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How to motivate owner occupants to take energy saving measures

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How to motivate owner occupants to take energy saving measures

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Preface

You are reading my master thesis report on the topic how to motivate owner occupants to take energy saving measures. This report is written to complete the Master program Innovation Sciences at the University of Technology in Eindhoven (TU/e). For the last ten months I have been an intern at Arcadis in 's Hertogenbosch. This has been a very interesting and educational period in which I have learned much about an engineering consultancy company, the challenges they have to face related to sustainability and of course about issues related to energy saving measures. Being an intern at Arcadis gave me the opportunity to experience the working environment of a large engineering consultancy firm. This period has been a great learning experience for me.

Writing this report was a lot of work and would never be possible without the excellent support of Wim Wenselaar and Nico Hendriks from the TU/e. Their feedback, knowledge, guidance and enthusiasm about the topic gave me motivation to continuously improve my thesis. I am really thankful for the time Wim and Nico made for me and for their effort and contribution to my research.

Furthermore I would like to thank the colleagues at Arcadis for their interest in the topic, their experience and their network to get in contact with several people to talk with about the topic of my thesis. I also would like to thank the people who I have interviewed during this research. Their input, view and information about the topic were very useful for writing this thesis.

Last but not least I would like to thank Linda, my parents, sister and friends for their interest, support and encouragement during this last stage of my study.

Eindhoven, June 14th 2011
Joost Jongejan

Executive summary

After the publication of the Brundtland report a couple of international arrangements were made to solve energy and climate problems. Also the Netherlands made national energy and climate policy goals. The Dutch government wants to obtain a CO_2 reduction of 20% in 2020 with respect to 1990 values. They also want that 14% of the total energy production in 2020 is produced with renewable energy sources. Furthermore a goals is to realize an annually energy saving rate of two percent since 2011. Several working programs are made to achieve those ambitious goals, but still a lot of work has to be done.

One of the sectors who get special attention is the built environment, because this sector is responsible for 30-40% of the energy consumption. This includes the indirect use via electricity. A reduction of this consumption in the built environment can have a significant effect in achieving the CO_2 and energy reduction goals set by the government. Within the built environment a distinction can be made between new buildings and existing ones. This report focuses on existing buildings because regulations are made to increase the energetic quality of new buildings and the existing building stock is both growing and ageing, thus becoming more important in trying to reduce the energy demand. Within the existing building stock the group of owner occupants is important to look at because, 1) it has a large share in the total stock, 2) this is increasing in the future and 3) there are problems with fragmented property. Thus the biggest challenge is to make the existing housing stock of owner occupants more energy efficient. The goal of this research is to identify barriers and give solutions that motivate owner occupants to take energy saving measures.

Firstly, the characteristics of the existing building stock are analyzed. This is done to determine which dwelling categories need the most attention, which energy saving measures are applicable and which opportunities for CO_2 reduction are available. A qualitative research is done by AgentschapNL where 5.000 dwellings, which serve as a reflection for the Dutch housing stock, are evaluated. It appeared that single family houses (detached, semi-detached and terraced houses) built before 1975 are for most owned by owner occupants and are in general of poor energetic quality. This is due to lack of regulation before 1975. After 1975 stricter regulations were made with respect to insulation. The energetic quality of those houses is improved over the years. Many dwellings have installed a high efficiency boiler or double glazing, however insulation is still lacking.

Secondly, the available measures that are applicable in single family houses are described as well as their efficiency. The most efficient measures are insulation measures, such as façade, floor and roof insulation. Those measures are in general profitable to take, however the profit is situation dependent. Insulation is not a very popular measure people are willing to take; this can be due to a bad image because of moisture problems that arose during the 80s. Installation of a high efficiency boiler or double glazing are popular measures to take. Measures that are, at this moment, not profitable yet, such as photovoltaic panels, are measures that people are willing to take. To increase the efficiency of a dwelling one must adopt an energy saving package because the whole unit functions only as well as the least effective component. Such a package costs on average 12.500 Euro whereas the annual savings are on average 1.100 Euros.

Thirdly, the factors that increase or decrease the motivation for some specific behavior are described. This will explain which factors are important in the decision process to adopt energy saving measures. Those predisposing factors can form the purpose for making the decision to start the desired behavior. The decision process starts with prior conditions, such as previous practice, awareness of a problem and norms of the social system. The experience with energy saving measures is low because it is a decision people make one or two times in a lifetime. It appears that people are aware of the importance to be careful with energy use. However the felt need to do something about it seems to be very low because many people think their house is of good energetic quality. Energy saving seems not to be an important social norm. People have a higher priority for contextual aspects, such as orientation of the dwelling and dwelling type, and emotional aspects, such as comfort and status, than for energy saving measures. It also seems that there is a lack of knowledge among owner occupants about energy saving measures. Another factor in the decision process is persuasion or attitude, which is influenced by five attributes. The most important attribute is relative advantage. The relative advantage of insulation becomes clear after the measure is installed, this causes uncertainty. The relative advantage is not known before. If one has a positive attitude about energy saving measures one has the intention to adopt energy saving measures. Several conclusions can be drawn from this section. The first is that the sense of urgency must be increased. Second is that the relative advantage must be made clear. Furthermore a 'model dwelling' can influence the attitude one has about energy saving measures. Fourth, the knowledge about energy saving measures must be increased. And finally unburden the owner occupant by helping searching suitable energy saving measures, because people have a low self-efficacy.

Fourthly, enabling factors that owner occupants can use to adopt energy saving measures are analyzed. Enabling factors are factors that facilitate the performance of an action. Thus if one has the intention to adopt energy saving measures one will search for available and accessible financial resources. Several researches have shown that the willingness to pay for energy saving measures is between two and four thousand Euro. Because the average investment costs for an energy saving measure are 12.500 Euro other resources are accessible. A subsidy granted by the government is a financial resource available however there is a limited amount of subsidy available. Therefore, most of the subsidies are exhausted in no time, which causes frustration among applicants. An interesting financial construction is a loan offered by SVn. This organization controls durability loans offered by municipalities. Owner occupants can lend money with a low interest rate to finance energy saving measures. A possible disadvantage of a loan can be that owner occupants are reluctant to lend money. Another disadvantage is that it is uncertain what the actual savings will be and therefore owner occupants think the monthly expenses are too high. A durability loan is also not in every municipality available. Mortgages can also offer options to finance energy saving measures. When one wants to finance energy saving measures with an Aegon mortgage a discount of 0.2 percent is offered on the mortgage interest rate. Those measures cause a reduction in monthly energy expenses as well as a reduction in mortgage expenses which is higher than the monthly investment costs. Some conclusions drawn from this section are that a lack of knowledge among owner occupants results in low popularity of financial resources. Furthermore, the investment costs are perceived higher because of resistance costs, those are lowest on natural moments.

Lastly, the factors that reinforce behavior are described. Several instruments can be effective to reinforce the motivation of owner occupants to take energy saving measures. The first instrument described is electronic or written feedback, this is proven to be an effective way to reduce energy consumption, however it is important that the right message is send. Experience of peers is also an important reinforcing factor. If someone in the neighborhood has adopted energy saving measures and is positive about the results others can be motivated. Those who already adopted measures can serve as ambassadors to share their experience. Also advice from experts is important; because energy saving measures can be complex and experience is low experts can give personal advice about the measures. Workshops about energy saving measures are proven to be effective in increasing knowledge and awareness, but do not change behavior. Combining workshops with personal advice seems to be effective because it gives owner occupants opportunities to act. Also stable policy of the government or municipality can reinforce behavior in favor of energy saving measures. Unstable policy causes uncertainty and frustration among the owner occupants but also among suppliers of energy saving measures or installations. The government can create certainty by setting a clear term for subsidies or policy. Setting clear deadlines increases the chance of success.

It can be concluded that there is no single silver bullet that will remove all the barriers and eventually can motivate owner occupants to take energy saving measures. It is essential that the three categories that influence the decision are evaluated to indicate what owner occupants find important. Those categories should be considered all at once and not just one. For example, do not focus only on financial aspects, because people make irrational decisions. Projects that are financially focused have low change of success. Furthermore it is important to start with evaluating the predisposing factors, because if the motivation to adopt energy saving measures is not present additional financial resources or subsidies will only work for those who already have the intention to adopt energy saving measures.

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1 Introduction

1.1 Background

In 1972 the Club of Rome made the world aware of the restrictions to growth in their report 'Limits to growth'. According to this report the world would run out of natural key resources within a century because of the economic development (Meadows 1972). Although there were some criticisms, the finite resource problem was put on top of the global political agenda.
This report was the beginning of several environmental initiatives to decrease the depletion of natural resources.

Another influential report was published in 1987 by the World Commission on Environment and Development (WCED) which was titled 'Our Common Future', also known as the Brundtland-report. This report mentions that environmental problems exist because there are no global agreements. In one part of the world people live in poverty and in another part people produce inefficiently and with high costs. According to this report there are no limits to growth if there is sustainable development. The definition of sustainable development in this report is:"*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED 1987).

These two publications concerning the environment have given an impulse to the social environment debate in the Netherlands (VROM 2001). After the publication of the Brundtland report a couple of international arrangements, such as the Kyoto Protocol, were made to solve environmental problems. In the Kyoto Protocol agreements were made to reduce the emission of greenhouse gasses (GHG) to 5.2 % below 1990 levels for the period 2008-2012. The percentage of reduction depends upon the economic strength of a country. For the Netherlands this means they have to reduce the greenhouse gas emissions with 6 percent in 2012. GHG are gasses that increase the temperature of the earth, and mainly consist of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorine compounds. Because carbon dioxide is, in amount, the prime contributor to the climate problem, the focus is mostly on the reduction of that gas (VROM 2010). The Netherlands aim at a CO_2 reduction of around 4 to 5 Mton per year in 2010 (Agentschapnl 2010).

In the 2010 coalition agreement of the first cabinet Rutte energy and climate policy goals are set for the Netherlands. The government wants to obtain a CO_2 reduction of 20% in 2020 with respect to 1990 values. They also want that 14% of the energy production in 2020 is produced with renewable energy sources. At this moment only 4% of the total energy production is produced with renewable energy sources. Furthermore a goal of the cabinet Rutte is to realize an energy savings rate of two percent per year since 2011 (Rutte 2010). In the previous 2007 coalition agreement of the cabinet Balkenende IV a goal of 30% GHG reduction and 20% renewable energy production was set. The Dutch government started a working group 'Schoon en Zuinig' in which the policy is set to fulfill those ambitious goals (Menkveld 2007). But at this moment the goals are less ambitious.

1.2 Problem definition

The Dutch Government recognizes the necessity to reduce the quantity of energy used and the amount of carbon dioxide emitted. In their working program 'Schoon en Zuinig' are the ambitions to reduce energy use and CO_2 emissions and the use of renewable energy described. One of the sectors who get special attention is the built environment. In this sector an ambitious goal of 6 to 11 Mton CO_2 reduction is set for 2020 (VROM 2007). To achieve this goal different actors, such as energy suppliers and 'Bouwend Nederland[1]', have signed the agreement 'Meer met Minder' in which they agreed to reduce energy consumption with 30% in 300.000 existing buildings per year, which results in an energy reduction of 100 PJ per year in 2020 (Minder 2008).

> "*I am convinced that the challenge is to bring the existing stock in order for the future*"
> Willem Krzeszewski, general director Staedion, during a conference on area development and the credit crisis, March 4th 2010, The Hague

There are several arguments why the built environment, and especially the existing building stock, is important to look at when discussing environmental issues. First of all, energy consumption in the built environment is approximately 40% of the total fossil energy consumption in Europe and 30% - 40% in the Netherlands (UNEP 2003) (Vreenegoor, Hensen and de Vries 2008). This includes the indirect use via electricity. A reduction of this consumption in the built environment can have a significant effect in achieving the CO_2 and energy reduction goals set by the government (Rooijers, Leguijt and Groot 2010).

A second reason why the built environment needs attention is because of specific environmental factors which can give some opportunities for this sector. There is the economic crisis which has had an impact on the housing market, especially the turnover rate stagnated. More private owners renovate their existing house instead of buying another house. Making houses more sustainable can distinguish them from the rest and make them more attractive to invest in (Brounen, Kok and Menne 2009). Another crisis is the energy crisis. The prices for energy are still increasing, among others, because of increasing demand. For example, the price of natural gas and electricity rose by respectively 48 and 73 percent in the last ten years (CBS 2010) (Wolters and Haufe 2009). And lastly there is the climate crisis which causes a growing awareness to undertake steps to solve environmental problems. By restructuring the built environment a solution is given to at least the energy and climate crisis and because of the financial crisis people are more willing to save money by taking energy saving measures. On the other hand, the financial crisis causes people, but also the government, to rethink their expenditures and this can have a negative effect on energy investments. According to the new coalition agreements of Rutte the Netherlands must become less dependent on other countries with respect to energy supply. The energy security must be enhanced and more attention will be paid to the earnings potential of energy. Generation of renewable energy must become competitive with conventional energy. To achieve this, the government will stimulate research on and application of

[1] Bouwend Nederland is a Dutch association for construction companies

new energy sources. Furthermore it promotes the cooperation between companies and research institutes (Rutte 2010). The challenge is to find a low-cost solution which reduces energy consumption and at the same time is attractive to invest in.

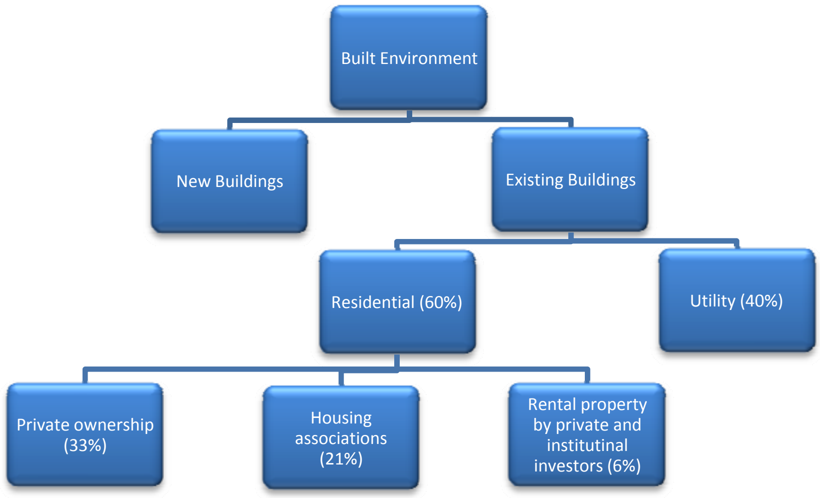

Figure 1.1: Structure of the built environment

Within the built environment a distinction can be made between new buildings and existing ones, as can be seen in Figure 1.1. For new buildings policy can be made to increase the energetic quality. For example, the Dutch government requires that new buildings have an energy performance coefficient (EPC)[2] of 0.6 in 2011 and there are plans to tighten it to 0.4 in 2015. The intention is to build energy neutral buildings in 2020 (Vreemann and ten Bolscher 2009) (Jensen, Wittchen and Thomsen 2009) (Agentschapnl 2010). This ambition is in line with the European Parliament's Industry Committee (ITRE) which declared that all "*newly constructed buildings, from 2019, must produce as much energy as they consume on-site*" (Ecee 2009). The percentage of new buildings compared to existing ones is very small (Rooijers, Leguijt and Groot 2010). Itard and Meijer estimate that the construction rate of new houses was approximately 2 percent of the total stock in 2003 (Itard and Meijer 2008). Up to 0.75% of the existing building stock was demolished. This means that the existing stock is both growing and ageing (I. Blom 2010). Existing houses are thus becoming more and more important in trying to reduce the energy demand.

