in a NCC Housing project in Fågelsten, in Lindome (Johansson C., 2011). Measurements for the households in Fågelsten were analysed together with measurements for other households in Alingsås. In total, measurements were collected for 39 households, of which 20 had an energy display installed. The households also participated in a questionnaire study. Interviews were conducted with residents in the ten households Fågelsten only.

The number of households was limited and the testing period was relatively short (from February to the end of May 2010). Despite limitations in statistical data, there is an indication that participating households reduced their household electricity use by 10% (if measurements are compensated for parameters such as number of people in the household as well as household area). There is also an indication that users having an initially high electricity use reduced their use considerably more if they had a display installed in their home compared to if they had not.

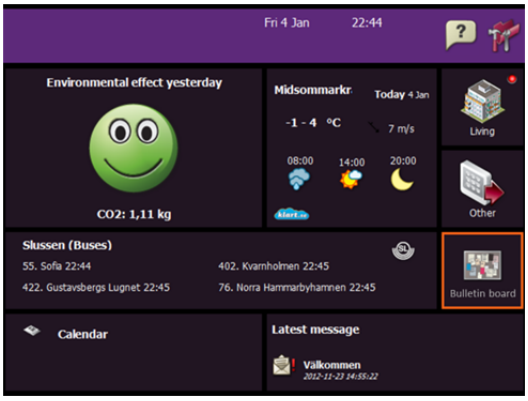
According to the questionnaires, the residents experienced the display as generally intuitive to use and all participants answered that they saved more energy during the test period than before the display was installed. All of the residents interviewed in Fågelsten answered that they had been surprised about something in the households electricity use.

Energy visualisation together with visualisation other service functions

The MANODO energy display is a data terminal for apartments that visualises electricity and water use and that also has a number of service functions such as laundry booking, service call, public transportation etc. see Figure 7 a) and 5 b). There is a smiley which is happy if usage is low compared to a certain reference and the smiley is sad if energy use is high. If the user clicks on the smiley, a bar chart showing the hourly energy use appears, see Figure 7 b).

One advantage of such a display may be if the residents use the display for booking laundry times, service calls, public transportation, and at the same time get a quick overview of their energy use.

a)



b)

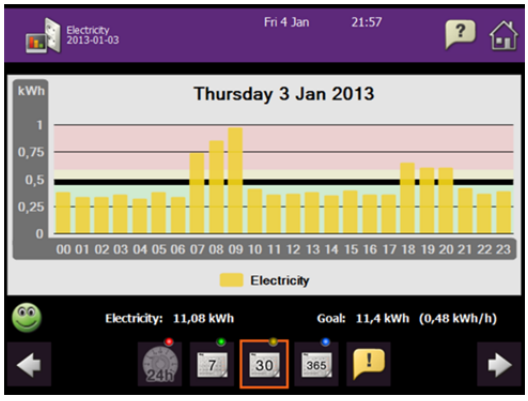


Figure 7: a) MANODO Energy display showing environmental load as well as a number of other service functions. b) Bar chart showing the hourly energy use. (MANODO, 2014)

An early version of the MANODO energy display was used in NCC's passive house project in Beckomberga. An evaluation study was made, and it was shown that the smiley had been sad half of the year, which residents' experienced as depressing. Since then, there have been further developments of the system. Today, many residents have their own displays in tablets, mobile phones and smart TVs, and they get direct access to their messages, bookings and a new energy presentation, see Figure 8.

Figure 8: Illustration of energy visualisation in tablets, laptops and screens (MANODO, 2014)

3.3.5.1 Other Possibilities not Tested by NCC

Ambient energy displays

Another way of visualizing electricity use is to use light as a representation of the electrical current. The idea is to visualize electricity use by light instead of watts, which are both invisible and intangible. Interactive Institute has developed the Power-Aware Cord prototype – an electrical power strip that displays the current amount of energy passing through it, see Figure 9. Current use of electricity is represented along the cord through glowing pulses, flow, and intensity of light. “The faster it goes, the more it glows”, one of the test persons expressed how it works.

It invites users to plug in different appliances and experiment with how these relate to each other in terms of energy. It can also be used to detect unnecessary stand-by consumption. It can be used in schools and at home as well as a tool for learning in research projects.

An initial user study with 15 test people was made by Gustafsson and Gyllenswärd (2005). “Static intensity, pulsating intensity and flowing intensity were tested in groups of five people each.” There is a “balance between visual comfort and ability to convey enough information“. “A constant glow, in varying intensities, was generally seen as calm and pleasing while the flow and the pulse were seen as the most information programs.” “The pulsing light and the flow, at high levels were often seen as irritating.” “It would be irritating when you sleep”. Bright levels of the static intensity were found uncomfortable.

Figure 9: Power-Aware Cord prototype (Interactive Institute, 2014)

Visualising energy use in design and art

Another way to visualise the use of energy is in design and art, such as the "Flower lamp" and the art work developed by Interactive Institute Swedish ICT, see Figure 10. These may be too expensive to be installed in households, but could be installed in staircases in apartment buildings, in main entrances and in conference rooms in offices.

The "Flower lamp" is a display for the usage of electricity and shows the overall trend in the energy use. Its functions have been described as follows: *"If the household has a decreasing trend of electricity use, the Flower lamp rewards you by slowly opening up to "bloom". If, on the other hand, use is increasing, the lamp folds its petals together. Thus, the light and form, is reflecting the cycles of local energy use in a subtle and poetic way"* (Backlund et al., 2006).

Figure 10: Flower lamp and art visualizing energy use (Interactive Institute, 2014)

3.3.6 Social Activities Related to Energy Use

During the interview with Illka Alvoitto, he said that "behaviour may be better influenced through collaborative financial incentives, such as in reduced property maintenance charges if all residents collectively save water or electricity. Greed, social pressure, and self-satisfaction gained from "virtuous" behaviour tend to be stronger drivers for behaviour change. For example, teenagers taking long showers and wasting hot water can be creating just as great an environmental impact in CO2 emissions as their parents driving oversized SUV's. However, it is easier to criticize a car owner, and ignore the waste of energy from hot water" (Le Roux, 2013).

Collective incentives and challenges could be a positive and fun incentive for residents to behave in a more energy efficient way. Another way is to organise energy inspiration meetings for children.

3.4 Discussion

The goal of this study was to identify success factors and critical aspects to consider when choosing methods and systems to influence end-user energy behaviour using experience from NCC. In this chapter, we summarise our main findings.

