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Energy efficiency of the Dutch housing stock

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1 Introduction

In a comparative study including eight European countries, Itard and Meijer (2008) found that the residential sector is responsible for 30 per cent of the total energy consumption. The energy saving potential of the building stock is large and is considered to be the most cost efficient sector to contribute to the CO2 reduction ambitions. However, as long as the price of renewable energy is still not competitive with fossil energy, the energy saving goals can only be reached when supported by severe governmental policies. The Dutch government aims to improve energy efficiency of Dutch dwellings by energy performance regulations for new dwellings and the issuing of Energy Performance Certificates for the existing housing stock. In 1995 energy performance regulations were introduced in the Dutch national building regulations. It consists of a calculation method laid down in a national standard EPN (energy performance norm) and a limit value, the EPC (energy performance co-efficient). A lower co-efficient stands for a higher energy performing building i.e. lower energy use. Since the introduction the EPC was sharpened several times. It started at 1.5 in 1995 and since the 1st of January 2011 it is now on the level of 0.6. The EPC is a non-dimensional digit. All building characteristics and building services that affect the energy demand for space and hot water heating, ventilation and lighting are incorporated in the calculation of the energy index (EI), which is the basis for the EPC. A further explanation of the calculation method can be found in Majcen (2012).

In Europe the Energy Performance of Buildings Directive, in short EPBD (European Commission, 2002) is a driving force for all member states to develop and strengthen energy performance regulations for new buildings and energy performance certificates for the existing stock (Nieboer et al., 2012). The goals are to build net zero energy buildings in 2020 and to reach a neutral energy situation in the whole stock by 2050.

Various studies in the residential sector showed that the impact of the policies and regulations are often not as expected. Theoretical energy use that is calculated on base of the standards differs largely from the measured actual energy use. In section X.2 the findings of these studies will be summarized. In the next sections the approach and results of two research projects in the Netherlands will be presented. The first project (X.3) deals with the effectiveness of energy performance regulations for new dwellings. The second project (X.4) evaluates the relation between the indicated theoretical energy consumption according to the issued energy performance certificates compared to actual energy use in the Dutch housing stock.

Technical improvements alone are not sufficient. A Post-Occupancy Evaluation (POE) of six renovation projects in the Netherlands showed that the end users are mainly interested in improvement of indoor quality, re-division of the dwelling, expanding living space, a safer neighbourhood and increased value of the dwelling. By taking into account a “merger of interest” tenants will be less resistant to change and more satisfied with the results. Section 5 discusses the approach and findings of this POE. This chapter ends with some methodological reflections (6) an overall discussion and conclusions on how to improve energy efficiency of the housing market (7).

2 Comparison between actual and assumed energy consumption

In research conducted by Tigchelaar et al. (2011), a so-called heating factor was calculated (actual heat demand divided by theoretical demand). The average heat factor in a sample of 4700 representative dwellings was found to be below one, meaning that the theoretical consumption is overestimated. Cayre et al. (2011) studied actual and theoretical energy consumption in 923 French dwellings and reached similar conclusions – the French EPC model overestimates the theoretical energy consumption in the sample, representative for the French dwelling stock. A similar result was discovered by Hens (2010), observing actual consumption of two types of dwellings in Belgium (from 80s and 90s) – the consumption on average was only half of the calculated energy use.

On the other hand, in 12 multi-family thermally retrofitted buildings in Austria, Haas (2000) has found evidence of actual energy consumption significantly exceeding the expected energy consumption. Similar results were obtained by Branco (2004) in a multi-family complex in Switzerland and in a similar sample in France (Marchio, 1989). Based on these results, it seems that the theoretical energy consumption tends to be overestimated when looking at the average dwellings and less energy efficient dwellings and underestimated when observing new or retrofitted buildings. Usually this phenomenon can be partly explained by the so-called rebound effect (Berkhout, 2000). The idea is that more efficient technologies (e.g. in low energy dwellings) make energy services cheaper and thereby encourage to an increased consumption. A typical example of the rebound effect was found to be the type of temperature control (Guerra Santin, 2010) - dwellings with thermostats actually turned out to consume more energy than dwellings without thermostat.