[2] EPC is since 1995 an instrument of the Dutch climate policy. EPC is a dimensionless number representing the energetic performance of a building. New buildings must meet specific requirements with respect to energy efficiency. A low coefficient means a more energy efficient building than a high coefficient (Rijksoverheid 2010). The calculation method is described in the Dutch norm 'NEN 5128'. The energy use is divided by energy budget (this depends on functional use, usable area of the heated zones and transmission loss area (ten Have 2006). In 1996 the EPC requirement was 1,4, but over the years this was tightened to 1,2 (1998), 1,0 (2000), 0,8 (2006) and 0,6 (2011). In 2015 it will be 0,4, which is considered to be a passive house (Jensen, Wittchen and Thomsen 2009), and in 2020 new buildings are built energy neutral (Buiting and Krevel 2010).

Within the existing building stock a distinction can be made between residential and utility buildings, this is also visualized in Figure 1.1. In this report the focus will be on the residential stock. This stock consists of rental property, which can be owned by housing corporations or private owners, and private ownership (also referred to as owner occupant). At the end of 2009 the building stock was about 7,1 million of which 40% was rental property (CBS 2010). Almost 80% of that rental property was owned by housing corporations. It is expected that the percentage of private property will increase in the future because of the fact that housing corporations are selling houses to generate capital to invest in restructuring of their own property and because the government wants to promote private property with 'Wet eigen woningbezit' to discourage impoverishment (VROM-raad 2004) (Dankert 2003) (VROM 2000). Corporations are aware of their 'social duty' to enhance sustainability in the built environment. They have more capital to invest in a sustainable restructuring project than private owners and they have already made some agreements such as 'Meer met Minder' which is an energy savings plan for the built environment (Goorts 2010) (PeGo 2007). Thus the biggest challenge is to make the existing housing stock of private owners more energy efficient. An important problem with private owners is the large diversion of building types as well as the problem of fragmented property. Corporations are able to renovate their property at once. For example, the different apartments in an apartment complex fully owned by the corporation can be renovated at the same time whereas an apartment complex with fragmented property has to deal with different proponents and opponents for the renovation and also higher costs because corporations have 'economies of scale' (Wielders 2008). Therefore the focus of this report will be on the existing building stock and especially the group of owner occupants.

For existing buildings the main problem seems to be that the investment is that high that owner occupants ask themselves if they can earn the investment costs back. If the investment costs are reduced, for example with subsidies, the owner occupant can be more willing to pay for energy saving measures. The government seems the actor who is able to do this, but as mentioned in Wielders et. al. 2008, they are not capable of financing the required investments in the existing building sector (Wielders 2008). Thus it is essential to find a way to finance sustainable restructuring within the market with less financial help of the government. The report of Wielders et. al. also highlights the problem of payback time. It is possible that during the payback time the former owner sells his house. The investment costs are made by the first owner while the benefits are earned by the latter. A better selling price can compensate for this but it is unclear if an energy label can influence this price (Wielders 2008).

The above mentioned problems lead to the following problem definition: Although there is an urgency for sustainable buildings and the technical measures seems to be available, the diffusion of them does not take off. Thus, a large part of the potential for energy reduction in the existing residential building sector remains unused. Research has been done in the field of measures to take and willingness of owners to take energy saving measures, but all those actions do not seem to work. It seems to be that there exist several barriers.

1.3 Goal Definition

The goal of this research is to identify barriers and give solutions that have a high potential to enhance energy savings in existing residential buildings of owner occupants.

1.4 Research Question

The research goal leads to the following research question.

"*How can owner occupants be motivated to take energy saving measures?*"

To answer this research question the following sub questions are formulated:

- Which energy saving measures are available?
    - Which measures are most used?
    - Which measures are most effective, and what are the costs benefits?

- Why are owner occupants reluctant to take energy saving measures?
    - What are the motivations to take energy saving measures?
    - What are the barriers to take energy saving measures?
    - Under which conditions does an owner occupant take energy saving measures?

- What kinds of measures to motivate owner occupants are already used?
    - What are the advantages and disadvantages?

1.5 Relevance

This section will describe the scientific and social relevance of this research. The scientific context focuses on the importance and the social relevance on the necessity to research this topic.

1.5.1 Social relevance

The temperature increase, due to anthropogenic emissions, of the earth is a problem of concern (Cox, et al. 2000). In the Netherlands the temperature increased with almost 1 degree Celsius in the last century. The correlation with temperature and greenhouse gases (GHG) is also clear. For the Netherlands it is important to reduce the emissions of GHG, especially because the country is below water level (MNP 2005). The built environment accounts for 30% of the total fossil energy consumption. The use of fossil energy causes GHG emissions, thus by reducing the energy demand in the real estate sector the amount of GHG decreases (UNEP 2003).

Besides the environmental problems there is also a financial interest. Demand for energy increases while energy supply decreases. This causes, among other things, a price increase of fossil fuels. The price of natural gas in the Netherlands increased with almost 50% in ten years (EnergieNed 2010). This results in higher living expenses of inhabitants. It is even estimated that rental price equals energy expenses in 2020 if nothing happens (Borstlap and Donze 2010).

This research contributes to solutions of these problems, because it tries to find a way to enhance the energetic quality of the building stock. The government has granted subsidies to enhance the energy performance of buildings, but those subsidies are finite. The market should invest in energy savings on its own.

1.5.2 Scientific relevance

Research has been done on several topics related to energy savings in the built environment.

In a research of Opstelten et. al. the energy savings potential for the existing building stock is calculated from now to in 2050. They propose energy saving measures such as insulation and heat recovery, but also avoidance of standby losses of electrical appliances[3]. Special attention was given to the use of advanced control measures. They estimated that a 19% reduction of the total energy usage of the Dutch built environment can be achieved with advanced control systems. They also conclude that the energy saving potential only can be achieved by using sustainable energy systems (Opstelten, et al. 2007). What they do not take into account is the costs for purchasing sustainable energy systems and advanced control systems.

Another research tries to develop an organization method to realize energy neutral buildings. One of the findings was that with only 6 technical interventions almost every house could be built or renovated to energy neutral. Again, this research does not take the costs of those measures into account and it also does not pay attention to human behavior (Ravesloot 2005).

Galvin examined the economic efficiency of thermal upgrades of existing homes in Germany. He investigated several renovation projects, calculated the investment costs and measured the amount of energy saved. He concluded that "*there is an inverse power law relationship between the amount of money invested in thermal renovation and the amount of energy saved per euro*" (Galvin 2010).

Several researches are done with respect to the willingness to pay for energy efficient investments. One concluded that most of the house owners put their own financial and qualitative profit above environmental gain (Oel, et al. 2010). A finding of another report was that a long payback-time is a serious threshold for consumers to not invest in energy efficiency measures, especially renewable energy (Denktank 2009).

The researches mentioned above are all related with energy efficiency in the built environment. But all those researches investigate aspects separately that should be linked together. It is important to know the opportunities for reducing the energy consumption of the building stock. When the opportunities are known the costs and benefits should be mapped but also the potential barriers to adopt energy saving measures should be found. After this a set of possible solutions can be made. This report tries to identify barriers and give solutions that have a high potential to enhance energy savings in existing residential buildings of owner occupants.

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[3] Some electrical appliances such as routers, servers and telephones cannot turned off, so standby losses always occur.

1.6 Research method

In order to find answers to the above formulated research questions a research method and strategy is given. The first question is investigated using a desk research/ literature study. By using the existing literature a better insight is obtained in which energy saving measures are available. Interviews with experts can confirm the measures found in the literature, but also give answers to the question 'what measures are most used' and 'what are the costs and returns of those measures and which measures are most effective'. Those expert interviews will take place within Arcadis, the university and experts in the field. After the literature studies and expert interviews a 'measure library' is known. These results are important because the advantages and disadvantages of the energy saving measures are identified. If all is well, the expenses and measures for the different houses are known. Hopefully the experts can also give an answer to the question what owner occupants are willing to pay for energy saving measures. When the amount of money the owner occupant is willing to spend is clear the affordable measures can be identified.

After the different measures are known the question arises why owners are reluctant to take measures with respect to energy saving. Is this a pure financial barrier or are there other barriers as well? To answer this question a literature study is done to know the barriers which owner occupants face. By investigating some marketing and psychology literature the conditions under which owners are more willing to invest can be found. The interviews held before could also give some indications of why owners are reserved with respect to energy saving measures. Combining the 'measures library' with the barriers should show where the demands of the inhabitants and effective energy saving measures have similarities or contradictions.

Interviews with, among others, energy companies and financial institutions will be held to get insight in their willingness to invest in energy saving measures. Those interviews can also be used to know what kind of financial constructions they already use to motivate the owner occupant to take energy saving measures. These findings are supplemented with literature studies about the already existing motivation mechanisms. Energy companies and financial institutions can give feedback about the advantages and disadvantages of the existing solutions.

Combining the findings of the efficient measures with the findings of motivation mechanisms should give an interesting solution of how owner occupants can be motivated to take energy saving measures.

1.7 Thesis outline

In the next chapter a description is given of a theoretical framework used to structure this thesis. This description is focused on behavioral change and the factors influencing behavior. The focus is on behavioral change because much research focuses on techniques to deal with energy saving issues, but to take energy saving measures are behavioral change is required. In chapter three the existing building stock is described and the current energetic quality of the different dwellings is given. The goal of this chapter is to determine which energy saving measures are applicable and which dwellings have a high potential to energetic be improved. Chapter four will describe which energy saving measures are available and which are most effective. It will also describe the advantages and disadvantages of the measures as well as an estimation of the investment costs. After this chapter a part of the first sub question is answered. Thereafter, chapter five will explain what kind of barriers exists and what kind of measures to motivate owner occupants are available. It will also describe which factors are influencing behavior and decisions of owner occupants. The findings of chapter five will partially be verified using a survey which is described in chapter six. This chapter is also used to find which energy saving measures are most used and under which conditions owner occupants take energy saving measures. The research question will be answered in chapter seven were the insights of the previous chapters are combined as well as recommendations are given. The final chapter will discuss this report and will give recommendations for further research.

1.8 Arcadis

This report is written at Arcadis ‘s Hertogenbosch. Arcadis is an international knowledge-driven company who offers consultancy, design, engineering and management services in several disciplines. Clients from the private and public sector appeal on Arcadis for their broad program of multidisciplinary services.

This research is conducted at the division Environment and the advisory group area and site development. This group gives advice to municipalities, developers and housing associations to determining and shaping spatial strategy. Arcadis assists housing associations to make their building stock more sustainable. Also the private building stock is becoming a more important sector wherein Arcadis can operate.

2 Theoretical Framework

Energy conservation is becoming more and more important and is for many municipalities a policy goal. Many researches focus on techniques to deal with this energy related issue. However, to take energy saving measures a behavioral change is required. Owner occupants are reserved to take measures; they should change their behavior and need to be more willing to take measures. Choosing for energy saving measures is usually a conscious choice where the advantages and disadvantages be considered before making a decision. To realize change it is important to know which factors can influence the behavior which is intended. To analyze this change several behavioral models are developed. In this section the three most common models found in the literature that focuses on that conscious choice are discussed, these are the model of Fishbein & Ajzen (Fishbein and Ajzen 1975), the conceptual environment behavior model developed in the Netherlands by Sociaal Cultureel Planbureau (SCP) (Hoevenagel, et al. 1996) and the PRECEDE-PROCEED[4] model developed by Green and Kreuter (Green and Kreuter 1999). At the end of this section one behavioral model will be chosen to serve as a theoretical framework throughout this report.

2.1 Theory of Reasoned Action and Planned Behavior

The model of Fishbein and Ajzen is probably the most known behavioral change model. It clarifies how behavioral change among people is realized and can be predicted. Their theory of reasoned action explains that conscious reasoned behavior is mainly determined by the intention. Intention is influenced by two independent determinants: the attitude against that behavior and the subjective norm, the idea if others want them to perform that specific behavior. In a later model, theory of planned behavior, an additional factor is added: perceived control. This factor represents the power people expect to have over different tools to execute the behavior, e.g. time, skills. Behavior which is thought to be easy feasible has a higher perceived control than when it is thought that it is difficult to perform that behavior. When one has a higher perceived control the chance that one will perform that behavior is higher and the intention can also be more easily converted in that behavior, despite the barriers one will face (Fishbein and Ajzen 1975) (Goorden 2005). These two models are represented in Figure 2.1.

[4] Precede stands for Predisposing, Reinforcing, and Enabling Constructs in Educational/ Ecological Diagnosis and Evaluation. Proceed stands for Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development (Green and Kreuter 1999).

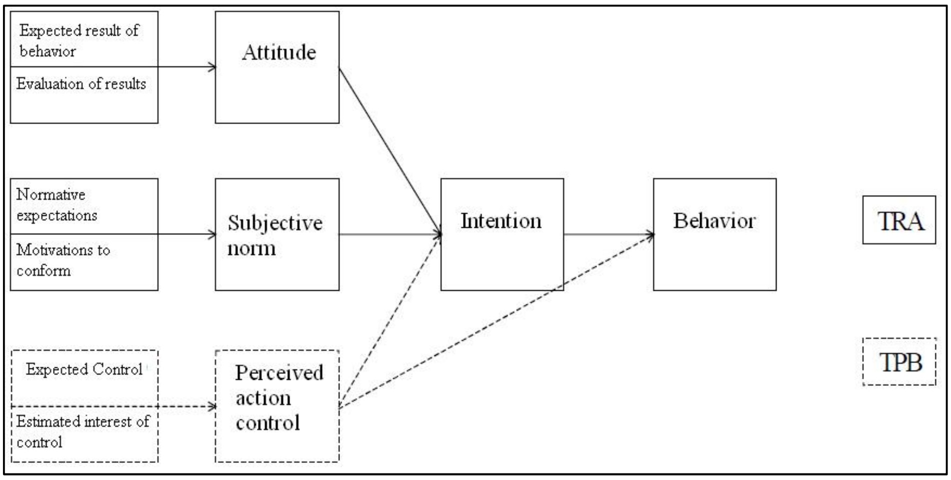

Figure 2.1: Basic construct of Theory of Reasoned Action and Theory of Planned Behavior (Goorden 2005)

An individual makes a trade-off between individual and collective benefits as a result of his behavior and the degree of how their behavior is appreciated in their social environment (Rooijers, et al. 2006). However, this model is not complete when applied to energy saving behavior. This model assumes that people make rational decisions by examining the costs and benefits and choose the option that maximizes their expected benefits. It also assumes that people systematically use the available information. Customers are not able to take rational decisions and to systematically process information (Rooijers, et al. 2006). The model does not pay attention to attitudes not directly related to that specific behavior. Some researchers have added a fourth factor to the model, personal norm. (Goorden 2005) (Görts and Jonkers 2000). Other factors such as personal knowledge and experience can influence attitude or subjective norms only indirectly. Another critique on this model is that situational restrictions are not taken into account; some people are not able to change their behavior because for example they do not have the financial capacity. Finally, there is no attention for habitual behavior (Goorden 2005).