More strict energy requirements are a reality in all EU member states, and since energy use related to end-user behaviour represents a large share of the total energy use in buildings, it is necessary to influence and to encourage end-users to exhibit more energy-efficient behaviour.

There are many different ways and methods to increase awareness and to influence end-user energy behaviour. One of the first tasks is to offer these possibilities, to help clients to make a better choice for the environment right from the start and, in this process, also consider different ways to involve and to influence the end-users. The possibilities for this look very different depending on the type of tenders, contracts and leases.

Type of tenders and contracts is crucial! Depending on the type of contracts with clients, the preconditions look very different for the possibility to focus on measures such as methods to influence end-user energy behaviour. Traditional contracts leave no margins for extra initiatives about energy issues from a contractor's point of view. However, by offering sustainable renovation projects, partnering projects and sustainable side tenders, there is an opportunity for the client to consider different suggestions for improvements and to make a better choice for the environment. This may include addition of energy visualisation, energy training sessions etc. to the contract.

Economic, cultural and social differences make sense! Once there is focus on energy issues and behavioural aspects in the specific project, the next step is to choose methods to raise awareness among residents and to encourage them to become more energy-efficient in their behaviour. At this stage, it is important to be aware that a certain method can have different effects in different countries and situations depending on economic, cultural and social differences. For instance, energy visualisation could be a successful tool to increase awareness and to encourage an energy-efficient behaviour in some countries, but may have minor effect on energy use in countries where it is a tradition to pay for your own energy costs and energy use has already been visualised through the energy bills.

Another example is individual billing for electricity, space heating and hot tap water, which can be a strong incentive for residents to save energy. However, implementation of individual billing may have different effect on energy use for different users in different countries depending on energy prices and private economy. At some point, there may even be a trade-of between comfort and money saved, for instance if residents cannot afford the energy bill and therefore decrease the indoor temperature. On the contrary, in countries where private economy is good and energy prices are too low to motivate

changed energy behaviour, climate change and other sustainability aspects may be a stronger argument to save energy.

In summary, make sure that issues about end-user energy behaviour are raised and choose the right method for the right occasion!

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4 End-user Evaluation

A common tenant questionnaire was produced, translated and distributed to all demonstration projects. The aim of the questionnaire was to evaluate the renovation from a tenant perspective and to get insight on more general attitudes on participation, inclusion and energy behaviour.

The situation before and after was compared through the following aspects:

- Well-being and health (indoor comfort and equipment standard)
- Experience of the built environment (proudness, quality of life, security)
- Evaluation and use of technical systems (heat and ventilation control)
- Architectural quality (of floor plan and room design)

For an evaluation of the renovation process and on more general issues concerning involvement and attitudes toward energy behaviour the following aspects was covered:

- Retrofit design and process (participation and information during retrofit, value of retrofit)
- Collaboration and participation (involvement in decision regarding house/apartment)
- Energy behaviour (awareness and interest in energy behaviour and willingness to change)

The questionnaire consisted of both open questions, where the tenant could write their own answers and check-box questions.

Table 4: Framework for evaluation of added values

Framework for evaluating social impacts	
Aspect	**Indicator**
Well-being and health	- Access to natural light - Noise protection (from within building) - Noise protection (from outside building) - Summer temperature - Winter temperature - Exterior wall indoor surface temperature - Draught from windows - Air quality (particles of dust and dirt) - Air quality (smell) - Indoor moisture/humidity - Kitchen equipment standard - Bathroom equipment standard - Overall indoor comfort
Experience of the built environment	- Quality of life is high in my apartment/house - Quality of life is high in my building - Quality of life is high in my neighbourhood - I´m happy with my apartment/house size - I´m happy with my building size - I feel safe in my apartment/house - I feel safe in my building - I feel safe in my neighbourhood - I feel proud of my apartment/house - I feel proud of my building - I feel proud of my neighbourhood - The status of my neighbourhood is high - Where I live is important for my identity - My apartment is important for my identity - I feel a strong connection to where I live now - I belong to the community in my neighbourhood
Architectural qualities	- Floor plan design in your apartment/house - Materials and surfaces - Windows - Light condition - Kitchen - Bathroom - Toilet - Living room - Bedroom

	- Floor plan design of your building - Balcony - Staircase - Elevator - Building roof - Building facade - Building entrance - Storage closet - Communal sauna - Laundry - Club room
Information, communication and value of retrofit	- Communication before retrofit - Information distributed about the retrofit - Participation from tenants in the design phase - The suggested design proposal - Work in the apartment during retrofit - Value of retrofit in relation to rent level - Overall impression of retrofit process - Overall impression of retrofit outcome (the design) - Information to correctly use heating and ventilation system
Energy behaviour	- Is your energy use an important aspect for you? - Are you aware of your energy use? - Are you interested in reducing your energy use? - Would it be possible for you to reduce your energy use? - Has the retrofit made you more aware of your personal energy use?

Many of the aspects covered by the end-user evaluation are analysed and discussed in the E2ReBuild Deliverable D3.3 Evaluation of Case Studies and Demonstrations with the focus of Added Values. In this report, tenants' energy behaviour is evaluated for the E2ReBuild demonstrations.

4.1 The E2ReBuild Questionnaire

The basis of the analysis was a tenant questionnaire that was distributed to all demos, except London which was still under renovation at the time of having to finalise the evaluation and the deliverable.

4.1.1 Means of Distribution at each Demo

Table 5: Summary, means of distribution and answering rate tenant questionnaires

	Means of distribution and answering rate, tenant questionnaire
Augsburg	Printed questionnaires were sent out to all demo households, 10 months after finished renovation. 23 out of 60 households answered the questionnaire. The questionnaire consisted of both before and after evaluation. The questionnaire was distributed and collected during February-March 2014.
Halmstad	Printed questionnaires were sent out to all demo households 12 months after finished renovation. 28 out of 71 households answered the questionnaire. The questionnaire consisted of both before and after evaluation. The questionnaire was distributed and collected during November-December 2013.
Munich	Printed questionnaires were sent out to all demo households, 10 months after finished renovation. 18 out of 46 households answered the questionnaire. The questionnaire only evaluated the after perspective, given that the demo was evicted prior to the renovation. The questionnaire was distributed and collected during February-March 2014.
Oulu	The demo consists of 8 apartments in a two-storey student accommodation building. Before renovation 3 phone interviews and 2 personal interviews were conducted in July 2012. The after perspective was gathered through an electronic questionnaire distributed by email to 4 households in March 2014. These were the only households resident in November 2013 - March 2014.