Sorrell (2009) provides an overview of methods for calculating the rebound effect and a summary of available studies. He concludes accordingly, in OECD countries, that the mean value of the long-run direct rebound effect is likely to be less than 30%. This means that up to 30% of the efficiency gained through technical improvements of building and appliances are turned into increased consumption (higher comfort) following from direct change in user behaviour.

However, the size of the samples in these studies is relatively small, which sometimes leads to problems when assessing statistical significance of the results. Moreover, the representativeness of the sample is not addressed in the studies where the main goal is to investigate the sample and not the national dwelling stock. Therefore, even though there are some studies comparing the national theoretical energy consumption, which is the basis for the energy performance certificate, it is very hard to predict what the certificates means globally within a member state. Even in countries where databases do exist, there are only a few analyses of energy performance certificates available.

3 Energy use in newly built dwellings in the Netherlands

After more than 15 years of Energy performance regulations in the Netherlands, only few representative statistical studies were conducted to assess the effect of the regulation on the actual energy use. The samples were of limited size as well. In two of these samples, no statistical correlation was found between the EPC-level and actual energy use per dwelling or per square meter. In the analysis of the WoON (2009) survey, carried out on behalf of the Ministry for Housing, Planning and the Environment in 2006 and containing a sample of 5000 dwellings which is representative for the Dutch housing stock, no correlation was found between the different levels of the EPC and the actual energy use per dwelling and per square meter. Figure X.1 shows the data on yearly gas consumption in Dutch dwellings 2004-2005.

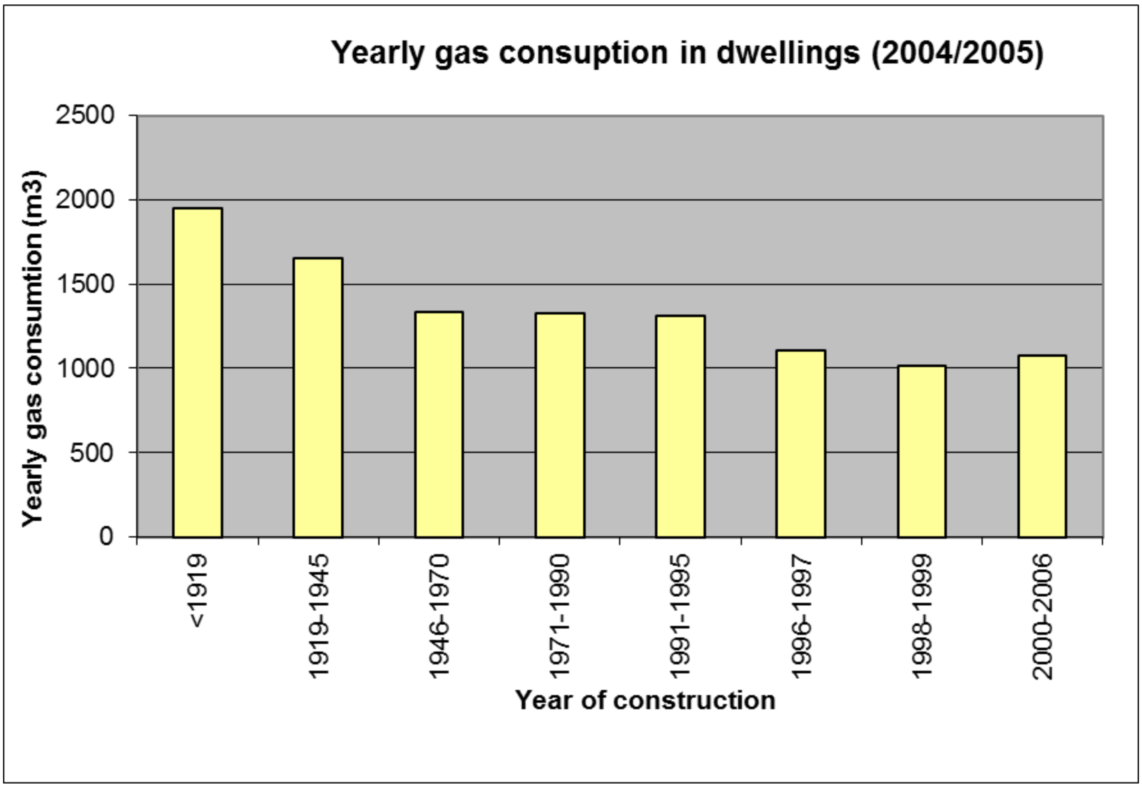

Figure X.1 Yearly gas consumption in m3 in Dutch dwellings (WoON 2009)