2.2 Environment behavioral model (SCP)

The environment behavioral model is developed by the Dutch Sociaal Cultureel Planbureau and from their viewpoint people choose to adopt a different behavior when they want (motivation) and when they are able to change their behavior. The attitude a person has towards alternatives is an important part of the factor motivation. A third factor is the supply of behavior alternatives, for example when people have to choose between regular light bulbs and energy saving light bulbs they not always select the most efficient one, because price and lifetime are important as well. This model has similarities with the model of Fishbein and Ajzen, but the model of SCP adds the term personal norm. This personal norm refers to the belief that a person has about what is good or bad. Someone’s view about the environment can influence his behavioral choice (Rooijers, et al. 2006) (Goorden 2005).

There are however still some elements missing in this model. The model cannot explain which instruments are suited to change specific behavior. In most cases, program development uses an instrument oriented approach. This means that instruments are developed to influence behavior but the precise effect of the instrument on that behavior is unknown. It is not possible to explain if and why the instrument results in other behavior. To explain the effects of the instrument on behavior a chance oriented approach can be used (Egmond 2010). The model of Green and Kreuter is a model that uses a chance oriented approach.

2.3 PRECEDE-PROCEED model

The third model discussed is the model designed by Green and Kreuter. According to Green and Kreuter many variables influence behavior. In their study[5] they categorized the variables into three main variables, which are predisposing, reinforcing and enabling factors, as can be seen in Figure 2.2. This model includes all the aspects of the above mentioned models. It brings together the different factors that play a role in realizing behavioral change (Görts and Jonkers 2000). An advantage of this model is that it pays attention to internal effects as well as external effects (Egmond 2010) (Green and Kreuter 1999) (Görts and Jonkers 2000). This model approaches a problem in a different way by breaking the process into manageable pieces. This is an advantage because, the process of behavioral change is very complex and this can be tackled by cutting the problem into smaller understandable pieces. This model is based on "*the assumption that designing and planning an intervention strategy that stimulates behavioral change*" depends on the understanding of the determinants of that behavior and the knowledge about the methods that effectively influence those factors to stimulate such a behavioral change (Egmond 2006).

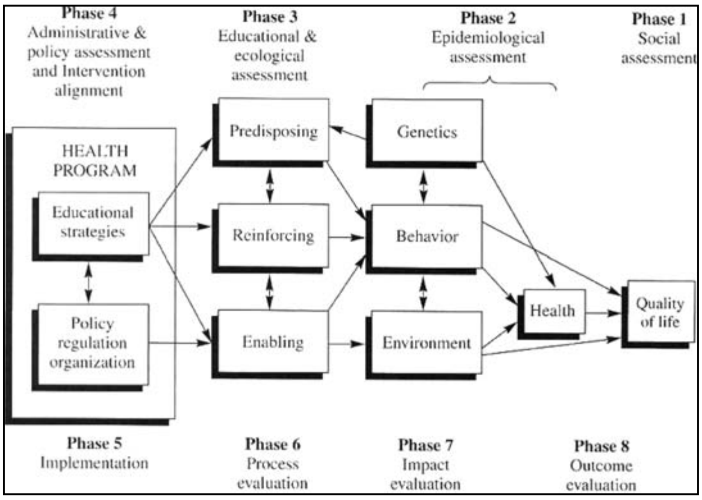

Figure 2.2: Precede-Proceed model of health program planning (Ashwell and Barclay 2009)

The Precede-Proceed model of Green and Kreuter "begins at the end". The reason to start at the end is twofold. First, people responsible for making policy programs "*had more or less predetermined what intervention strategy they were going to employ. Second, in some cases, there was no clear reason for choosing either the problem to be addressed or the target population to be reached*" (Green and Kreuter 1999). Beginning at the end forces the policy makers to first asking why before how. Thus,

[5] The model of Green and Kreuter has been applied in almost thousand published studies. "*The goals of the study are to explain health-related behaviors and environments, and to design and evaluate the interventions needed to influence both the behaviors and the living conditions that influence them and their consequences*" (Green 2011).

"*the determinants of…*the desired behavior…*must be diagnosed before the intervention is designed; if they are not, the intervention will be based on guesswork and will run a greater risk of being misdirected and ineffective"* (Green and Kreuter 1999).

The model starts with determining the desired effect. Phase two "*describes the environmental circumstances that may be constraining or conditioning behavior*" (Green and Kreuter 1999).

Phase three of their approach classifies factors that can influence behavior and explains what has to be changed to bring the result about. They have divided the factors into three categories: predisposing, reinforcing and enabling. Predisposing factors are factors that motivate behavior; these can form the purpose for making the decision to start the behavior. This process starts with the awareness of a problem or need. Most of the problems or needs are solved in a routine way. This is called 'habitual behavior'. However, when a problem does not regularly occur new information must be sought (Rogers 2003). With this information advantages and disadvantages of alternatives are evaluated. These are not only concerned with money but also with characteristics such as quality, uncertainty and comfort. Furthermore, aspects such as regulations influence the assessment. All these factors make up the attitude that a person has against an innovation or alternative. According to Rogers there are several conditions an alternative has to meet. These conditions also determine the attitude. The conditions are: relative advantage, compatibility, complexity, trial ability and observe ability (Rogers 2003). If this attitude is positive a person has an intention to start the behavior. Self-efficacy, the perceived capacity for successful organize and implement the behavior, will increase the ease of adoption. Reinforcing factors are factors that give positive or negative feedback. In case of positive feedback the behavior of a consumer is encouraged. Positive feedback can increase the intention to start behavior. The feedback can be given in several ways, among others, through communication or reactions of other customers, through financial rewards or through recognition and status. Enabling factors are factors that enable new behavior (Egmond 2006). When there is an intention to start the behavior, the possible adopter will search for available and accessible external resources. These resources can be technical, financial and organizational.

Phase four gives a mix of intervention policy instruments. According to Hoogerwerf and Herweijer a policy instrument is all that an actor uses or can use to achieve a specific goal. A policy instrument which has a direct effect on a specific situation is sometimes called government provision or physical facilities. Other instruments are legal, economic and communicative policy instruments (Egmond 2010) (Hoogerwerf and Herweijer 2008). The fifth to eighth phase evaluate if the instruments which are implemented actually realize behavioral change in the right direction.

2.4 Conclusion

This chapter described several models that have tried to explain human behavior and motivation. None of them has been universally accepted. The model of Fishbein and Ajzen was one of the first models which tried to explain behavior with motivation and intention. It was based on the assumption that customers make rational decisions, this is however not the case. To improve the model of Fishbein and Ajzen the Dutch Sociaal Cultureel Planbureau added the term personal norm. A drawback of both models is that they cannot explain the effect of instruments on behavior. This is important because this rapport tries to search for solutions to motivate customers to take energy saving measures; therefore the model of Green and Kreuter is used. This model is the most complete model which cuts the complex problem in smaller understandable pieces. The model of Green and Kreuter combines all the aspects of the other two described models. This model can serve as a framework in which the solution should be sought. *"The classification of predisposing, enabling, and reinforcing determinants of behavior offers a broad framework within which one can organize more specific theories and research"* (Green and Kreuter 1999).

Originally this was developed as a health program planning and evaluation model for influencing and optimizing health care programs. However, several researches[6] have used this model for behavioral change with respect to energy saving behavior (Egmond 2006) (Görts and Jonkers 2000). The model of Green and Kreuter is also applicable to clarify which factors explain specific energy saving behavior and makes it possible to determine intervention strategies to persuade the owner occupant to take energy saving measures. In this research the desired effect is energy reduction in the built environment. The desired behavioral change is that the owner occupant is motivated to take measures that reduce energy use. Or even better, that the occupant take energy saving measures.

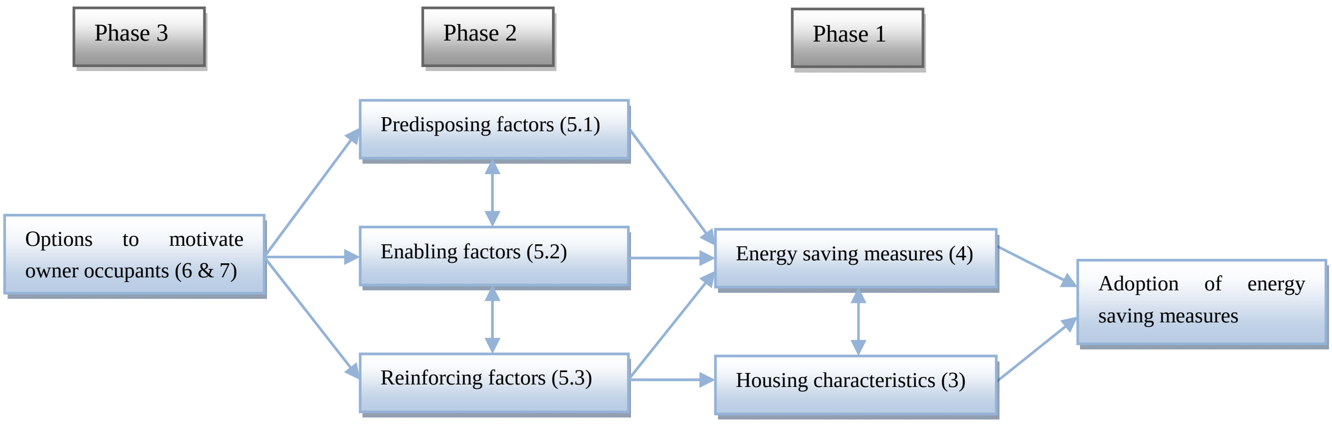

Figure 2.3: Modified model of Green and Kreuter

The figure above shows the important factors to achieve the goal of this research (Figure 2.3). The first phase is an orientation of the existing housing situation and the available energy saving measures which are described in chapter three and four. Housing characteristics are an example of external factors that influence behavior. If an installation, such as a water boiler, needs to be replaced this will influence behavior, because the consumer must replace it. As already mentioned behavior is explained by several determinants. The determinants explain under which conditions the owner occupant takes energy saving measures. The determinants can be divided into predisposing (chapter 5.1), enabling (chapter 5.2) and reinforcing factors (chapter 5.3). These determinants can also explain some barriers. For example, it could be that investment costs for energy saving measures are too high, for this

[6] Egmond used this model for *"influencing segments of housing associations to adopt energy conservation measures and innovations"*. Görts and Jonkers explored the determinants of domestic energy use and especially of domestic appliances with this model.

problem an enabling factor, such as subsidy, should be found. Those three factors reinforce each other. If a person receives feedback, from another person in the neighborhood for example, one can be motivated by that information or feedback. If one is motivated and receives positive feedback one can be more willing to access financial resources.

After phase two several opportunities and threats are known. Phase three will use those opportunities and treats to find instruments that motivate owner occupants to take energy saving measures (chapter 6 & 7). In other words, which instruments are best suited to enhance behavior towards energy saving measures? According to the model of Green and Kreuter the most optimal instruments are implemented in new policy and evaluated if they actually realize behavioral change in the right direction. Since it is not possible to execute the instruments in practice the successful instruments will be summarized in the conclusion.

The next chapter will describe the existing building stock and which measures are applicable.

3 Housing characteristics

As a result of the Kyoto agreements, 10 percent of the 1990 CO_2 emission level has to be reduced by 2012 for the existing building stock in the Netherlands. This can be achieved by reducing electricity consumption or natural gas use. Several measures are available to reduce energy consumption in the building sector. To determine which of these measures are applicable, first an overview of the existing building stock has to be given. This chapter will start with that overview and will then continue with a short notion of the regulations that have changed over time, followed by the opportunities for CO_2 reduction in the existing building stock. At the end, a short conclusion on how these findings contribute to the research will follow.

3.1 The characteristics of the existing building stock

Every five years the ministry of VROM[7] performs a qualitative building research (WoON) to measure the quality of the building stock[8] and also whether the Kyoto target is achieved. In this research 5.000 houses, which serve as a reflection for the Dutch housing stock, are evaluated (AgentschapNL 2011). The houses are divided into seven different types of dwellings and 5 different periods in time. This distinction results in 30 model homes. Those homes serve as theoretical basis whereby both architectural and technical installation characteristics are described. Figure 3.1 gives the subdivisions of those 30 different (model) dwellings according to the build periods used in WoON of 2011 (AgentschapNL 2011). The first 13 model homes are single family houses, while the other 17 model homes belong to the category of multifamily houses. According to this research the majority of single family house is owned by owner occupants (79%) and the majority of the multifamily houses are tenants (76%). Since the target group of this research is the owner occupant only single family houses are analyzed.

Dwelling Types	Building period				
	<1946	1946 - 1964	1965 - 1974	1975 - 1991	1992 - 2005
Single Family Houses					
Detached House	1		2	3	4
Semi - Detached House	5		6	7	8
Terraced House	9	10	11	12	13
Multifamily Houses					
Maisonette	14		15	16	17
Gallery Flat	18		19	20	21
Staircase-access Flat	22	23	24	25	26
Other Flat	27		28	29	30

Figure 3.1: Subdivision existing building stock (AgentschapNL 2011)

[7] The ministry of housing, spatial planning and the environment deals with all things related to living, space, integration and environment. This ministry is now under control of the ministries of internal affairs and infrastructure and environment.

[8] Building research the Netherlands (WoON) replaced KWR and building necessity research (WBO).

Detached houses

Figure 3.2: Detached houses from four building periods (AgentschapNL 2011)

Detached houses refer to free-standing residential building thus without any houses attached to them. They are characterized by a large user surface of around 130 to 170 square meters. In general detached houses exist of four to seven rooms. Figure 3.2 shows the different detached houses from those built before 1965 (most left) to those built between 1992 and 2005 (most right). In 2005, almost one million houses (959.000) out of the total building stock are classified in this category. This represents 14.2% of the total building stock.