Roosendaal	Interviews based on the questionnaire were conducted by personal visits at 7 out of 70 demo households, in March 2014. The interviews consisted of both before and after evaluation.
Voiron	Interviews based on the questionnaire were conducted by phone. A total of 10 phone interviews were conducted in February 2014. The interviews consisted of both before and after evaluation.
London	The London demo was still under renovation, May 2014, when the deliverable went into review, why this demo is excluded from the evaluation.

4.1.2 Interpretation and Validity of Data

Each of the indicators listed in Table 4 represents a question within the questionnaire. The tenant, when answering the questionnaire, was asked to evaluate each indicator and could also provide comments. In the below analysis each aspect is evaluated and summarised for all demonstrations.

Given the variety of respondents, from 4 in Oulu to 28 in Halmstad, a consequence of the variety of number of households in the different E2ReBuild demo projects, the below presented statistics should be interpreted with great care. The validity of the results can be questioned by the variety in answering rate and the different means of collecting the data. The questionnaire in Halmstad, Augsburg, and Munich and partly in Oulu was done by a printed questionnaire giving the tenants more time to fill in and reflect on the answers. In Roosendaal, Voiron and partly in Oulu[15] the interviews was conducted by phone or personal interview, giving the tenants less time to think about their answers and possibly they further feel less inclined to be critical. Although, the questionnaires gave insights that should not be neglected or underestimated, as they represents the experiences made by the people living at the centre of the renovations, forming their lives around it and suffering or benefitting from the changes the renovation undeniably causes.

The summary which ends each demo evaluation focuses on highlighting indicators where strong changes have occurred in comparison before and after. Motivation for these changes will also be made, with reference to comments from tenants.

For further reading regarding the demonstration projects; Deliverable 3.1 describes and evaluates adopted stakeholder collaboration models (also including the tenants involvement), Deliverable 4.2/3 describes adopted technical systems and Deliverables under work package 2 (D2.1-D2.7) gives a full description of each demo retrofit. Also, Deliverable 3.3 Evaluation of Case Studies and Demonstrations with the focus of Added Values and Deliverable 5.5 Guidelines to Operators, describes and analyse the indicators above not covered by this deliverable.

4.2 Experiences from the End-user Evaluation – Focus on Tenants' Energy Behaviour

For the assessment of the E2ReBuild demonstration tenants' attitudes toward energy behaviour, indicators on the awareness and interest in energy behaviour and willingness to change were evaluated.

4.2.1 Importance of Tenants' Energy Use

The first indicator evaluated the tenants' perception of their own energy use, and how important they feel this aspect is for them.

[15] the Before evaluation in Oulu was done by verbal interview (3 over telephone, 2 in person in the tenant's homes)

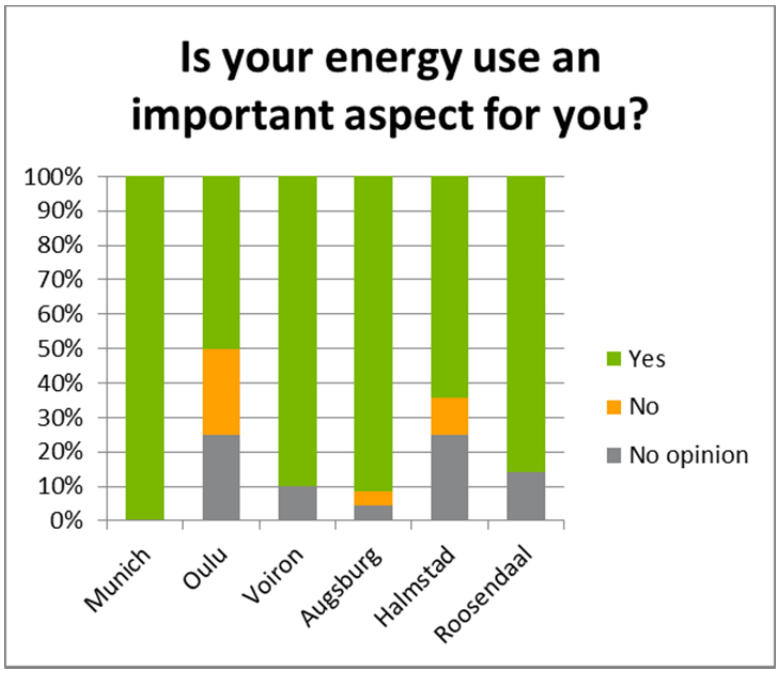

Figure 11: Tenants' view on the importance of their energy use

It is clear that a large majority of the tenants feel that this is of great importance. All demonstrations give this a high rating and with the exception of Oulu, Finland, and Halmstad, Sweden, more than 85% feel that this is personal importance.

4.2.2 Tenants' Awareness of Personal Energy Use

The tenants were also asked about their own energy use and awareness of this.

Here there are large variations between the demonstrations. In Munich, Oulu, Augsburg and Halmstad the tenants are well aware of how much energy they use while Voiron and Roosendaal show the opposite. Still, when asked whether they consider personal energy use important these demonstrations show a high interest in this regard. The discrepancy indicates a need for information and possibly better understanding of energy bills as elaborated on earlier in this report.