In recent research, Guerra Santin (2012) compared the actual and expected energy consumptions for 313 Dutch dwellings, built after 1996. The method included an analysis of the original EPC calculations that were submitted to the municipality as part of the building permit application, a detailed questionnaire and some day to day diary's. This combined methodologies generated very detailed and accurate data of the (intended) physical quality of the dwellings and installations, about the actual energy use (from the energy bills) and of the households and their behaviour. The dwellings were categorised according to their EPC value (see the introduction of this chapter).The EPC (NEN 5128) calculation method is roughly similar to the energy index calculation method, which is nowadays used as the basis for the energy label.

In energy inefficient buildings with a high EPC, actual heating energy consumption was almost twice lower than expected, whereas in buildings with a low EPC (energy efficient) both heating energy consumptions coincided much better. Due to the relatively small sample size the differences between the actual heating energy of buildings with different EPC values were insignificant, although the average consumption was consistently lower in buildings with lower EPC. We found that building characteristics (including heating and ventilation equipment) were responsible for 19 to 23% of the variation in energy used in the recent building stock. Household characteristics and occupant behaviour seem to be responsible for 3 to 15% of the total variance. Neither our study nor the studies found in the literature allow to state that building characteristics, household characteristics and occupant behaviour altogether are responsible for more than 38% of the variation on energy consumption of dwellings built after 1995. Therefore at least 62% of the variation in energy use is unexplained yet.

There are indications from literature that the explanation for this remaining part could be related to buildings being realized differently than written in official documents and to HVAC services running under very different conditions than assumed on paper. A report by Nieman (2007) showed that in a sample of 154 dwellings, 25% did not meet the EPC requirements: the EPC was incorrectly calculated. Nevertheless the building permit was issued. In 50% of the dwellings, the realization was not in accordance with the data used to calculate the EPC. Gommans (2007) monitored for 17 years the energy performances of energy efficient buildings. 40% of solar boilers appeared to function poorly. Only 25% of the heat pumps reached the expected efficiency. This was essentially due to realization faults, lack of control and lack of continuous monitoring. Another study by Elkhuizen e.a. (2006) in office buildings showed that up to 28% energy could be saved by better monitoring.

Taking into account the fact that tightening the EPC did not lead to less energy use for heating and that 62% of the variation in energy use is still unexplained, it seems legitimate to be careful about a further tightening of the EPC and to search if there are more efficient means to really decrease the energy consumption of newly built dwellings. This could be done by ensuring a correct realization and monitoring of the calculated performances, putting attention on the knowledge needed by contractors and on an effective building control process.

4 Energy use in the existing Dutch housing stock

Although new buildings make it easier to apply energy saving measured, the largest energy saving potential is in the existing building stock, because new dwellings annually add less than 1 per cent to the existing stock. Furthermore the Dutch housing sector shifted its focus from new construction towards the existing stock, because the market for new houses was seriously affected by the current economic situation. Energy efficiency in the existing housing stock became a big issue in a short time amongst building specialists (Van Hal et al., 2011). National and local governments have formulated ambitions, programmes policies and instruments to stimulate the improvement of the energy performance of the existing stock. The most important policy tool required by the EPBD in the European member states is the issuing of Energy Performance Certificates. All member states have to produce an energy label for a building at the moment it is sold or re-rented. This is not yet current practice everywhere, mostly due to lacking enforcement. In the Netherlands however, the whole social housing stock, owned by housing associations is labelled. The label indicates the energy demand for heating and cooling. It is a communicative instrument and there are no obligations to improve buildings as a consequence of a low label, but the labels are used as a basis for recommendations of improvement. Subsidy schemes are more and more related or combined with the labels. There are some signs that a better label affects the price of houses.

The present label data base covers a large share of the housing stock in the Netherlands. They form a basis to monitor the progress of the renovation practices. Besides this it is also useful to study the effect of improving energy labels on the reduction of the actual energy use.
The progress of renovations and energy upgrading measures stays far behind expectations and formulated ambitions in 2008 when most of the policies, covenants and improvement programmes were set up. The social sector in the Netherlands is still relatively large (35%), well organised and relatively ridge. A few years ago the sector formulated ambitious programmes, but these are nowadays scaled down because of several reasons. The economic

crises reduced the financial position of the housing associations. The housing market also dramatically slowed down which also affected the funding for renovations because this largely depends on the sales of property. Also it proved to be difficult to get approval of tenants for renovations that require an increase of the rents (70% of the tenants have to agree). It is hard to assure the saving of energy costs resulting of the improvement of the dwellings.