Figure 3.3 shows how this part of the building stock can be divided according to their building period. The figure also shows which part of the detached houses is owner occupant and which is rental. The detached houses that were built before 1965 represent almost 46% of all detached houses in 2005. This is equivalent with 6.5% of the total building stock in 2005. Out of these detached houses built before 1965, 91% is owned by owner occupants, leaving 9% for rental.
A little over 100.000 detached houses were built in the period between 1965 and 1974. This is over 12 % of the detached houses and almost 2% of the total building stock in 2005. Out of these types of detached houses again most are owned by owner occupants, namely 95%.
Detached houses that were built in the period between 1975 and 1991 represent 23% of the detached houses, which matches 3.3% of the total building stock. Again, the largest group of detached houses is owner occupant owned, with 96%.
The last category of detached houses, the ones that are built between 1992 and 2005, accounts for 18.6% of the detached houses and 2.6% of the total building stock. The group of owner occupant owned houses is in this category highest. Only two percent of the detached houses in this category is rental.

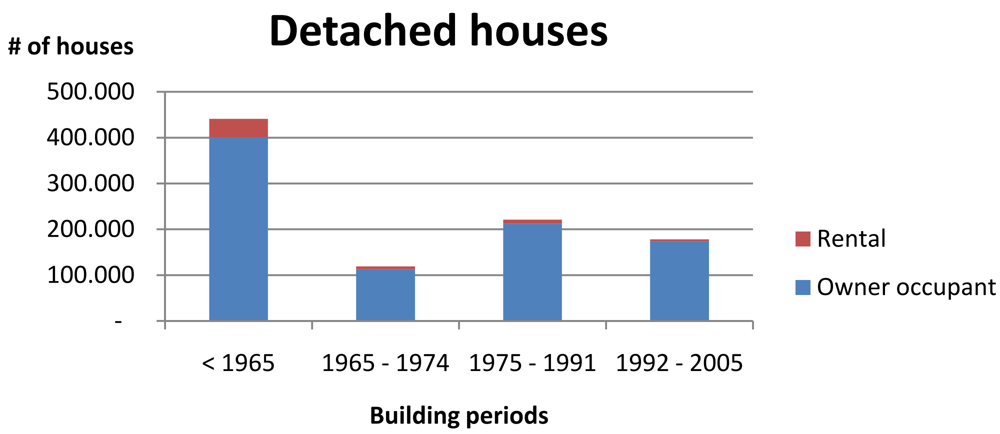

Figure 3.3: Detached houses in 2005 according to their building period

Semi-detached houses

Figure 3.4: Semi-detached houses from four building periods (AgentschapNL 2011)

Semi-detached houses are houses that are on one side attached to each other. They are characterized by a user surface of around 110 to 132 square meters and exist of four to six rooms. The different semi-detached houses from those built before 1965 (most left) to those built between 1992 and 2005 (most right) are visualized in Figure 3.4. In 2005, 824.000 out of the total building stock are classified in this category. This represents 12.1% of the total building stock.

Figure 3.5 shows how this part of the building stock can be divided according to their building period. The figure also shows which part of the semi-detached houses is owner occupant and which is rental. The semi-detached houses that were built before 1965 represent almost 35% of all semi-detached houses in 2005. This is equivalent with 4.2% of the total building stock in 2005. Out of these semi-detached houses before 1965, 84% is owned by owner occupants, leaving 16% for rental.
The total building stock in 2005 exists of 142.000 semi-detached houses that were built in the period between 1965 and 1974. This is over 17% of the semi-detached houses and more than 2% of the total building stock in 2005. Out of these types of semi-detached houses most are owned by owner occupants, namely 84%.
Semi-detached houses that were built in the period between 1975 and 1991 represent 27% of the semi-detached houses, which matches 3.3% of the total building stock. Again, the largest group of semi-detached houses is owner occupant owned, with 90%.

The last category of semi-detached houses, the ones that are built between 1992 and 2005, accounts for 21% of the semi-detached houses and 2.6% of the total building stock. Just like the previous category, the group of owner occupant is highest. Only five percent of the semi-detached houses in this category is rental.

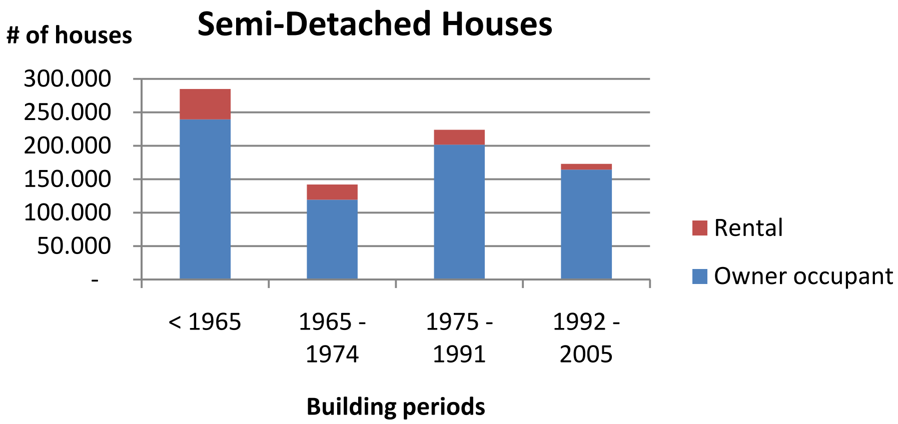

Figure 3.5: Semi-detached houses in 2005 according to their building period

<u>Terraced houses</u>

Figure 3.6: Terraced houses from five building periods (AgentschapNL 2011)

Terraced houses refer to houses that are on both sides enclosed by another, mostly, identical house. They are characterized by a user surface of around 87 to 114 square meters and exist of three to five rooms. Figure 3.6 illustrates the different terraced houses. The most left house is built before 1946 and the most right is built between 1992 and 2005. In 2005, almost three million houses (2.839.000) out of the total building stock are classified in this category. This represents 41.8% of the total building stock.

Figure 3.7 shows how this part of the building stock can be divided according to their building period. The figure also shows which part of the terraced houses is owner occupant and which is rental. The terraced houses that were built before 1945 represent more than 18% of all terraced houses in 2005. This is equivalent with 7.7% of the total building stock in 2005. Out of these terraced houses before 1945, 71% is owned by owner occupants, leaving 29% for rental.

The total building stock in 2005 exists of 478.000 terraced houses that were built in the period between 1946 and 1964. This is almost 17% of the terraced houses and 7% of the total building stock in 2005. Out of these types of terraced houses least are owned by owner occupants, only 40%.

A little over 600.000 terraced houses were built in the period between 1965 and 1974. This is over 21% of the terraced houses and almost 9% of the total building stock in 2005. The group of tenants is a little bitter higher than the group of owner occupant, respectively 53% and 47%.
Terraced houses that were built in the period between 1975 and 1991 represent more than 30% of the terraced houses, which matches 12.9% of the total building stock. The largest group of terraced houses is owner occupant owned, with 61%.
The last category of terraced houses, the ones that are built between 1992 and 2005, accounts for 12% of the terraced houses and 5.2% of the total building stock. Just like the previous category, the group of owner occupant is highest, namely 78%.

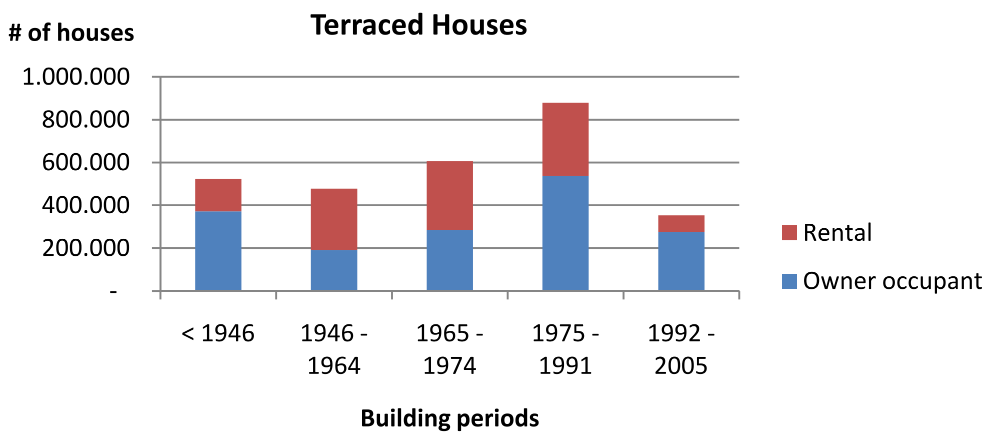

Figure 3.7: Terraced houses in 2005 according to their building period

<u>Energy consumption</u>

WoOn research also estimates the current energy use of the different houses. These estimates for the detached, semi-detached and terraced single family houses are shown in Table 3-1 and Figure 3.8. Next to the building period and the number of owner occupant houses, Table 3-1 shows the estimates for the annual gas use, the annual electricity use and the average annual energy costs per house. It can clearly be seen that the gas use decrease as the building period is more recent. However, this is not the case for the electricity use. The latter the houses are built, the higher the electricity use. This is due to the use of more electrical installations, such as mechanical ventilation (AgentschapNL 2011). The total energy costs, based on both the gas use as the electricity use, decreases as the building period is more recent as is also shown in Figure 3.8. Especially a clear decrease in energy costs can be seen from the houses built in 1965-1974 and the ones built in 1975-1991, where the costs have fallen enormously.
This all is summarized in the last column of Table 3-1, where the energy label of the houses is given. In general, the houses built before 1975 are of poor energetic quality as can be seen in Table 3-1, with a best energy label of E. Therefore in looking at the opportunities for CO_2 reduction in the existing building stock in section 3.3, only the houses built before 1975 are taken into account.

Table 3-1: Energy use for single family houses

Dwelling type	Building period	# of owner occupant houses	Gas (m³/y)	Electricity (kwH/y)	Energy costs (€/y)	Label
Detached house	< 1965	401.310	4.731	1.103	€ 2.641	G
	1965 - 1974	113.050	4.110	1.207	€ 2.387	F
	1975 - 1991	212.160	2.616	1.282	€ 1.742	D
	1992 - 2005	174.440	1.882	2.018	€ 1.555	B
Semi-Detached house	< 1965	239.400	3.453	954	€ 2.050	F
	1965 - 1974	119.280	3.046	1.051	€ 1.888	E
	1975 - 1991	201.600	1.915	1.051	€ 1.389	C
	1992 - 2005	164.350	1.497	1.580	€ 1.304	B
Terraced House	< 1946	371.330	3.337	895	€ 1.987	G
	1946 - 1964	191.200	2.246	783	€ 1.485	F
	1965 - 1974	284.820	2.030	924	€ 1.416	E
	1975 - 1991	536.190	1.542	924	€ 1.201	D
	1992 - 2005	275.340	1.135	1.383	€ 1.107	C

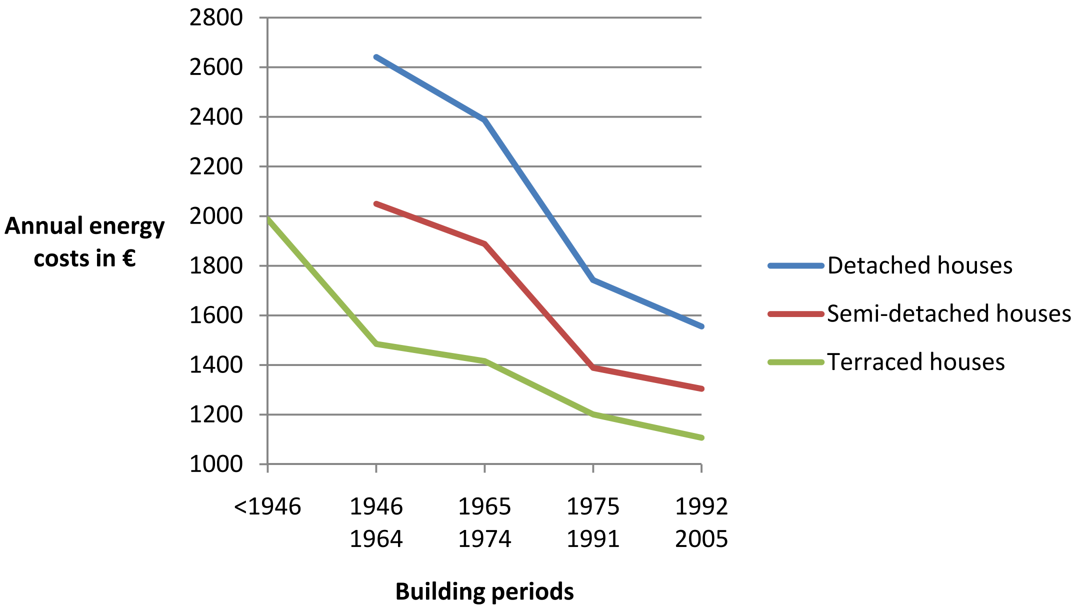

Figure 3.8: Energy costs of the detached, semi-detached and terraced single family houses according to the building period

The differences in energy use between the dwelling types can be explained by the characteristics. Because terraced houses are flanked by other houses, their energy use is lower. In general, detached houses have a larger user surface than terraced houses, which could be another explanation for their higher energy use because the larger the volume the larger the energy use (AgentschapNL 2010b). The difference in energy use between the different periods can to a large extent be explained by the regulations that have changed over the years. The next section will deal with these changing regulations.

3.2 Changes in regulations

In 1961, an important new regulation was introduced that contributed to the reduction of the energy use. Because moisture penetration in walls had become a problem, the use of a cavity wall[9] became mandatory. Up until 1961 cavity walls have only been used on a voluntary basis (Oel, et al. 2010).

The model building code of 1965 included, for the first time, requirements for improving the quality of new houses. This building code was a municipal building code which was not supervised by the national government (Overveld 2005). Although the model building code improved isolation and therefore the energy use of the house, the houses built in the period 1965-1975 are still rather poor insulated because national regulation was missing.

In the period 1975-1991, several requirements were further tightened. For example, insulation of closed parts and roof insulation required a heat resistance (Rc) of 1,3 m²K/W after 1975. In 1979 double glazing in the living room became mandatory. Insulation of the ground floor became mandatory in 1983 (Rc 1,3) and in 1988 the NEN 3661 came into force, in which requirements were made with respect to air permeability and water tightness (Mewe 1988). Also the requirements for roof and closed parts insulation increased to a heat resistance of 2 m²K/W in that period (VROM 2002).

The insulation requirements were further tightened in 1992 to a heat resistance of 2.5 for all building parts and also double glazing in all windows became mandatory (AgentschapNL 2011).
Because of the regulation made it is the case that the latter the construction year, the higher the degree of insulation (CBS 1999). Thus, houses built after 2005 have in general a good energetic quality (AgentschapNL 2011).