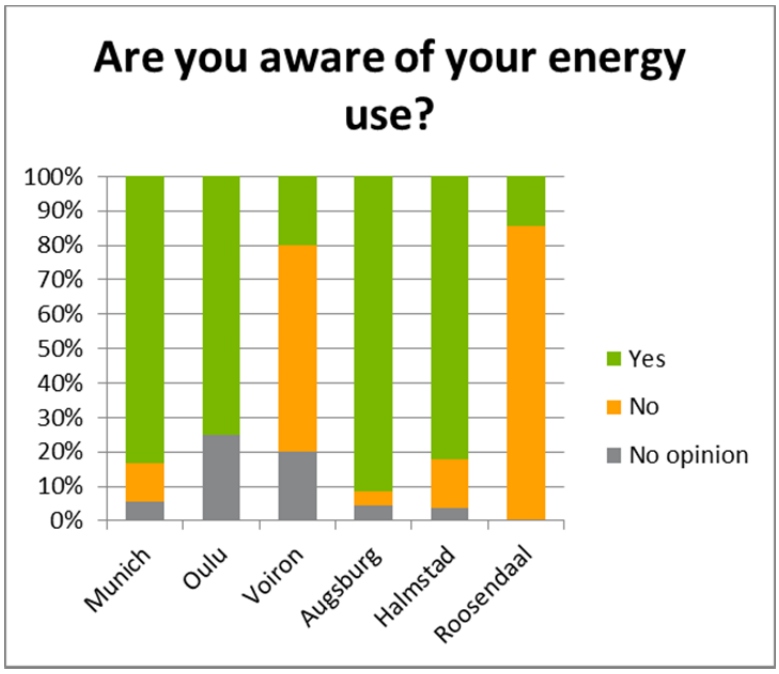

Figure 12: Tenants' view on the awareness of their energy use

4.2.3 Tenants' Interest in Reducing Energy Use

Coupled to the tenants' awareness of their personal energy use, their interest in reducing their energy consumption was also evaluated.

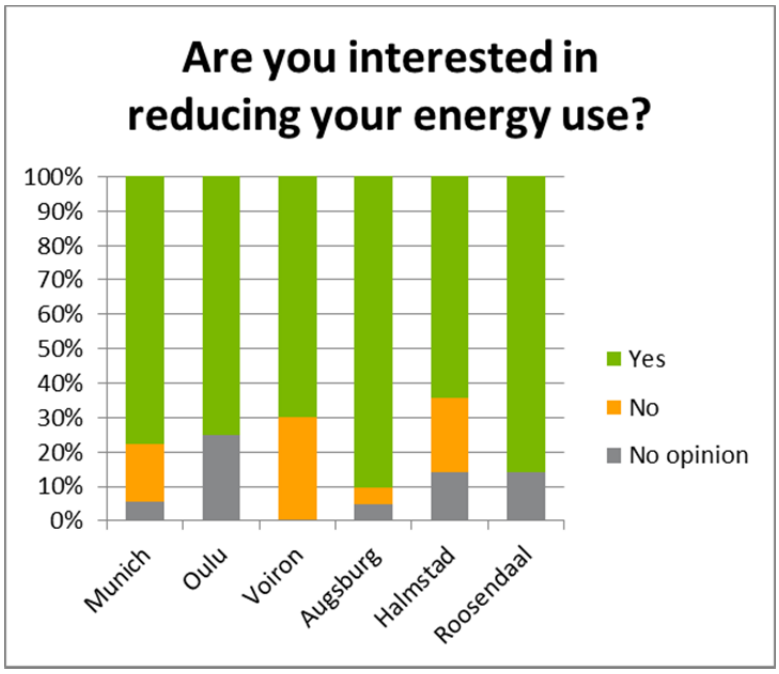

Figure 13: Tenants' view on the interest in reducing their energy use

All demonstrations show a large majority of tenants being interested in reducing their energy use, irrespective of the previous indicator evaluating their awareness of personal energy use.

4.2.4 Tenants' View on the Possibility to Reduce their Personal Energy Use

They were then asked whether they feel it would be possible to reduce their personal energy consumption. Here there was a mixed response and many did not feel this was possible of were unable to answer the question. This could be due to a lack of information on how to achieve this.

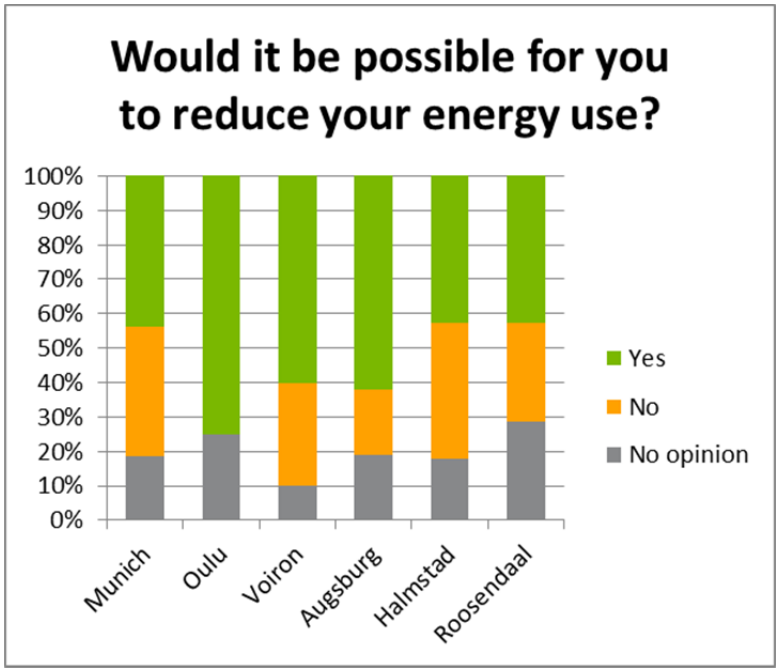

Figure 14: Tenants' view on their possibility to reduce energy use

4.2.5 Tenants' Interest in Receiving Information on How to Reduce Energy Use

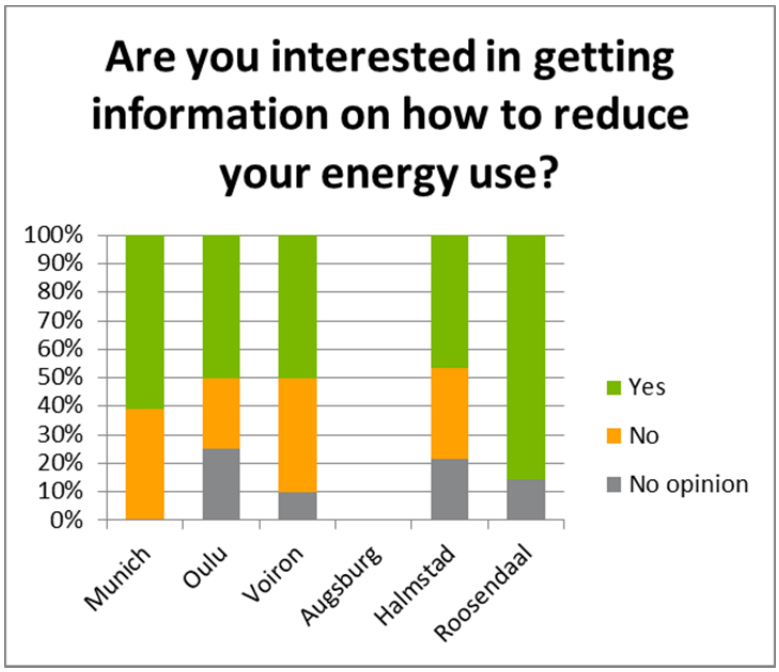

Figure 15: Tenants' interest in receiving information on how to reduce energy use

While a vast majority of tenants in Roosendaal was positive to receiving information, the tenants of the other demonstrations had a mixed response. Still, around 50% of the tenants were interested. The

tenants who were interested in receiving information were then asked how they would like to receive information.