The actual energy use is largely influenced by the use and behaviour of the tenants. Some preliminary figures demonstrate the difficulty in 'forcing' reduced energy use by improvements of dwellings. The dwellings with the worst energy label (G) in practise use far less energy as expected, while the most advanced dwellings (A) use much more, probably due to a combination of the rebound effect and an increase in comfort level of the dwellings. Figure X.2 shows the actual and theoretical gas consumption per dwelling per energy label.

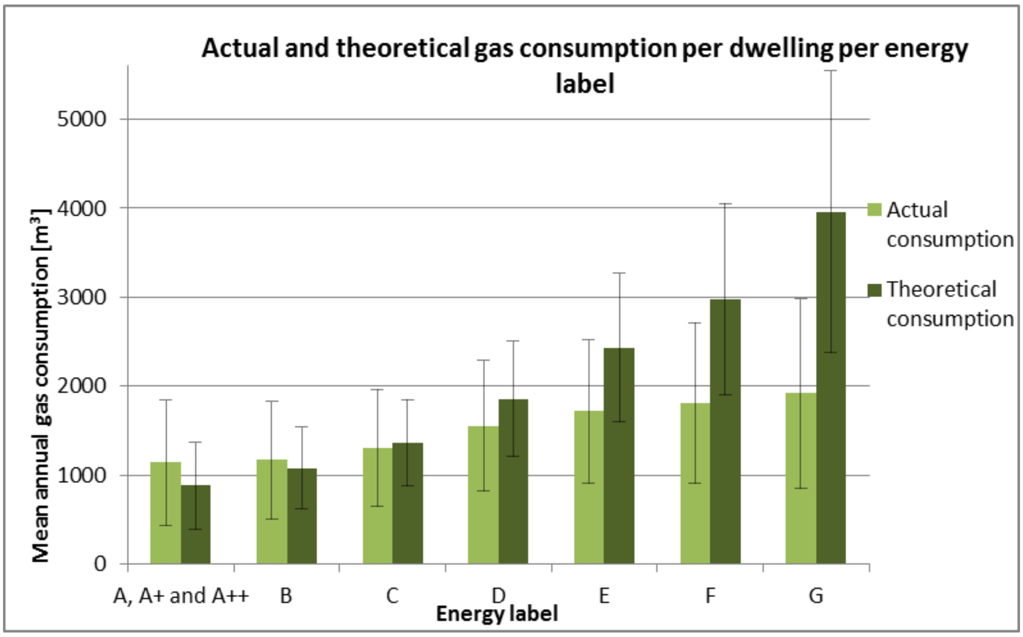

Figure X.2 Actual and theoretical gas consumption in Dutch dwellings (Majcen et al., 2012)

In the home owner sector the issuing of energy labels stays yet far behind. Although they were mandatory, until now there has not been an enforcement system. From 2013 on a label will be required for each property transaction and this will be checked by the notary in the Netherlands. Energy labels will become common practice and affect the sales price. Still there are no obligations foreseen to make improvements and higher labels mandatory. It is hard to require investments and property rights are probably an obstruction. Still there are some ideas for taxation measures. Bad labels could be punished with higher transaction taxes or higher property taxes than good labels. Such measures were suggested by the Platform for Energy Transition in the Build Environment. It is not likely that these measures will be adopted by the government on a short term however. But if the saving potential of the existing stock is taken seriously it seems that firm policies and regulations will be needed.

5 Merger of interest

A major task in the Netherlands is in maintaining and improving homes from the sixties and seventies. These houses, which are a third of the entire housing stock in the Netherlands (VROM, 2009), have a high need for renovation in both technical and energetic sense (Andeweg, 2009). In addition, these houses which often have a high energy need and therefore a high energy bill are occupied mostly by families that have the least amount of money to spend (Savanović et al., 2012). Tenants often resist high level renovations of their dwelling by housing associations and also home-owners do not want to invest substantially in large home improvements regarding energy efficiency (Van der Werf, 2011). In order to understand this resistance and to explore ways to cope with it, Post-Occupancy Evaluations have been conducted on the attitudes of residents regarding an energy efficient transformation of their dwelling. This study aims to creating an optimal match between energy efficient actions regarding dwellings from the sixties and seventies and the interests of residents involved. The assumption was that aimed technical solutions alone might not be appropriate and had to be adapted to better suit the interests of residents.