3.3 Opportunities for CO_2 reduction

Section 3.1 showed the existing building stock for single family houses and showed that especially houses built before 1975 are of poor energetic quality. Mainly this is due to the lacking of regulation to increase the energy efficiency. As section 3.2 has shown, nowadays a number of measures have been regulated for new building stock. Table 3-2 estimates the percentages of the existing building stock built before 1975 that have applied these measures. Originally many dwellings built before 1975 were provided with local gas fires and electric boilers or conventional boilers in the early 70s. Most of the houses built before 1975 nowadays have a high efficiency boiler, although a little less than 40% of the houses still lack this relatively easy improvement in energy reduction. A similar pattern is shown with the double or high efficiency glazing. A little less than 30% of the houses have not taken this measure. However it was not until 1979 that double glazing became mandatory in the living room and it took another 13 years until double glazing became mandatory in every window in the dwelling. Therefore 70% of installed double or high efficiency glass is quite a high percentage. For insulation

[9] A cavity wall is an external wall which consists of two brick walls with a small space of 4 to 6 centimeters between them.

however this percentage is lower. Only around 25% of all houses have façade insulation, which is even pretty high compared to floor and sloped roof insulation. Floor insulation is only applied in about 12% of the single family houses built before 1975, while sloped roof insulation is applied in about 20% of all houses. Flat roof isolation is applied most with an average percentage of about 30%.

Table 3-2: Estimated percentages of houses that have applied energy saving measures

Dwelling type	Building period	High Efficiency boiler	Double Glazing	High Efficiency glass	Insulation			
					Facade	Floor	Sloped roof	Flat roof
Detached house	< 1964	68%	58%	13%	19%	17%	24%	33%
	1965 - 1974	70%	69%	14%	20%	15%	20%	32%
Semi-Detached house	< 1964	65%	57%	15%	20%	14%	31%	41%
	1965 - 1974	70%	57%	18%	33%	10%	11%	32%
Terraced House	< 1945	56%	52%	10%	11%	12%	24%	23%
	1946-1964	54%	60%	12%	27%	7%	16%	14%
	1965 - 1974	61%	60%	18%	35%	8%	17%	26%

3.4 Conclusion

The goal of this chapter was to give an overview of the existing building stock in the Netherlands. It can be concluded that single family houses represent the largest group. Those houses are in general dominated by owner occupants. Single family houses built before 1975 are poor insulated and therefore have a gas use that is now and then more than two times higher than houses built after 1975. This is mainly due to the lacking of regulations during that period. Several owner occupants have, however, taken measures to increase the energetic quality of their house. For example, most of the single-family houses built before 1965 use nowadays increased efficiency boilers for central heating as well as for warm water. The dwellings built between 1965 and 1974 use currently the same installations as the dwellings built before 1965. Also the use of double glazing and high efficiency glass is widespread, although this was not mandatory until 1979. There are however still opportunities for improvement because insulation of building parts such as façade, floor and roof insulation is still behind. The next chapter will go further into detail about the possible options to increase the energetic quality. It will describe the different insulation types as well as the advantages and disadvantages of that kind of insulation.

4 Energy saving measures

The previous chapter gave an overview of the existing building stock in the Netherlands. It concluded that detached houses, semi-detached houses and terraced houses build before 1975 have opportunities for energy saving measures. When one discusses energy saving measures it is important to know in which situation it is applicable. There are many energy saving measures which all have their own savings potential and accompanying investment costs. The goal of this chapter is to give an overview of possible measures one can take to reduce energy consumption. It will first start with a common view to reduce energy consumption. This will be used to determine the structure of this chapter. It will than give an overview of possible measures. At the end of this chapter effective measures one can take are known.

4.1 Available measures

The total energy balance consists of energy losses through conduction[10] and convection[11] and the energy demand for installations and hot water. There are several measures to reduce those losses or demands. Many follow the steps of the Trias Energetica (Figure 4.1). The first step in this theory is to reduce energy losses by energy saving measures such as insulation. The second step is the use of renewable energy sources, such as photo voltaic panels. The third step is to increase the efficiency of energy consuming equipment (ECN 2010).

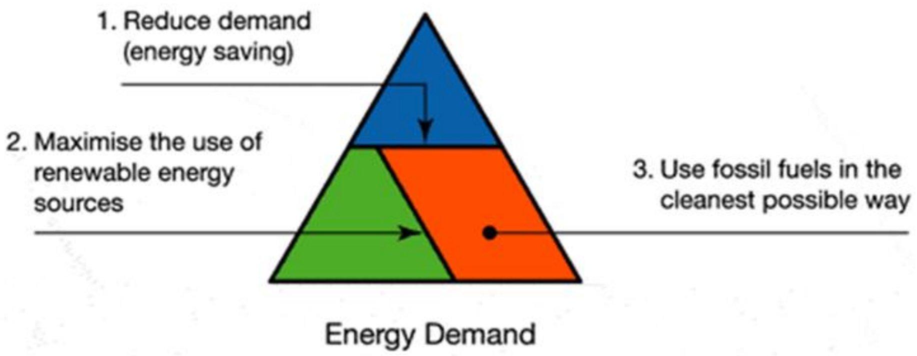

Figure 4.1: Trias Energetica (ECN 2010)

The Trias Energetica is based on the belief that the first step is the most profitable. This can be confirmed by Figure 4.2. This figure shows the potential measures that can reduce CO_2 emissions sorted by the cost of abatement. The height of a bar represents the cost of reduction. Negative abatement cost means that it has a positive return on investment. The width of a bar shows the CO_2 abatement potential. Thus, the wider the bar the higher the amount of CO_2 that is reduced. And the bigger the surface the higher the profit or loss.

[10] Conduction is the process where heat flows directly through walls, windows and doors. It is the process by which heat transfer takes place in solid matter.

[11] In a building are always cracks, gaps, or deliberate ventilation ducts which causes uncontrolled ventilation. It is the transfer of heat by physically moving the molecules from one place to another.

This figure makes clear which measures are cost effective and which are not. Related to the topic of this report one important conclusion of this figure is that insulation improvements, lighting systems and water heating are very effective and profitable measures to reduce CO_2 emissions. Renewable technologies such as wind and solar energy are at this moment not cost effective but can be over the years. They are necessary to achieve the goals set by the government. A higher energy price causes a decline in abatement costs and because of this wind and solar energy can become profitable.

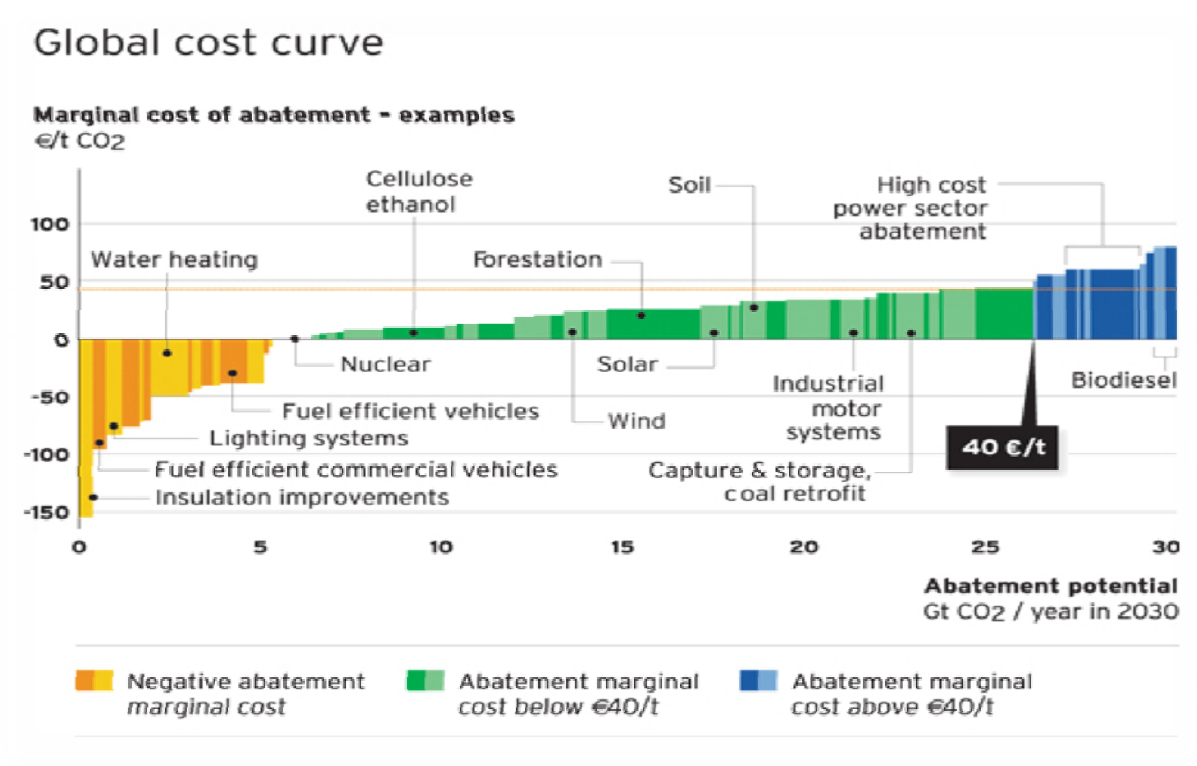

Figure 4.2: Global GHG abatement cost curve (Nauclèr and Enkvist 2009)

As is shown in Figure 4.2 insulation improvements have a positive return on investment as well as improvements in water heating systems. Renewable energy sources are not profitable yet but are necessary to achieve the goals set by the government.
Therefore this section will first describe the energy saving measures, then the installations are given and at the end the possible renewable energy sources are discussed.

4.2 Insulation

Insulation always concerns insulation of the building envelope. The building envelope is the separation between the interior of a building and the outside environment. It protects the occupants from the elements and it controls for transmissions of cold, heat, moisture, and sunlight (Kutscher 2007). When making improvements it is important that the building envelope is considered as a whole because the whole unit functions only as well as the least effective component. The building envelope consists of several components which will be described in the following paragraphs.

4.2.1 Façade insulation

Heat losses can take place through an un-insulated outer wall. Besides energy reduction, façade insulation also increases the comfort because there is a reduction in cold and noise (Ecofys 2005).
Cavity wall insulation, insulation of the outside of the façade and insulation of the inside of the outer wall are three different types of façade insulation. But all can achieve a high reduction in energy demand.

4.2.1.1 Cavity wall insulation

A cavity wall is an external wall which consists of two brick walls with a small space of 4 to 6 centimeters between them. When insulating the cavity wall a specialized company makes holes in the outer wall on the intersection of the horizontal and vertical joint. Via those holes insulation material such as polyurethane foam, glass-wool or expanded polystyrene (EPS) pearls are put in the cavity.

There are some conditions under which cavity wall insulation can be done. The first condition is that the cavity wall is not already insulated. In most houses built between 1920 and 1975 the cavity walls are without insulation. Some of those buildings were insulated during the 1970s but because of mistakes during the renovation process those houses suffered from moisture problems. However, nowadays techniques are available to remove the cavity insulation and replace it with better insulation. Houses built between 1976 and 1988 are provided with cavity insulation but the degree of insulation can be improved. In general houses built after 1988 have good cavity wall insulation. Another condition is that the cavity is free from rubble and there is no excess of mortar. Rubble and excess of mortar can result in moisture problems because thermal bridges are formed. A third condition is that the level of ventilation of the cavity wall is average. Moisture in the cavity wall must flee through the outer wall otherwise moisture problems arise again.

An advantage of cavity wall insulation is that retrofitting insulation can be done without nuisance for the owner. Nevertheless a major disadvantage of cavity wall insulation is that moisture problems can easily arise and that additional insulation is necessary to fulfill the requirements of the building regulations.

According to research of Janssens & Rummens EPS pearls have the highest heat resistance, lowest density and have a low degree of water absorption. Insulating with EPS pearls is the best way to insulate a cavity wall, because it has the lowest risk on moisture problems (Janssens and Rummens 2007).

4.2.1.2 Interior wall insulation

In this case an extra wall is placed against the internal wall. This is the only option when occupants want to insulate the building on their own. Placing insulation on the outside of the external wall or cavity insulation requires the use of professionals. Another, better, reason is that insulation on the outside of the external wall is not allowed because the exterior may not change. This applies for terraced houses, semi-detached houses and protected urban monumental buildings. If occupants want to apply outer insulation an environmental permit is needed. When choosing for façade insulation from the inside three options are most used. The first is placing insulation and a facing wall of plasterboard against a wooden or metal stud framework. Another option is to use different layers of heat reflective foil instead of insulation material but also use a facing wall of plasterboard. The third option is the use of ready-made panels of hard foam insulation board and plasterboard. An advantage of placing insulation on your own is that the costs are very low and the investment is earned back faster. Disadvantages are that moisture problems can arise because connections of facing walls with floor or ceiling are not well done. Also the fact that the constructions take place inside is a disadvantage. Power points and fixation of radiators also has to be changed. Finally the surface of the floor will decrease because the walls get approximately 10 centimeters further inside (SenterNovem 2009). (Milieucentraal 2010a).

An innovative product to insulate the interior wall is multipor. This is insulation which is comparable with aerated concrete. It contains much still air which results in high insulation values. It is light weighted and has the same qualities as concrete (AgentschapNL 2009).

4.2.1.3 Exterior wall insulation

The last option, insulation on the outside of the external wall, is the most expensive but also the most effective form of façade insulation (Milieucentraal 2010b). Insulation is placed against the outside of the external wall which sometimes results in a different exterior. In some cases this is not allowed. Fewer problems with moisture and higher thermal resistance of the insulation material are advantages. Nevertheless there are several disadvantages. First of all it is the most expensive form of insulation and secondly it has to be done by a specialized insulation company.

Exterior wall insulation changes the exterior and this can cause resistance because of aesthetic reasons. Therefore there is an innovative type of exterior wall insulation which is called ‘thermo-stone’. It exists of stone strips which are attached to insulation foam. It has the same appearance as masonry. Because it is light weighted no additional constructive adjustments have to be done (AgentschapNL 2009).

The effectiveness of façade insulation appears to have a big influence on the decision to install insulation or not. The costs for insulation are highly dependent on the building type, building year and the absence or presence of a cavity wall. The research of TNS NIPO shows that the costs estimated by home owners are in most cases higher than the real costs of insulation. Especially the costs for insulation in terraced houses are overestimated; the real costs are only 25% of the estimated costs. The monthly savings of insulation are underestimated among owners of detached houses. Owners of terraced houses estimate the monthly savings at the same level as the actual savings. The investment costs are overestimated while the savings are under estimated. Thus there appears to be a shortage of knowledge among home owners with respect to façade insulation.

The risk for moisture problems is an important point of attention. Home owners find it important to get information about this problem before they decide to take façade insulation. Moisture problems are also considered as the most important argument against façade insulation. Because this was a problem of façade insulation during the 80s and 90s it is important that there is good communication about moisture problems. 21% of the home owners find the amount of effort to achieve façade insulation a disadvantage. 25% do not know where and how to start with insulation and one third of the respondents consider the amount of nuisance and mess as a disadvantage (Schalkwijk and Mulder 2009).