4.2.6 Tenants' Preference in Method of Receiving Information

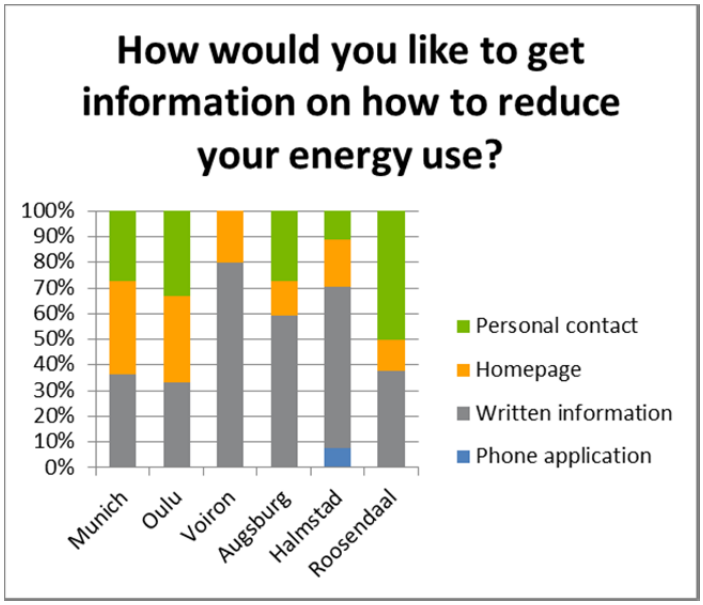

Figure 16: Tenants' preference in method of receiving information

Overall, written information was the preferred choice of receiving information on reduction of energy use, but there were large differences between the demonstrations. Munich and Oulu saw about one third preferring information over internet, while in Roosendaal about 50% preferred a personal contact by someone informing them. Interesting to see was also the small interest in smart phone applications, where only Halmstad expressed some interest. These differences are important to highlight and evaluate before starting an information campaign on reduction in energy use, and while the base of information from respondents in E2ReBuild may be too weak, regional and demographic differences are still of great importance.

4.2.7 Tenants' Awareness of Personal Energy Use Coupled to the Retrofit

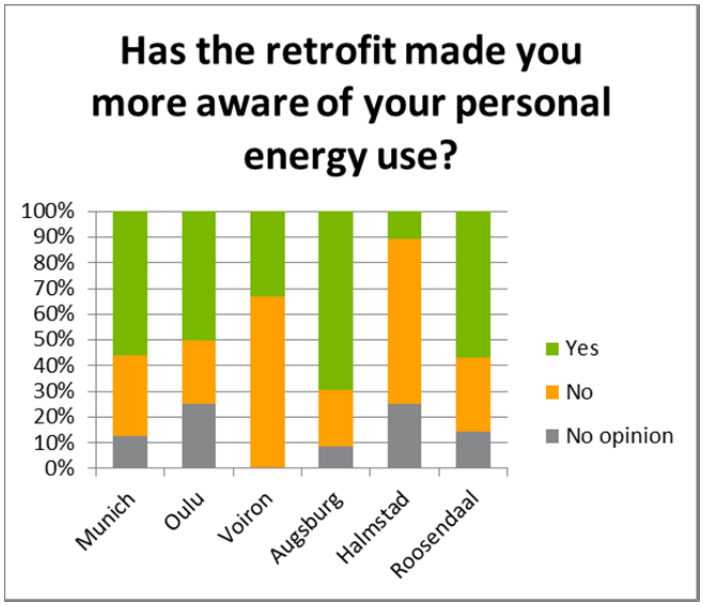

Figure 17: Tenants' awareness of personal energy use coupled to the retrofit

The tenants were also asked whether they felt the retrofit of their building had influenced and raised their awareness of their personal energy use. Interesting to note is that the responses differ from the previous indicator on awareness of personal energy use. In Halmstad most tenants were already well aware of their personal energy use and didn't feel that the retrofit had influenced their awareness. In Roosendaal and Augsburg however, a majority of tenants feel that the retrofit of their buildings has made them more aware of personal energy use.

4.2.8 Tenants' Use of Electrical Equipment

The last indicators of the questionnaire dealt with the tenants' use of electrical equipment, standby functions, low-energy equipment, and considerations when purchasing new electronic equipment.

While most tenants in all demonstrations used low-energy equipment such as lighting in their apartments, many use standby functions on electrical equipment. With the exception of Oulu (which only had 4 respondents) a great majority of tenants consider energy performance and use when purchasing new electric equipment.