The study is based on the 'merger of interest' approach that has been developed by the Center for Sustainability (CfS) of Nyenrode Business University (Van Hal, 2009). To be able to apply sustainable measures the merger of interest approach takes into account both the interests of people, environmental aspects and economic interests. This connects to the well-known triple-P of People-Planet-Profit (Elkington, 1997). One of the reasons to develop the merger of interest approach is the lack of enthusiasm amongst home-owners and tenants regarding investments in the energy efficiency of their homes. This negative attitude is often due to prejudices about additional costs and risks and fear of innovative measures. The CfS approach aims to discovering sources of existing enthusiasm and to relate this enthusiasm with sustainable measures. The approach is characterized by three steps: determining the interests of stakeholders, serving those interests in a way that also benefits people in other parts of the world and in the future, and developing a smart financial structure. The idea behind the first two steps is to create a demand for sustainable products and services. If there is a strong wish to acquire these products and services there will be much more willingness to find ways to finance them (Van Hal et al., 2012).

5.1 Research methods

By means of a Post-Occupancy Evaluation it is examined if prejudices also played a role in Dutch renovation projects and if the 'merger of interest' approach can stimulate enthusiasm. Literature on the factors that are important to residents with respect to a renovation of their house (Schillemans et al., 2006, Tiemeijer et al., 2009, Dijkstra and Brouwer, 2010, Boerbooms et al., 2010) showed that in general residents of dwellings are more interested in usability, the neighbourhood and the appearance than in technical characteristics of the dwelling. Interests of residents in a renovation are mainly focused on improving indoor quality, re-division of the dwelling, expanding living space, reducing living costs, a safer neighbourhood, better living environment, increase in value of the dwelling, and adjustment of the dwelling for elderly. This knowledge about interests of people is specified through post occupancy evaluation of six renovation projects in the Netherlands. Figure X.3 gives an impression of the six projects. Cases were selected on the following conditions of which at least four had to comply:

- year of construction 1960-1980
- large energy savings through renovation
- improvements to current housing needs
- residents did not need to move out during renovation
- intensive residents support/communication

Figure 3: Impression of the six renovation projects.

The cases involved individual interviews with residents, the contracting authority (in most cases the housing association) and other related professionals. The interview questions were derived from the general research questions and connected to the findings from the literature study. Two separate questionnaires have been developed, one for interviewing the professionals and one for interviewing the residents. For the interviews with professionals an extensive questionnaire was used with open questions to obtain actual information about the whole process, from the initiation to completion, which measures are taken, and which problems were encountered during the process. For the interviews with the residents a shorter and simpler questionnaire was used, so that the questions could be answered by all residents and the interview would not take much time. The residents' questionnaire consisted of a checklist with factors that play a role before and during the renovation process and open questions to ask their views on the proposed measures and implementation of the process.

In each project residents were contacted by ringing randomly at houses or to speak with people at street. For the interviews with the housing association it was previously decided to only conduct an interview with the project leader of the renovation project. However, in the implementation phase more variety came up, because the information was spread over more people. To get most complete information it would have been optimal to speak with all staff involved, but due to time restrictions and organizational impracticalities this was not possible. In one case the owners association was the contracting party. In this project the chairman of the owners association was interviewed. In addition, if possible at all and relevant we also spoke with the contractor or other involved professionals such as the architect, installation specialist and the independent consultant living quality.

5.2 Findings per project

In the Kroeven neighbourhood in Roosendaal row houses from the sixties have been renovated according to the ‘passive house’ principle. To this end, the exterior walls and the roof of the dwellings have been removed and replaced with prefabricated elements in one day. For the residents the renovation meant that they had to leave their dwelling for one day and had to cope with renovation work inside the dwelling for fifteen days. After the renovation the tenants showed to be satisfied with the end result, apart from complaints about the high temperature inside and lack of measurements to reduce the noise nuisance between the dwellings. When asked for what they found most important improvements to their home, the tenants did not spontaneously mention the extra insulation package, but rather artefacts related to the use and appearance such as deep window sills.