Existence of a cavity wall is an important factor for the financial consideration for installation of façade insulation (Schalkwijk and Mulder 2009). The research of TNS NIPO also shows that the influence on the energy bill, comfort and indoor climate are strong points to consider façade insulation.

4.2.2 Roof insulation

There is a high savings potential in this type of building envelope; some say 26% of the total energy losses of a building can be reduced with roof insulation (Vandekerckhove 2007). The degree of reduction depends on the way the attic floor is used. If this floor is heated regularly than the heat losses through the roof are higher than when this floor is unheated. Insulation of the roof also results in noise reduction and higher comfort (Ecofys 2005). Basically there are two types of roofs, a pitched roof and a flat roof. Insulating a pitched roof with insulation on the outside is the most effective measure. A professional company installs insulation boards and a layer of vapour-resistant material.

When the roof needs to be renovated it is the best moment to install the insulation. Insulating a pitched roof from the inside is also possible but there is a chance on moisture problems. Another option is insulation of the un-heated loft floor. For flat roofs insulation the same options apply, only insulation from the inside is strongly discouraged because moisture is a serious problem. Insulation on the outside gives problems with the roof edges.

4.2.3 Floor

There are different types of floor insulation. Which option is best depends on the characteristics of the building. Heat losses of a building depend on the difference between temperature inside and outside of the envelope. The temperature of the soil is reasonable constant, thus heat losses through floor surface is lower than for windows, walls or roofs. However, floor insulation can result in energy reduction. Without the existence of a basement or crawl space insulation needs to be attached to the top of the floor. This can be bothersome for the residents because the floor space must be empty and doors and doorsteps must be adjusted.

Insulation of the crawl space can be relatively easy and inexpensive. For example, TONZON is special insulation for crawl spaces which has a very high heat resistance. A high heat resistance means that there are less heat losses and thus less natural gas is used (TONZON 2011).

In a research of van Leth and Roijen the difference between theoretical reduction and actual reduction for floor insulation was given. The theoretical calculated saving was 2.5 m^3/m^2. However the actual savings they measured in three different projects was 7.8 m^3/m^2. Several causes can be given for this difference. One explanation is that people are lowering the thermostat because the comfort increases. In practice, the savings will always be dependent on the quality of the residence and heating behavior (Leth and Roijen 2006).

4.2.4 Windows

Insulating windows can also have a significant effect on the gas consumption of a building. According to MilieuCentraal a saving of 315 to 460 m^3 per year can be achieved when replacing 20 m^2 of single glass with high efficiency glass (HR++). There are different types of window glass. For example, double glazing is glass with a cavity filled with normal air and high efficiency glass is filled with an inert gas called Argon. The inside of high efficiency glass has a coating which reflects solar heat and thus increases the level of insulation. The higher the level of insulation the lower the transfer rate of heat. High efficiency glass with triple glazing is the most energy efficient choice but also the most expensive.

When replacing windows it is also essential to take a critical look at the window frames because heat transfer can also take place through window frames and high efficiency glass is not suitable for single glass window frames. The window frames need to be replaced in most cases, this results in higher investment costs and therefore in longer payback times. Despite the fact that double glazing or high efficiency glass has a long payback time many home owners have double glazing in their living area and bed room (Schalkwijk and Mulder 2009). Why this is the case, is explained in the following chapter.

4.2.5 Air infiltration

Weather stripping and crack sealing are small measures which can reduce energy- and heat losses. Almost 90% of the home owners of houses built before 1976 have applied weather stripping or crack sealing[12] (Schalkwijk and Mulder 2009). Also attention should be given to the choice of the front doors (SenterNovem 2009). Because measures to reduce air infiltration are that small and inexpensive no further attention will be given to this kind of measure.

4.3 Installations

In general, energy consuming installations consists of heating, ventilation, and air-conditioning (HVAC) systems, water heating and lighting. There is an inverse correlation between HVAC systems and the efficiency of a building. When a building envelope is well insulated the need for HVAC systems reduces. However, these systems need to be in good balance with the building in order to fit with the heating, cooling and ventilation needs (Laustsen 2008). When a building is well insulated health problems can arise because fresh air cannot enter the building. Therefore ventilation systems are needed.

4.3.1 Heating systems

There are different heating systems that can heat a building. For example, a boiler, electric heaters, heat pumps, low temperature heating or district heating.

A low temperature heating system is a system whereby the water temperature supplied is no more than 55 degrees Celsius. Through increasing the surface of the heating element low temperature heating can supply the same heat as in high temperature heating (SenterNovem 2009). It is important that this surface is as high as possible because a higher surface results in a lower delivery temperature. There

[12] This is a research of TNS NIPO among almost 27 thousand home owners, however, only 2 thousand of the respondents are in the target group of their research (home owners with houses built before 1976).

are different low temperature heating systems such as floor and wall warming, LT-radiators, LT-convectors and LT-air heating. Floor and wall systems first heat the building part before the heat is transferred through the area. Because of this the low temperature heating system is a little slower than traditional heating systems but, the comfort of these systems is higher than traditional ones (SenterNovem 2009). When retrofitting a building the existing floor can be increased a couple of centimeters whereby low temperature heating can be installed.

District heating is in discredit because of several lawsuits, consumers think that they pay too much for district heating. For example the case of Almere and Nuon (Eck 2010) (Rijsdijk 2010).

Water heating is the second largest energy consumer in houses, after space heating. There are several efficient installations that reduce the amount of energy used for water heating, such as high efficiency boilers. Conventional and increased heating appliances are over the years replaced with high efficiency boilers. According to the qualitative building registration almost 40% of the houses are equipped with a high efficiency boiler in 2000 (VROM 2002). This percentage is increasing and was 58% in 2004 and 84% in 2010 (Woon 2010). In general boilers are replaced once in 15 to 20 years (Schillemans, Rooijers and Benner 2006). This means that houses built before 1990 should replace their boilers, also because over time the efficiency of installations decreases. A high efficiency boiler can be replaced with a micro combined heat and power boiler (CHP). This technique is still in the development phase. With this technique heat loss is captured to generate electricity. This installation requires more maintenance; is more expensive and is not able to heat tap water, but it is more efficient than a regular high efficiency boiler (Hoppe 2009).

4.3.2 Ventilation

If buildings are well and airtight insulated active ventilation is needed to remove used air and supply fresh air (Laustsen 2008). With a balanced ventilation system it is possible to use the heat of the outgoing air to warm the ingoing air. With high efficiency heat recovery almost 95% of the energy can be reused. However, when retrofitting a building, additional pipes need to be installed for balanced ventilation, which can be a problem when the pipes cannot be integrated in the floor or wall (SenterNovem 2009). Another problem is that fresh air is blown into an area from one central point. When a building is well insulated no air flow is available which spreads the fresh air through a room. In case of mechanical ventilation the risk exists that fresh air is automatically removed without the possibility to refresh.

4.3.3 Lighting

Incandescent lamps, energy-saving light bulbs, fluorescent tubes, halogen lamps and led-lighting are different kinds of lighting. Led-lighting is seen as the most energy efficient kind of lighting, but this type is not yet applicable for every application. According to ECN an energy-saving light bulb uses four times less energy and has a durability which is 10 times longer than an incandescent lamp. It is more expensive in purchase but because of the low energy use an energy-saving light bulb has a payback time of one or two years (ECN 2009). Lighting in residential buildings is a measure which was not taken into account when calculating the energy index. However, the new calculation method of 2010 also takes lighting into account (AgentschapNL 2011) (Hulshoff 2010). In utility buildings this is taken into account because it has a significant impact on the energy consumption of companies.

4.4 Renewable Energy

Renewable energy is a natural energy, such as wind, water and solar, which never can be depleted. Renewable energy is becoming more important in the future because it is a ‘clean’ energy with no carbon dioxide emission. Biomass, hydro-, geothermal-, solar- and wind- energy are different kinds of renewable energy sources. However not all are applicable for the built environment or more specifically for the existing building stock. Geothermal energy is not always applicable because it depends on location. Another point is that it is only profitable when more houses are connected to it. Smaller installations such as heat pumps are only applicable in newly built houses (Rijsdijk 2010). This paragraph only discusses solar energy used for electricity generation as well as for warm water and wind energy.

4.4.1 Solar energy (electric)

All solar panels work in a similar way. Sun light that is intercepted by a solar panel causes a positive and negative charge in the panel. The negative and positive charges are generated in different layers and because of that a current occurs. If a solar panel is interesting to invest in depends on costs of investment and returns, but also on the applicability on a roof. Not every roof construction can bear the weight of a solar panel installation. There are also other restrictions, such as shading, roof edges, roof dormers and not every building has an optimal position with respect to the sun. In the Netherlands solar panels can generate on average an optimal return when placed under an angle of approximately 35 degrees on the south. According to a research of Arcadis a solar panel in the Netherlands with an efficiency of 14% should generate 119 kWh annually. In practice this will be a bit lower because of efficiency losses in the system, e.g. cables and inverters (Meijer and Simon 2010). Also the kind of panel used influences the performance. Amorphous panels have a better performance for diffuse light than crystalline silicon. The efficiency of solar panels decreases over the lifetime (20 to 30 years) with 20 percent. Installations of 3,5 kW_p[13] are most used among individuals, according to research of ECN. They estimate that investment costs for this kind of installation is around 4,57 €/W_p (Lensink and Cleijne 2009). A recent development on solar panels is the thin film technology. This kind of film is light, flexible and can be used as roofing. However the efficiency of thin film compared to crystalline panels is lower, respectively 6 percent and 14 percent. The expectation is that thin film technology is getting cheaper soon because it uses less silicon. This material is becoming scarcer because of its use in the growing computer and television industry (Meijer and Simon 2010).

It is expected that the price for electricity and natural gas will rise over the years. Probably the investment cost will decline and therefore renewable energy can be profitable over a couple of years (Meijer and Simon 2010). This is visualized in Figure 4.3 and Figure 4.4. Figure 4.3 shows that the

[13] The return of a panel varies with the temperature of the surrounding. To give an impression of the returns the returns are measured under standard conditions. The determined returns are expressed as peak power (W_p)

investment costs are declining. The price per watt peak had declined from 5.40 in 2001 to 2.70 in 2011 (Solarbuzz 2011).

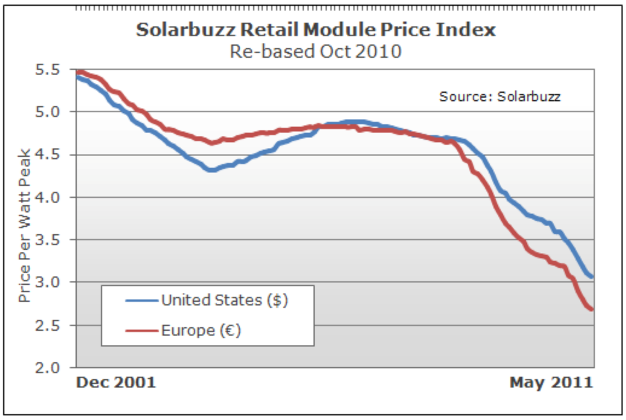

Figure 4.3: Investment costs solar panels

In Figure 4.4 can be seen that the price for solar energy is declining where the price for electricity from the grid is increasing. According to this figure it is expected that around 2018 the price for solar energy equals the price of electricity from the grid if the electricity price has an annual increase of three percent. If, on the other hand, the electricity price increases with one percent the price for solar energy equals the price for electricity in 2021 (Sinke 2005). In a more recent article in a newspaper Sinke expects that solar energy is competitive with 'normal' electricity in 2015 (NRC 2010).

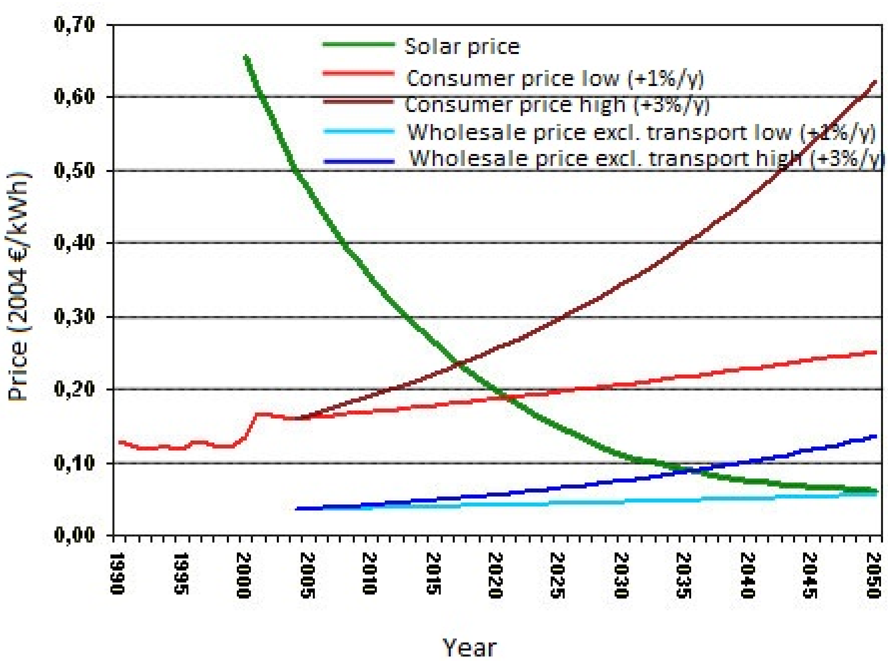

Figure 4.4: Solar price compared with electricity from the grid (Sinke 2005)

4.4.2 Solar energy (thermal)

This system uses a solar collector and a storage tank. Water streams through tubes and is heated by solar energy. The produced warm water is stored in a tank because the supply and demand of warm water is not the same. In most cases natural gas is used to additional heat the water. To pump water through the system electricity is used. However, less natural gas is used for the heating of water. According to the research of Arcadis a solar boiler is more expensive than a high efficiency boiler and cannot be earned back during its lifetime (Meijer and Simon 2010).

4.4.3 Wind turbines

Urban wind turbines are turbines that can be placed in an urban environment. The returns depend on the wind speed, wind direction and surrounding factors. Wind turbines require a high altitude in order to be efficient. This altitude is above the average building height. The high investment costs of 10.000 Euros per turbine make a wind turbine not attractive to invest in (Meijer and Simon 2010) (PRC 2010).

Renewable energy can be profitable over several years, but at this moment it is not profitable. Photo voltaic panels are expected to be competitive in a few years. Solar collectors are still expensive and have another alternative, namely a high efficiency boiler. Wind turbines are still too expensive. Because of this no further attention will be given to solar collectors and wind turbines.