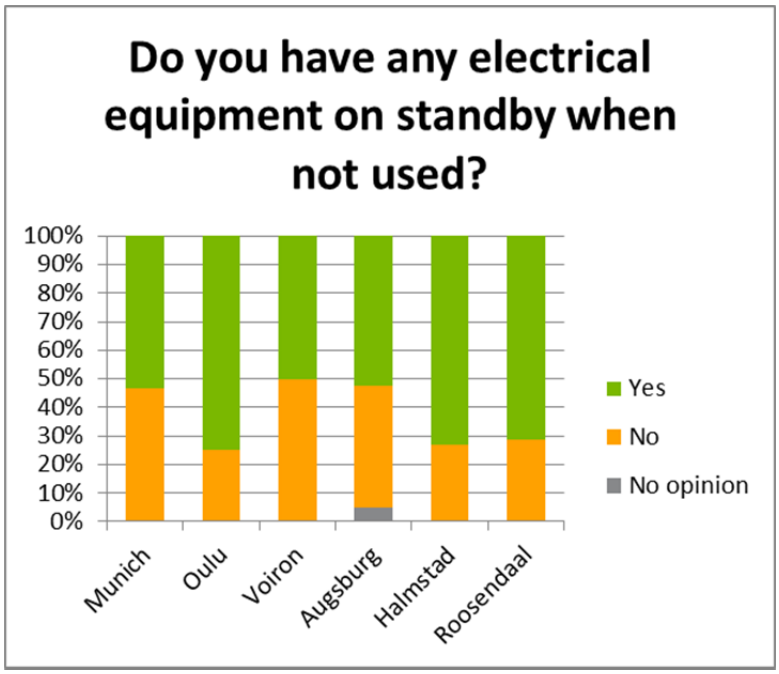

Figure 18: Use of electric equipment on standby

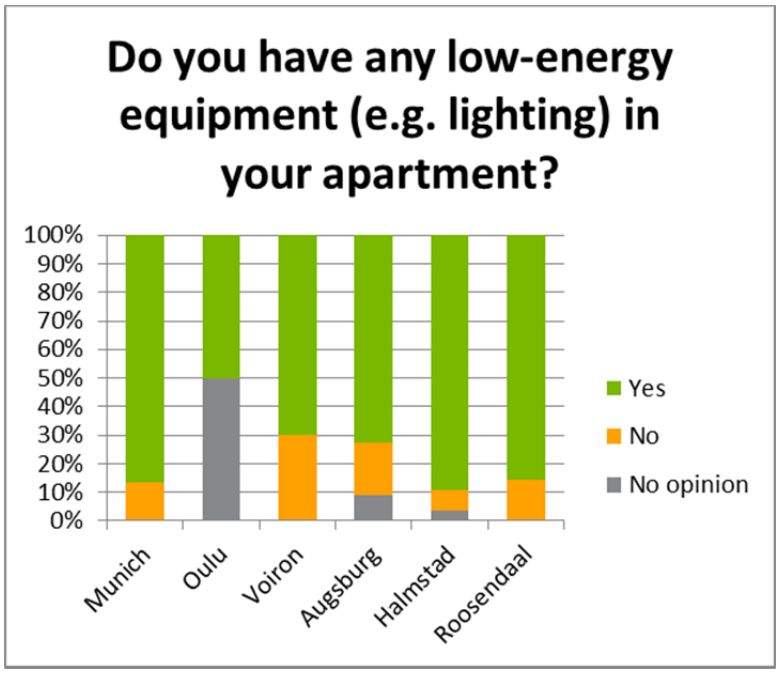

Figure 19: Use of low-energy equipment

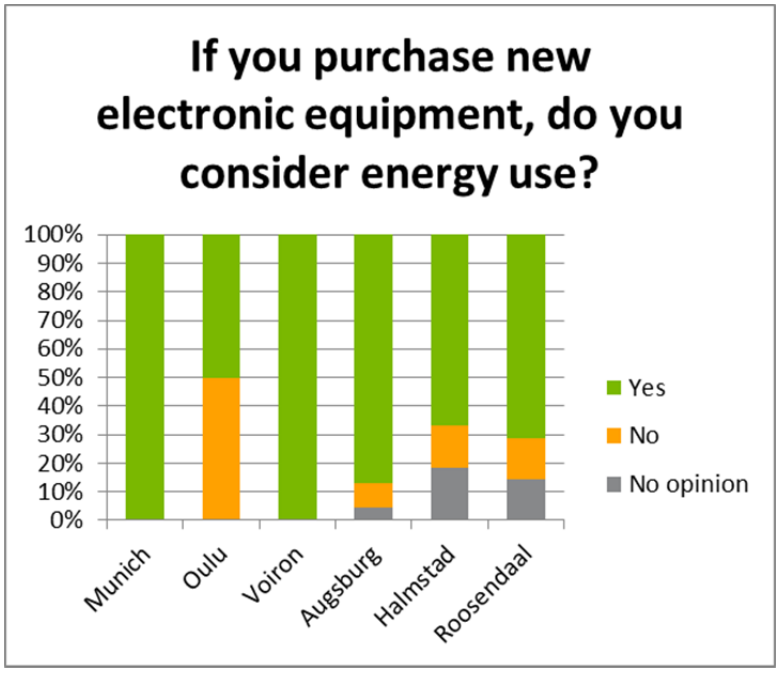

Figure 20: Considerations of energy performance and use when purchasing new electronic equipment

4.3 Summary and Conclusions of Experiences from the End-user Evaluation

Overall the tenants of the E2ReBuild demonstrations show an interest in energy use and have a high awareness of their personal energy use. Most of them use low-energy and consider energy performance when purchasing new electronic equipment. However, the indicators show a lack of information and knowledge on how to reduce personal energy use and the need to address this.

Table 6: Summary evaluation – Augsburg

Summary of evaluation – Augsburg		
Aspect	**Positive social impacts**	**Identified conflicts**
Tenants' energy behaviour	*Strong awareness of energy use and motivation on how to reduce personal energy consumption* *Good correlation between retrofit process and increased energy awareness.*	*None.*

Table 7: Summary evaluation – Halmstad

Summary of evaluation – Halmstad		
Aspect	**Positive social impacts**	**Identified conflicts**
Tenants' energy behaviour	*Awareness of energy use and interest in reducing personal energy consumption.*	*Low correlation between retrofit process and energy awareness.*

Table 8: Summary evaluation – Munich

Summary of evaluation – Munich		
Aspect	**Positive social impacts**	**Identified conflicts**
Tenants' energy behaviour	*Very strong interest and awareness of personal energy use. Interested in learning how to reduce energy.*	*Low perception of possibility to reduce personal energy use.*

Table 9: Summary evaluation – Oulu

Summary of evaluation – Oulu		
Aspect	**Positive social impacts**	**Identified conflicts**
Tenants' energy behaviour	*Good awareness and interest in personal energy use.*	*Low consideration in energy use when purchasing new electronic equipment.*

Table 10: Summary evaluation – Roosendaal

Summary of evaluation – Roosendaal		
Aspect	**Positive social impacts**	**Identified conflicts**
Tenants' energy behaviour	*High interest in receiving information on how to reduce personal energy use. Good correlation between retrofit process and personal awareness of energy use.*	*Low perception of possibility to reduce personal energy use.*

Table 11: Summary evaluation – Voiron

Summary of evaluation – Voiron		
Aspect	**Positive social impacts**	**Identified conflicts**
Tenants' energy behaviour	*Strong interest in the importance of energy use and interested in reducing their own energy consumption. Considers energy performance of electric equipment very important when purchasing new equipment.*	*Low awareness of personal energy use. Low correlation between retrofit process and awareness of personal energy use.*

5 System for Handling of Tenants Complaints

Within E2ReBuild procedures for dealing with complaints from tenants concerning the indoor environment and/or energy use was established for the demonstrations. These procedures consider both technical and social aspects of the retrofit process and focus on the interaction between tenants, building owner and on-site contractors.