The Prinses Beatrixlaan complex in Voorburg consists of portico dwellings that are transformed into gallery apartments. This renovation caused much inconvenience for the residents as half the number of dwellings had to sacrifice one bedroom for a new entrance and got a new bedroom in another place in return. Most residents liked the final results, in particular that the building from the outside looks like new. The residents are dissatisfied about the bad workmanship in the dwelling that led to daily irritations. The accessibility of the complex is improved by adding elevators and galleries, but not all residents like these solutions mainly due to extended walking distances and noise nuisance resulting from the new side-stairs.

In the renovation of the row-houses in the centre of Biddinghuizen the housing association could hardly change the outside because some houses in the building blocks were privately owned. To attain energy reduction extra emphasis was put on trying out new installations. Most of the tenants liked these improvements. To prevent overheating of the dwellings constructional awnings have been placed. The tenants found these awnings ugly and ineffective. The dwellings for the elderly were enlarged on the first floor by using a dormer. Some of the residents found this unnecessary and “only more cleaning work”. The small row-houses would probably have preferred more of an enlargement, but that was not considered here.

The renovation of the Rembrandt gallery flat in Zwolle included a large investment in installations for energy generation. An energy campaign was set up by an independent energy expert to decrease the behaviour related energy consumption which resulted in enthusiastic and more conscious residents. Critical success factors were a clearly defined starting point with a residents’ party that led to a positive attitude, making communication with residents not too technical, and not underestimating residents and using their initiatives. This project shows that the largest inconvenience for residents in a gallery flat is the renovation of the concrete construction. The noise can be heard in the whole building block. The flat is situated close to a highway. The renovation lessened noise from traffic, but as a result the residents hear their neighbours now, what is found to be more annoying.

The Blue Print dwellings in Heerhugowaard show that delivering technical quality is extremely important. Ten years after these starter-dwellings were built it was already necessary to replace the façade due to moisture problems. Although most of these dwellings were owner occupied, it was not difficult to get everybody to agree with a renovation. Due to the major problems with the houses and very high estimated costs of renovation, the dwellings became unsalable in recent years. By maximizing prefabrication the building time and construction work in the home could be reduced with lower costs for relocation and refurbishment. The residents are very pleased that the problems with the houses have finally been resolved. The dwellings got a new look in order to get rid of their bad name. Although the residents are very satisfied with the renovation, many people displayed their homes for sale because they are outgrowing their homes and now, after the renovation, finally they can move to another house.

The renovation of the Koningsvrouwen van Landlust in Amsterdam could not be realized in an inhabited state. The residents were involved in the process as much as possible in order to combine their wishes with energy ambitions and to attain a merger of interest. Instead of floor heating ceiling heating was chosen, because many people have rugs on the floor. Among the multicultural population of this complex many residents have the habit of pulling off their shoes before they enter their home. Many other tenants are not amused by many shoes in the hallway. To solve this problem an integral solution was chosen. The gateway to the house was partly changed in an outdoor storage space for shoes and an area for the new heating installation. An additional advantage of this solution is that the noise of the installations is kept outside the house and the tenants do not have to be at home for maintenance of the installations. This project shows that technical objectives and the way the residents want to use the dwelling do not need to interfere but can reinforce each other. The residents appreciated the process of the project and their new dwelling very much.

6 Methodological reflections

Comparisons between actual energy consumption and estimated energy consumption according to calculations based on energy performance certificates showed that theoretically calculated energy use of dwellings usually overestimates the actual use of energy in older dwellings with a low energy performance and underestimates the actual use of energy in new high performing dwellings. Up to 30% of the expected efficiency gained through technical improvements of buildings and appliances showed to be turned into increased energy consumption due to a change in user behaviour, the so-called rebound effect. Both our own study and studies found in the literature showed that building characteristics, household characteristics and occupant behaviour altogether are responsible for no more than 38% of the variation on energy consumption of dwellings built after 1995. Therefore 62% of the variation in energy use is unexplained yet.