4.5 Energy saving package

Above the different measures one can take are described. However one must adopt an energy saving package because the whole unit functions only as well as the least effective component. As already described in chapter 3 AgentschapNL did research on the energetic quality of the existing building stock. They also estimated the costs and benefits of an energy saving package, which are represented in Table 4-1. It can be seen that the roof insulation has the highest investment costs, followed by replacing single or double glass with high efficiency glass. Façade and floor insulation are relatively cheap measures. The total average investment costs are about 12.500 Euros. The investment costs for detached houses are higher than for terraced houses, this is due to the fact that the surface of detached houses is larger. However the annual energy savings for detached houses are also higher than for terraced houses. Houses built before 1975 are in general of poorer energetic quality and therefore more profit can be achieved when applying energy saving measures. For example, terraced house built in the period 1992-2005 can only energetic improve with high efficiency glass instead of double glass. The costs to install high efficiency glass are estimated to be 1.000 Euros and the annual savings are 32 Euros, this result in a payback time of 31 years. The payback time of the package of energy saving measures is on average 12 years; this is visualized in the last column of Table 4-1.

Table 4-1: Investment costs and savings

Dwelling type	Building period	Investment costs / measure (in €)[14]				Total investment costs	Gas savings (m³/year)	Annual savings energy bill[15]	Payback time[16]
		Facade	Floor	Roof	Glass				
Detached house	< 1964	€ 2.870	€ 1.860	€ 6.790	€ 3.990	€ 15.510	3235	€ 1.784	8,69
	1965 - 1974	€ 3.460	€ 2.020	€ 6.400	€ 4.990	€ 16.870	2508	€ 1.383	12,20
Semi-Detached house	< 1964	€ 2.050	€ 1.320	€ 6.360	€ 3.670	€ 13.400	2259	€ 1.246	10,76
	1965 - 1974	€ 2.200	€ 1.200	€ 6.160	€ 4.430	€ 13.990	1830	€ 1.009	13,86
Terraced House	< 1945	€ 1.030	€ 1.100	€ 6.370	€ 2.980	€ 11.480	2231	€ 1.230	9,33
	1946-1964	€ 890	€ 940	€ 3.040	€ 3.010	€ 7.880	1290	€ 711	11,08
	1965 - 1974	€ 850	€ 1.040	€ 3.470	€ 3.620	€ 8.980	980	€ 540	16,62

In a study of Ecofys the economics of suitable energy saving measures for the building sector are examined (Eurima 2005). One of the findings is that most energy saving measures "*can be carried out in a cost-effective way*". The measures are divided into two categories; insulation of walls (external, cavity and interior), roof and floor and replacement of windows and boilers. When energy saving measures are carried out at the same time with general maintenance and retrofit measures the investments are cost effective and earned back within two to fourteen years. Those retrofit opportunities occur when buildings reach an age of about 30-50 years. When energy saving measures are carried out independent of renovation or maintenance the payback times are around 4 (for cavity wall or roof insulation) to 38 years (for replacement of windows). Therefore effort should be directed at a combination of retrofitting and energy saving measures (Eurima 2005).

Ecofys estimates that almost 85% of the insulation measures have a payback time of less than 15 years. Furthermore, they find that half of the energy savings can be realized with insulation of the façade and roof insulation also has an important share in the reduction potential (Ecofys 2005).

As additional energy saving package, AgentschapNL also calculated the investment costs for photo voltaic panels and the related benefits. They estimate the investment costs at 532 Euros excl. VAT per square meter and annual returns of 90.8 Euros per square meter[17].

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[14] The investment costs are based on research of PRC and AgentschapNL (AgentschapNL 2011) (PRC 2010).

[15] The annual savings are based on the natural gas price of 2010. In 2010 the natural gas price was €0,55/m³ (CBS 2010).

[16] The term payback time refers in this report to simple payback time, which is the investment costs divided by the annual financial savings.

[17] The investment costs and benefits are estimated on April 2010 (AgentschapNL 2011).

4.6 Conclusion

This chapter first describes the possible measures owner occupants can take. Much energy saving measures are available, but insulation is most profitable. To determine the cost effectiveness standard data of AgentschapNL was used. It was not possible to calculate the costs and benefits of state-of-the-art measures because it is very situation depend which makes it difficult to determine the precise costs. Also too few information was available about those measures. For example, finding the natural gas price was a research in itself. A drawback of using data of AgentschapNL is that they used normal standard energy saving measures. There are better, superior measures available which are equal expensive or even cheaper which can result in higher savings.

With the data of AgentschapNL and researches of Eurima and Ecofys it can be seen that insulating measures are cost effective measures and then especially insulation of the cavity wall, façade insulation and roof insulation. Double glazing and floor insulation are less cost effective. A high efficiency boiler and efficient light bulbs are effective measures which private owners are willing to take; this was also shown in chapter 3. Some are even willing to pay for solar panels, while these are not very cost effective at this moment. It is remarkable that some measures which require high investment costs such as solar panels and high efficiency glazing are popular measures while other, cheaper solutions, are not. Improving the energetic quality of a dwelling will cost on average 12.500 Euros whereas the annual savings are on average 1100 Euros.

The next chapter tries to explain why those cheaper measures are not taken by owner occupants. From this point on this research will focus on insulation, double or high efficiency glass, high efficiency boiler and photo voltaic panels. Further installations are not taken into account. However it has to be noticed that if buildings are well and airtight insulated active ventilation is needed to remove used air and supply fresh air. But first buildings have to be insulated before this is becoming a problem.

5 Influencing factors for energy saving measures

There are many efficient measures one can take which have a short payback period. However, these measures are not taken. This is known as 'the efficiency gap'. Basically the "*efficiency gap refers to the difference between levels of investment in energy efficiency that appear to be cost effective based on engineering-economic analysis and the (lower) levels actually occurring*" (Golove and Eto 1996). This gap is a reflection of the existing market barriers to take energy saving measures. Without barriers all saving measures that are profitable are done. Not always the best solutions or innovations are adopted. When they are, it takes a lot of time from the moment they become available to the time they are adopted. What is needed is a way to increase this rate of adoption.

This section tries to describe what aspects are important in the decision process to increase the rate of adoption. This will be done by keeping in mind the precede-proceed model and the diffusion theory of Rogers[18]. Adopting energy saving measures can be seen as a diffusion of something new. According to Rogers diffusion is: "*the process by which an innovation is communicated through certain channels over time among the members of a social system*" (Rogers 2003). In this case the members of a social system are occupants of a district or city. The innovations are the energy saving measures. The rate of adoption/diffusion is determined by the characteristics of the innovation as observed by the members of a social system. What are influencing factors and restrictions of the diffusion process of energy saving measures which make owner occupants reluctant to take energy saving measures?

This chapter will describe the three main categories which can influence behavior. What is important to keep in mind is that those conditions are considered all at once and not just one (Green and Kreuter 1999). For example, an information campaign to increase the predisposing factors, such as awareness and knowledge, without recognizing the importance of the enabling and reinforcing factors is likely to fail to achieve the goal except for those people who have the (financial) resources available. First the predisposing factors and the elements of the innovation decision process will be discussed. Then the enabling factors will be given and finally the reinforcing factors as well as the different categories of adopters.

[18] Rogers is seen as a pioneer and leading author on the topic of innovations, who has done a lot of research and published many scientific articles (Hal, Postel and Dulski 2008) (Stacks and Salwen 2009).

5.1 Predisposing factors

According to the theory of Green and Kreuter there are more than hundred factors that influence behavior. They categorized these factors into three main groups. One group is the motivating or predisposing factors that are present in advance. They increase or decrease the motivation for some specific behavior, including "*cognitive and affective dimensions of knowing, feeling, believing, valuing, and having a sense of efficacy*" (Green and Kreuter 1999). This section will describe the decision process in general and focused on energy saving behavior. At the end of this section the barriers for predisposing factors are known as well as some solutions to overcome them.

Predisposing factors can form the purpose for making the decision to start the desired behavior. This process starts with the awareness of a problem or need. Most of the problems or needs are solved in a routine way. This is called 'habitual behavior'. However, when a problem does not regularly occur new information must be sought (Rogers 2003). With this information advantages and disadvantages of alternatives are evaluated. These are not only related to money but also to characteristics such as quality, uncertainty and comfort. Furthermore, aspects such as regulations influence the assessment. All these factors make up the attitude that a person has against an innovation or alternative. According to Rogers there are several conditions an alternative has to meet. These conditions also determine the attitude. The conditions are: relative advantage, compatibility, complexity, trial ability and observe ability (Rogers 2003). If this attitude is positive a person has an intention to start the behavior. Self-efficacy, the perceived capacity to successfully organize and implement the behavior, will increase the ease of adoption.

5.1.1 Awareness and Knowledge

Predisposing factors follow the same procedure as the decision process of Rogers. The process described in Figure 5.1 gives the method through which an individual passes from knowledge, to forming an attitude and a decision to adopt or reject the innovation and to conformation of the decision.

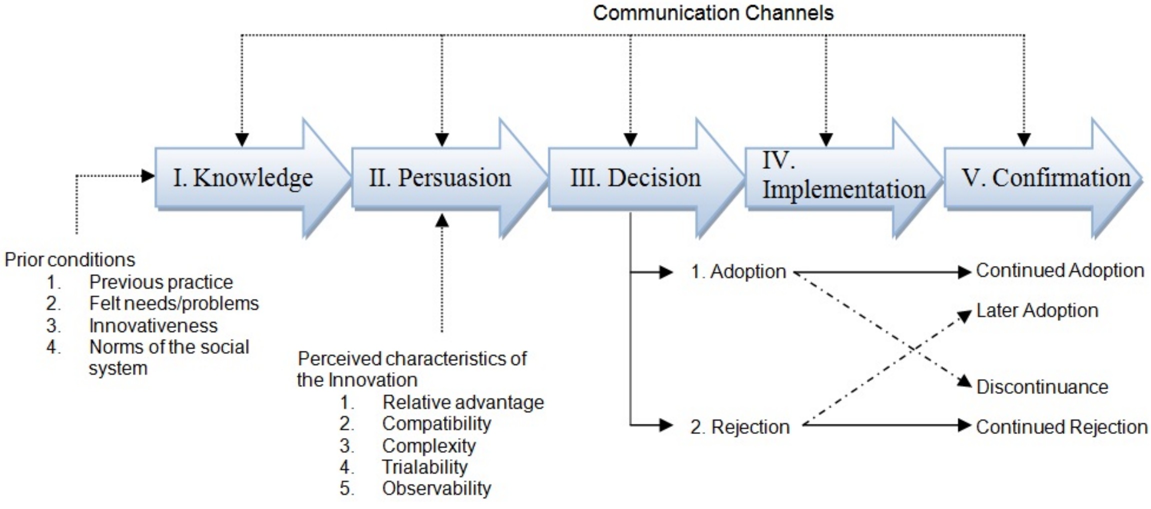

Figure 5.1: Innovation Decision Proces (Rogers 2003)

According to Rogers the prior conditions in the innovation process is that people become aware of a problem or a felt need. In the case of energy efficiency people must be aware of the problem or need to do something against the poor energetic quality of their houses. In a research of TNS NIPO among 1087 respondents it turns out that 82% of them find it important to be careful with energy use (Horst 2008). Another research among 818 respondents shows that 89% of them find energy savings important in their household. That research also found that almost 93% of the respondents thought that their house was of good or average energetic quality (GfK 2009). In chapter 3 it is shown that the overall energetic quality of houses is poor. The awareness can be increased when infrared cameras are used. This shows energetic leakages in the dwelling and makes the energy losses more visible (Boerbooms 2010).

The prior conditions such as previous experience and felt needs or problems determine also the decisions made. If future problems and needs are recognized knowledge about options to solve this problem increases (Rogers 2003). For example, if a private house owner is aware of likely higher energy prices in the future he will gain more knowledge about possible solutions to deal with that. A research of Meijer and Visscher shows that an increase in energy price does not result in energy saving measures. More than 50% of the 6.000 respondents indicate that they continue as before (Meijer and Visscher 2009). An explanation for this result is that the felt needs are missing because of the limited part of energy costs on monthly expenditures. The differences between different target groups are large. Low income households spend 7.5 percent of their annual income on natural gas and electricity, while high income households spend 2.5 percent on energy costs (NIBUD 2009). This is quite paradoxical because high income groups live, in general, in larger or detached houses and spend more energy than low income groups while their urgency to save energy is lesser (Elbers 2011). A felt need can also arise when something needs to be replaced, for example when a conventional boiler is broken down or when there is a leakage in the roof. A felt need must pass a certain threshold for action to occur. When this threshold is met one will search for information to increase the knowledge.

Knowledge of an innovation can create a motivation to learn more about it and eventually adopt it. If one has a bad previous experience with an innovation one is less likely to adopt an almost similar innovation. This seems to be the case with cavity wall insulation. A research of ‘MilieuCentraal’ among nearly two thousand respondents showed that almost half of them had a negative attitude towards cavity wall insulation. Due to poor execution of cavity wall insulation during the 80s and 90s a negative image arose (Schalkwijk and Mulder 2009).

There are basically three types of knowledge, awareness-knowledge about the existence, how-to knowledge to use the innovation properly and principles-knowledge to give a deeper understanding of the innovation. Especially how-to knowledge is an important knowledge, which can be influenced by change agents[19]. If a consumer gains more knowledge about how the innovation works he is probably more likely to adopt the innovation, if this additional knowledge is positive (Rogers 2003).

[19] According to Rogers: *“a change agent is an individual who influences clients’ innovation-decision in a direction deemed desirable by a change agency”* (Rogers 2003).

5.1.2 Social norms and values

Social norms are general accepted determinants which form a point of departure to evaluate what is wrong or right. For example, a norm is that one shall not steal. Social norms can change over time. This is the case with smoking cigarettes. In the beginning smoking was not seen as something wrong. Nowadays it is, also because of high government interference. That energy saving is not an important social norm becomes clear when people buy a house. Older houses which are monuments or are in a nice neighborhood are more attractive than newer houses. The energy usage of those kinds of dwellings is inferior. What is remarkable is that houses which differ in quality have the same selling price. A newly built house and a house built during the 60s that are in the same neighborhood and are of the same size almost have the same selling price, while the first has a higher quality than the latter. The latter is inferior in energetic and acoustic quality; the indoor climate is worse and has a higher humidity rate. Financial institutions do not see a difference in risk profile between those houses, while one can argue that the latter has a higher risk profile because of deferred maintenance. Apparently factors such as location, size and orientation are more important determinants to buy a house than energetic quality (Munckhof 2011). Also the government can influence this by making campaigns, e.g. it can make a campaign where houses with a bad energy label are represented as houses with low comfort, bad for the environment, etc.