5.1 The Opac38 System for Handling of Tenants Complaints

Handling of complaints from tenants must be seen as an overall process during the all management of the refurbishment project, since it is a process mainly based on communication toward and participation of tenants during the project.

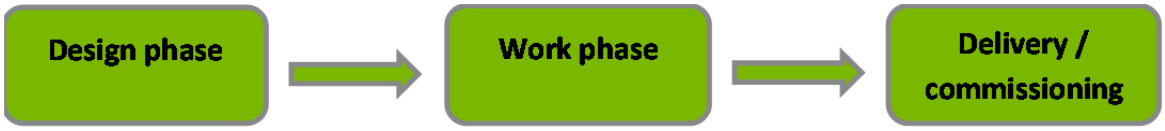

Figure 21: Handling of complaints is part of the process during all management of the refurbishment project.

OPAC38 is thus setting a key focus on transparency. It starts with the participation of tenants during the design phase of the project, Figure 22. Tenants are participating to the definition of the project objectives by using different means: questionnaires, meetings… This is a way to prevent future complaints by taking into account at this stage tenants expectations on the technical program and the rent increase and/or explain why some requests are difficult to meet.

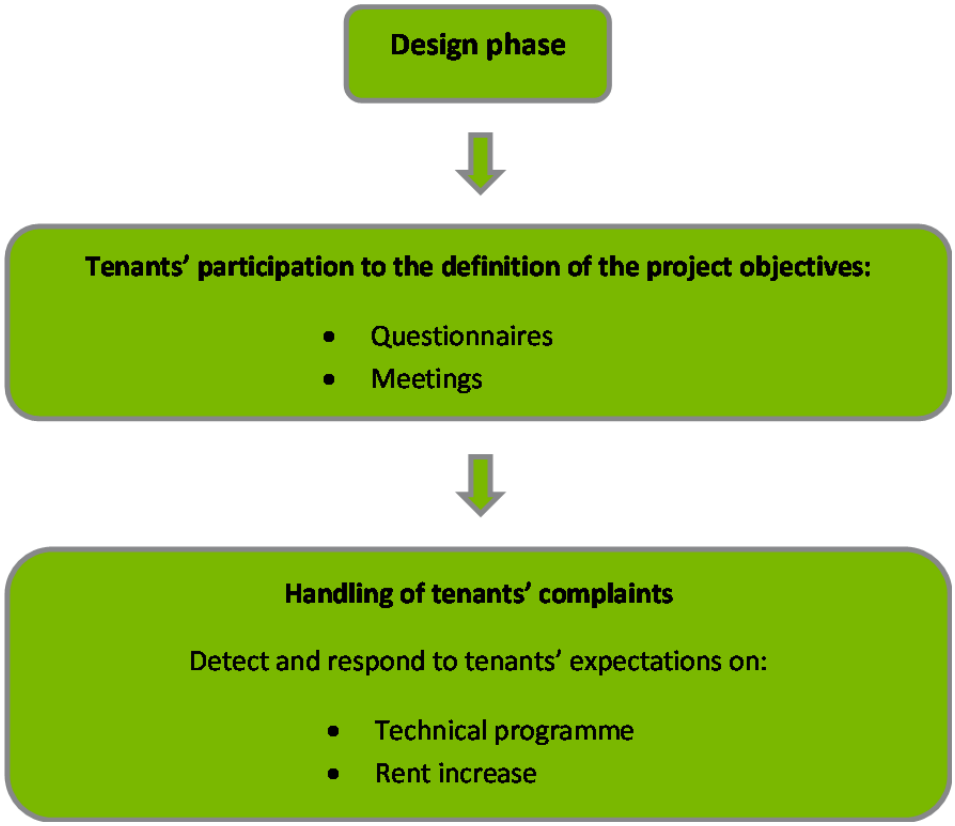

Figure 22 Tenants' expectations are considered during the design phase to prevent complaints.

During the work phase, tenants concerns are the task of the site manager, also in charge of supervising the entire work together with the architect, see Figure 23. At this stage, tenants usually only interact with workers, and contact the site manager when they have to complain. In order to prevent this usual functioning, often leading to already rather long and difficult discussions, OPAC38 experimented an

on-site “weekly-open desk”. It is an open tenants meeting with presence of the architect and site manager of OPAC38. Within these meetings tenants can receive responses to their questions and complaints by the site manager or the architect. It has been shown that those meetings are more or less a favoured contact point for residents to talk and exchange. Complaints can be treated at a very early stage and can often be answered directly by some other tenants. Furthermore, the “weekly open-desk”, which was held the day before the regular construction meeting, gave the opportunity to inform involved companies immediately in order to resolve complaints.