The interviews that were conducted as part of a Post-Occupancy Evaluation helped to trace which aspects the end users find most important when their dwellings are ready to be renovated. It turned out to be important to include interviews with different stakeholders and residents. Plan makers often try to think for users, but it appeared that their assumptions about the interests and mindset of the residents are not always entirely accurate. For the interviews, especially with residents, it is very important to carefully attune the questions to interviewees. It proved difficult to hold on the questionnaire. People like to tell their story first before they are willing to provide answers to specific questions. The evaluated projects were mainly part of the social housing sector, with a large percentage of multicultural residents. Sometimes this led to difficult communication so that questions had to be simplified. This might reduce the usefulness of the interviews. Finally, when conducting a Post-Occupancy Evaluation it is important to consider the best time to do so. Shortly after delivery residents seem to focus more on the process and what is still not good, while after a longer occupation time people seem to focus on the end result.

7 Discussion and conclusions

The necessity to drastically reduce fossil fuels seems without any doubts these days. The built environment offers a large potential of savings. Severe insulation and product innovations can reduce the energy demand for heating and cooling for a large part. The remaining energy demand can be delivered by renewables like sunlight and heat, district heating, heat pumps etc. The remaining electricity demand for appliance's can in the first place be reduced by further product innovation and then be provided by photo voltaic panels. Solutions are available. There are no reasons not to apply this in new buildings at a large scale on the short term. However, a successful transition requires quite much from the designers, engineers, installers and builders. They will have to use new techniques and improve the quality and accuracy of the work. Solutions have to be found that are robust. Solutions that are vulnerable for the application in practice and/or for the unpredictable use of the occupants should be avoided. Evaluations of the current practice show that there is still a large world to win. The building regulations should set demanding targets, but what is surely needed is a better quality control in the whole process. This control should be carried out by the building practitioners themselves. They are the experts! But this will only start working if it is demanded and supported by regulations for certification of people and processes.

Although the potential is higher, the existing stock will be harder to tackle. Experiences show that it is hard to increase the numbers of severe renovations. And even more that the savings in renovated dwellings stay behind expectations because of rebound effects. There are many barriers: renovations are expensive, occupants mostly do not want the trouble and sometimes aesthetics make a change of the facade unwanted or impossible. On the other hand a large share of the current existing stock will have a very long life span, just because the replacement grade by new dwellings will simply be too low to provide enough new dwellings. In this perspective, there will always be a large need for renovations to expand the life span and this provides possibilities to improve the energetic quality. The fear however is that this 'normal' process goes too slowly. Maybe there is still a need for further smart product innovations to develop solutions that have a high contribution to the reduction of energy demand, are cheap, easy to apply and don't cause trouble to the occupants. The fast decrease of the price of PV cells is promising. The markets need to be stimulated by regulations. It is especially hard to persuade homeowners to invest in energy saving measures. Besides that more insight has to be developed in the effect of behaviour on the actual energy use. Possibly the pricing of energy could contribute to more consciousness use.

From the post occupancy evaluation of six renovated projects it turned out that afterwards the residents mainly speak about the overall improved appearance of the dwellings or the complex as a whole. The improved energy efficiency and technical improvements were rarely reasons to opt for the renovation. The daily use and perception of the home and the neighbourhood were far more important. Comfort, social security, the appearance of the complex and the entire neighbourhood and directly foreseeable costs are most important for residents in discussing an intended renovation. Residents seem to be more positive about their 'new home' when they have the feeling that it has become something of them and gives them a "sense of ownership" or "a sense of belonging". To overcome resistance of tenants to renovation of their dwellings, policy makers should manage on a merger of interest by combining energy efficient measures with measures to improve residential quality of life.

This leads to the conclusion that decision makers should take care of the involvement of residents in renovation processes so that people get the opportunity to defend their own interests, and not only come up with the best technical solution for the property. To properly meet the needs of the residents, planners will have to explore how residents use their home. During the design process, the residents should have a major influence. To improve the acceptance of new measures, people should get the opportunity to see and experience the measures beforehand. It seems to be even more important *how* a renovation is being conducted than exactly *what* is done. If the interests of residents are taken as a starting point for a renovation and if the general aspirations and high energy ambition are connected to these interests, residents will more readily accept a renovation, accept more inconvenience, think about creative solutions, both technically, financially and socially, be prouder of and more careful with their homes and living environment, and – last but not least - show a larger willingness to pay.

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