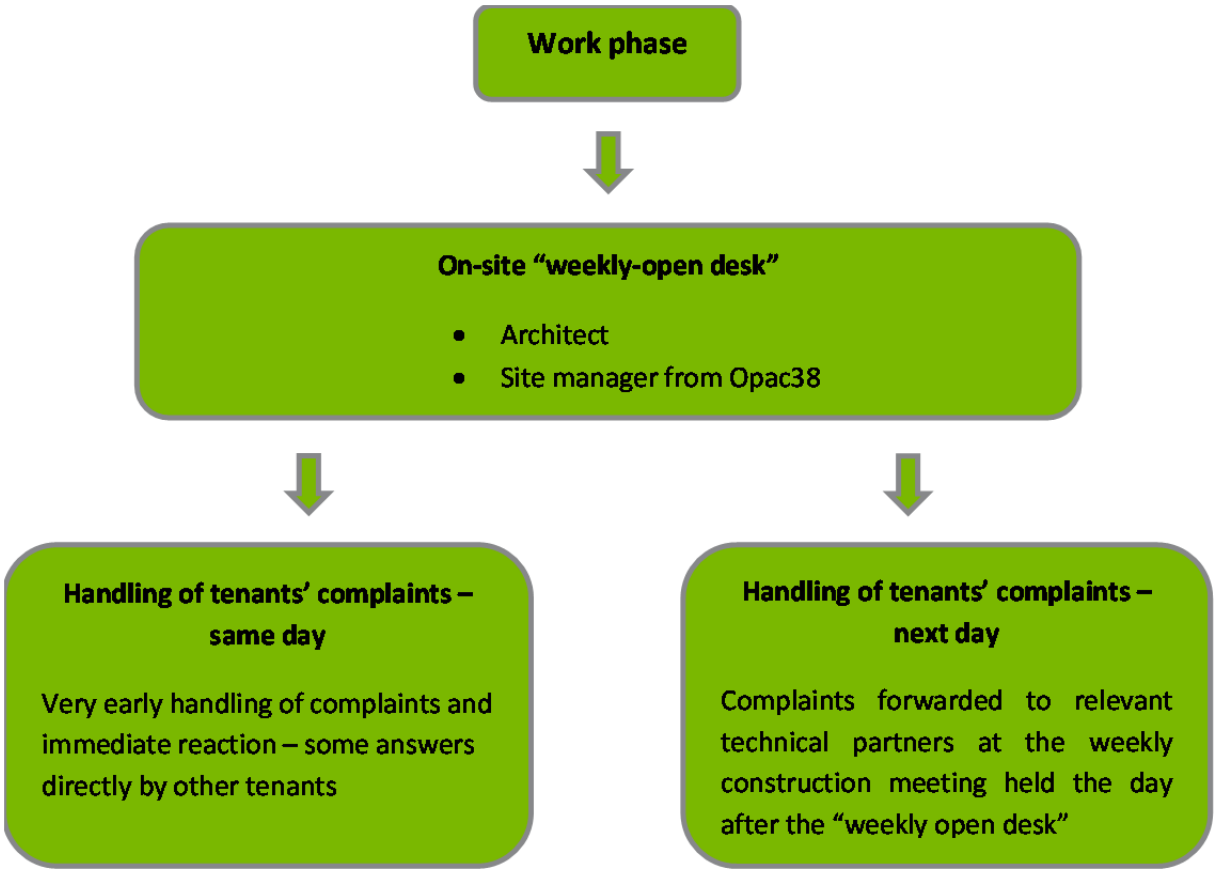

Figure 23: Handling of tenants’ complaints during work phase.

Finally, OPAC38 has created a “residence committee”. This is a meeting held with tenants, designers (architect and energy consultants), maintenance companies and OPAC38. It starts at the end of work and is meant to follow-up and to evaluate the benefits of the project, on both social and technical aspects, also to remind all stakeholders of their actual role for reaching initial goals. The “residence committee” offers the opportunity for tenants to point out possible malfunctions. Their remarks can be better understood by other tenants, which are now confronted with different perceptions (example: cold is a feeling that will be perceived differently from one to another). Once again problems can be solved before getting too annoying for tenants, and explanations can be given to all present tenants. The meetings are usually held on a biannual basis, depending on the actual needs of the project. Of course, beside these committees, tenants still can directly contact their local agencies at any moment. A positive side effect of the “residence committee” is a better communication within OPAC38 between different departments.

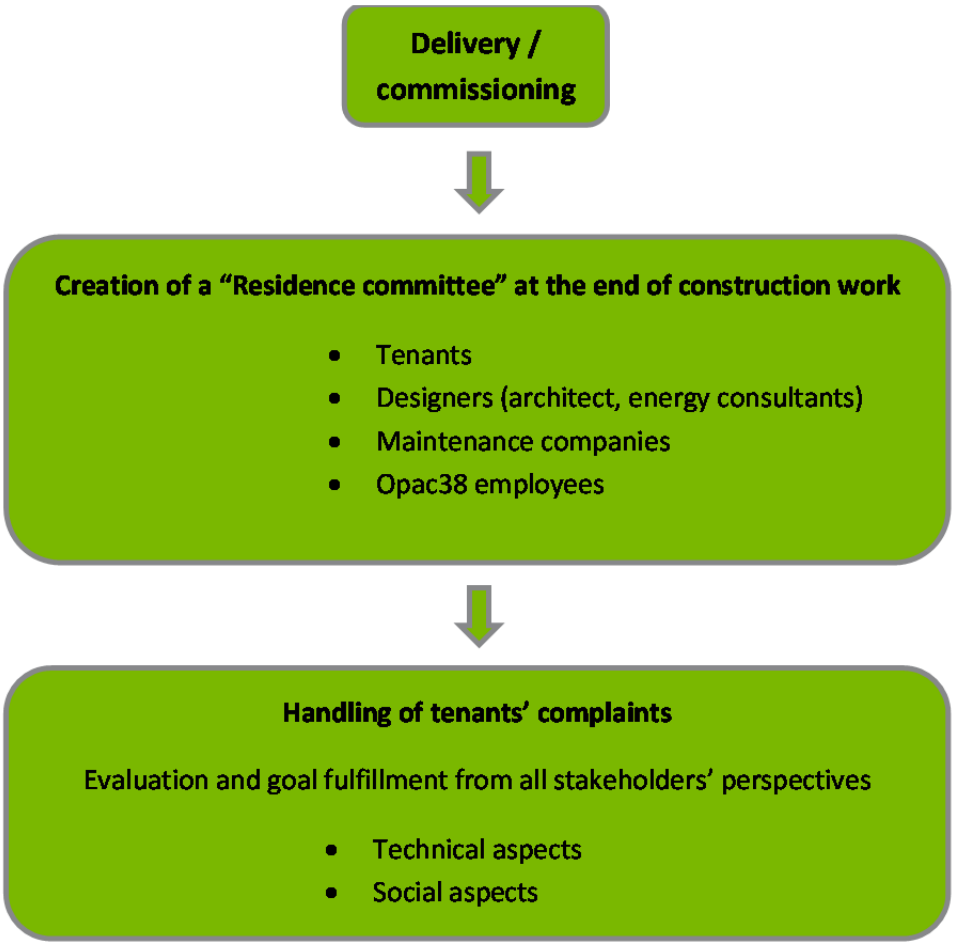

Figure 24: Handling of tenants complaints after the refurbishment project.

Of course, tenants can still use the usual channel, i.e. contacting OPAC38 either by phone, or going to the local agency, or sending a (e-)mail.

Within the other E2ReBuild demonstration projects other systems for handling of tenants' complaints have been used. These are schematically described in E2ReBuild deliverables D3.1 "Evaluation of collaboration models" and D3.3 "Evaluation of case studies and demonstrations with focus on added values".