The influence of an earlier request is a way to change a norm or behavior. According to research of McKenzie-Mohr to environmental behavior, people are more willing to accept a large request when they have reacted positive on a smaller request before, than people who had no request at all. For example, first a small request to adopt energy efficient light bulbs and then a request to adopt wall insulation. An explanation of this behavior is that the (environmental) image one has is changed with the earlier request. With this small request one can think that others expect that one also accepts a larger request (McKenzie-Mohr and Smith 1999). Another option to increase the importance of saving energy is by linking energy saving to another norm. Several researches have shown the importance of commitment. Also McKenzie-Mohr did research to the effect of commitment and showed that when people are committed to a request, for example making their dwelling more energy efficient, they keep three to four times more their promise than those not committed. Written commitments are more effective than oral commitments and public commitments in which the names are published are more effective than private commitments. An explanation for this is that people have a social norm not to break a promise (McKenzie-Mohr and Smith 1999). Normative concerns can provide a solid base for energy conservation because this is seen as an internal motivation. When this internal motivation is replaced by an external motivation, such as a payment, the behavior can stop when the external motivation is removed (Steg 2008).

"*Values underpin the right and wrong, the good and bad dimensions of people's outlook on specific behaviors*" (Green and Kreuter 1999). Values are linked to specific behavior. Therefore it is important to know what the values of the owner occupant are in order to influence behavior. In a research of the Clean Energy Group and Smart Power they found that Americans associate solar systems barely with a better environment, but more with financial certainty over a longer period. They tested 5 different statements to determine the most important factor. The statement 'Good for the environment' was not selected by one of the respondents. There appeared to be an aversion against "preachy" messages. Thus, "*the environmental message is not the most compelling to the broad public*" (Sinclair and Rosoff 2009). Also a marketer, Seth Godin, recognizes the importance to connect to personal values of consumers because, "*It's a lot easier to sell something that people are already in the mood to buy. Consumers with needs are the ones most likely to respond to your solution. Start with a problem that you can solve for your customer*" (Boerbooms, Hal and Diepenmaat 2010). In other words, you must know the priorities of the customer. Apparently energy saving has not a high priority among customers, but combining this with aspects that have a high priority can have a positive effect. For example, when an owner occupant complains about cold feet, mold on the walls and vapor on the windows, solving these problems has a high priority and those problems can be solved with energy saving measures (Munckhof 2011). Owners are the most important actors in the restructuring process. They bear the financial risks, are responsible and can make the decision to retrofit their building. However, they are led by comfort and emotion instead of sustainability. They rather buy a new kitchen or bathroom instead of taking energy saving measures (Eck 2010) (Hulshoff 2010).

To summarize, when trying to reach the mass do not focus on energy saving but on more emotional aspects such as quality, health and safety.

5.1.3 Attitude

The second stage in the decision process of Rogers is the persuasion stage. During this stage an individual forms a positive or negative attitude towards an innovation. According to Rogers an attitude "*is a relatively enduring organization of an individual's beliefs about an object that predisposes his or her actions*" (Rogers 2003). There are five attributes that are important in this stage. These are relative advantage, compatibility, complexity, trialability and observability.

5.1.3.1 Relative advantage

Rogers argues that how greater the relative advantage is the quicker the adoption takes place. Relative advantage means that an innovation is experienced as being better by the adopter than existing alternatives. Some examples of relative advantage are lower initial cost, social prestige, lesser inconveniences and the speed of reward. This latter factor is the reason why preventative innovations have a difficult diffusion process because it takes some time before the actual benefit can be seen.

This is the case for energy saving measures, because people first have to invest in the measure and the savings can be seen on the energy bill later that year. There is a relative advantage and that is a lower energy bill, but the speed of reward is very low. A lower energy bill has a large impact on the attitude towards energy saving measures (Schalkwijk and Mulder 2009). The speed of reward can be increased when energy companies make a monthly bill instead of an annual. At this moment consumers pay their energy bill in advance based on their previous bill. When they use less they get the surplus back. However when they use more they have to pay an extra amount. A monthly energy bill is very variable because it depends on external factors such as weather.

When energy companies start with monthly repayments the relative advantage of energy saving measures increases because the speed of reward increases. Energy companies are not enthusiastic to do this because this increases the uncertainty and administration costs for them. Another reason why they are reluctant to do this is because they belief consumers do not want a monthly energy bill. Essent experimented with meters that gave insight in households energy use. A result of that research was that people were interested in those meters for two or three months, after that they lost interest. Essent expects that a monthly energy bill can have effect for some months but after that period people are not interested anymore. Besides that Essent already has a tool which consumers can use to view their monthly energy expenditures; the ‘consumption manager’. Thus according to Essent a monthly energy bill is not a good option (Lalieu 2011).

Pointing out a decrease in discomfort is an effective method to enhance energy saving. A research of TNS NIPO concluded that 70% of their respondents found the influence on comfort an important advantage in consideration for façade insulation (Schalkwijk and Mulder 2009). This finding is also confirmed by energy companies and VEH. In the beginning they put a lot of effort in pointing out the advantages of energy saving measures on the environment, but now they focus on increase in comfort and cost savings (Lalieu 2011) (Umlauf 2011).

Sometimes an argument to adopt an innovation is to gain social status. This can be the case with solar panels, especially for companies. By installing a solar panel on their roof they create a ‘green’ image (Hulshoff 2010).

5.1.3.2 Compatibility

Compatibility is the degree to which an innovation fits into the existing values and norms of an adopter, with earlier purchased products or with the existing needs of the potential adopter. Thus if an innovation is perceived as totally new and the adopter is unfamiliar with the innovation the diffusion of the innovation is slower. This applies to energy saving measures. Decisions about measures such as insulation of façade, roof and floor are decisions people make only one or two times during their lifetime (Lalieu 2011). They are therefore unfamiliar with the measures. For example, 54% of almost 2000 respondents are unfamiliar with external wall insulation (Schalkwijk and Mulder 2009). Buying energy saving light bulbs is more compatible with existing values and earlier purchased products. This can also apply to high efficiency glazing instead of single glass.

5.1.3.3 Complexity

The term complexity refers to the easiness to use a product. If a measure is difficult to use and understand it is less likely that it will be adopted. This is for example the case with climate installations. According to research of TNO[20] the complexity of those installations increases because of stricter requirements to energy and comfort. Because of this complexity installations can have a poor performance (Lieshout 2006).

5.1.3.4 Trialability

If there is a possibility to try the product people can experience the product and can form an attitude towards that innovation. Insulation has a low trialability. It is not possible to try cavity wall insulation and when one is not satisfied to remove the insulation. Light bulbs have a high trialability because one

[20] TNO is a Dutch independent research organization for applied scientific research.

can buy an energy saving light bulb relatively cheap and when one is not satisfied it can be easily replaced by the old light bulb.

5.1.3.5 Observability

This is the degree to which an innovation can be seen by others. In general, the more an innovation can be observed the faster the diffusion rate. Observability can play an important role in forming an attitude towards energy saving measures. Double glazing is a measure with high observability, therefore the rate of adoption increases. Also solar panels are observable. This can be an explanation why solar panels are popular measures while they are at this moment not profitable. People who install solar panels do not get financial rewards but can gain social status (Lalieu 2011). This is according to Rogers an important relative advantage and can even be more important than financial rewards. As already mentioned many companies install solar panels just to create a 'green image' and are willing to invest in it even when it is not financial profitable (Hulshoff 2010). Furthermore, observability also increases the knowledge of its existence.

To summarize, the better the relative advantage, compatibility, complexity, trialability and observability the faster people adopt an innovation. During this process communication plays an important role. If an innovation is perceived as being better this is communicated to different persons in the social system, and if others are positive about it, it is more likely that others will adopt. An effective method to positively influence those five factors is a 'model' home in the neighborhood (Egmond 2011). The five attributes mentioned above can also explain why a high efficiency boiler, double glazing and efficient light bulbs are popular measures to take.

5.1.4 Self-Efficacy

Self-efficacy is the estimation of an actor if he is capable to successfully perform the new behavior. It is mainly based on experiences of similar behavior or conditions performed in the past. Self-efficacy is about the personal skills to perform a specific behavior (Egmond 2006). Self-efficacy for energy saving measures is very low. People can apply insulation on their own but this requires a lot of time and effort. As already mentioned, these are decisions one makes only one or two times during their life-time. Communication is an important instrument which can increase ones self-efficacy (Boerbooms 2010).

5.1.5 Barriers

Several cognitive barriers exist that should be removed in order to enhance the energetic quality of owner occupant buildings.

5.1.5.1 Absence of a sense of urgency

One barrier is the absence of a sense of urgency. As already mentioned many people think their house is of good energetic quality. Therefore they do not recognize the necessity to adopt energy saving measures. People are stuck in habitual behavior. This kind of behavior is difficult to change. An owner occupant is not familiar with this kind of decisions. People only change habitual behavior when the urgency becomes clear, as was the case after the oil crisis of the 70s or when they are out of their natural environment, e.g. removals (Blom, Korteland and Schepers 2009) (Hoppe 2009). Furthermore the energy costs account for a small percentage on the total living expenses of an owner occupant, this amount is increasing but at this moment the percentage is too small (Uihlein and Eder 2009). Also the focus of households is on the initial investments, while the focus should be on the life cycle costs (Blom, Korteland and Schepers 2009) (Egmond 2011). Another barrier is that energy saving or the environment have not a high priority in the valuation of a house, compared to size, orientation and location of that dwelling.

5.1.5.2 Lack of Knowledge

Knowledge about energy saving measures is an important barrier. At this moment people do not exactly know their gas and electricity use. When people know their energy use and know what kind of measures result in what kind of energy savings the willingness to adopt those measures can increase (Meijer and Visscher 2009). A lack of knowledge exists about energy saving measures and their returns. According to Steg (2008) people rely on several heuristics when they have to estimate the energy use. For example, people think that the energy use of large appliances is larger than smaller ones, while this is not always the case (Steg 2008). Another finding of that research was that "*people underestimate the energy use involved in heating water, which suggests that people are not well aware of the fact that energy sources are needed to do this*" (Steg 2008).

5.1.5.3 Bounded rationality

This is an important barrier to take into account. Many program and policy makers assume that people make economic rational choices. This is a wrong assumption because people are sensitive to irrational influences of their environment and emotions and not every choice can be analyzed due to lack of time, knowledge, or other reasons (Hoppe 2009). An example is habitual behavior or imprinting. According to Ariely and Prast people make their first decisions with arguments based on what they perceive in their environment and they stick to that decision even when the environment changes. A simple example of this is when people live far away from their work and need a car to get there. When they move closer to work or start working in the neighborhood they still take the car while they do not necessarily need it anymore (Prast, Thomas and Tiemeijer 2009). Applied to energy saving behavior, people who move from an energy efficient dwelling to a less efficient will retrofit their dwelling in a simple way by for example, painting the walls. They do not apply insulation because this was not necessary in their former dwelling.

5.1.5.4 Lack of visibility

Another barrier is the lack of visibility. People who adopt energy saving measures do not see the results immediately on their energy bill. Also the measures are not visible. Increasing visibility can have a positive effect on the adoption rate.

5.1.5.5 Low self-efficacy

Because self-efficacy of the owner occupant is low, one needs to spend much time searching for additional information to save energy. One will not spend that much time searching for advice, subsidies or contractors. Because energy saving measures are not decisions occupants make every day they estimate their self-efficacy lower and spend more time searching for information because they lack the skills. Clinch and Healy describe this as transaction costs. They argue that those costs are difficult to measure but can be an important factor in explaining the slow adoption rate of financially efficient measures (Clinch and Healy 2000). Also research of the Clean Energy Group confirms that transaction costs are an important barrier. In their research to solar panels they found that the complexity of the purchase process discouraged consumers to buy solar panels. One respondent even remarked that “*it feels like a full time job*” (Sinclair and Rosoff 2009).

5.1.6 Conclusion

This section describes the important aspects of the innovation decision process. As is described in the beginning the process starts with the awareness of a problem or need. It appears that people are aware of the importance to be careful with energy use. However the felt need to do something about it seems to be very low because many people think their house is of good energetic quality. The felt need for a high efficiency boiler, double glazing or roof insulation can be high because the installation is broken down or there is a leakage in the roof whereby insulation is applied. Then there is an urgency to replace the installation or apply insulation. Those problems or needs are mainly solved in a routine way. Floor and façade insulation are normally applied because people are stuck in habitual behavior. The percentages of people’s annual income spend on energy costs seem to be small, especially for those with a higher income. Furthermore previous experiences are important in the innovation decision process. A research of MilieuCentraal showed that a negative image arose because of negative previous experiences with cavity wall insulation. The last prior condition mentioned by Rogers: norms of the social system are also described in this section. Energy saving seems not to be an important social norm. People have a higher priority for contextual aspects, such as orientation of the dwelling and dwelling type, and emotional aspects, such as comfort and status, than for energy saving measures.

Recommendation 1: Increase the sense of urgency with information and visualization

It seems that there is a lack of knowledge among owner occupants about their energy use; therefore it is difficult to give insight in the benefits.

An attitude one has about energy saving measures is determined by five attributes. If one has a positive attitude about energy saving measures one has the intention to adopt those measures. Insulation is a measure with a low trialability and observability. Because it concerns a decision one makes once in a lifetime it has a low compatibility and therefore it is difficult to recognize the relative advantages. Therefore a ‘model dwelling’ can give owner occupants information and can let them experience the relative advantages. Energy saving measures, especially insulation, causes uncertainty because people are unfamiliar with the measures and they are afraid to have a decrease in comfort afterwards. The five attributes can explain why other measures such as a high efficiency boiler, double glazing and efficient light bulbs are measures which have a higher adoption rate.

Recommendation 2: Point out the relative advantage by linking energy saving with other aspects that have a high priority, such as comfort

Recommendation 3: A ‘model dwelling’ can increase the relative advantage, compatibility, trialability and observability which positively influence the attitude of a person towards energy saving measures

There are also several possibilities to overcome the problems described above. What is needed to motivate owner occupants to take energy saving measures is an increase in knowledge about those measures. This can be done by change agents who give information and also unburden the owner occupant. The awareness about the poor energetic quality of the dwelling can be increased by using infrared cameras. Furthermore an earlier request results in some experience with energy saving measures, but also can change a social norm according to McKenzie-Mohr and Smith (1999). Commitment is also an effective way to motivate owner occupants to take energy saving measures.

Recommendation 4: Increase knowledge about energy saving measures

What is also important to motivate owner occupants is the visibility or observability of a measure. Because of the visibility people can gain social status which they experience as a social reward which sometimes can have a larger effect than a financial reward.

Recommendation 5: Make energy saving measures visible to increase the rate of adoption because it can give social reward

A final conclusion of this section is that self-efficacy of owner occupants with respect to energy saving measures is low. Since insulation can be complex and has a low self-efficacy owner occupants have to spend much time searching for additional information.

Recommendation 6: Unburden the owner occupant by helping searching for suitable energy saving measures

Financial opportunities must however not be forgotten. The next section will describe which financial resources one can use to finance energy saving measures.

5.2 Enabling factors

Enabling factors are factors that facilitate the performance of an action. Important factors are the accessibility and availability of resources. Those resources include financial, technical and organizational resources, for example subsidies and loans. For most of the owner occupants the high initial investment costs seem to play a critical role in the decision process to take energy saving measures. Thus, accessibility and availability of financial resources is important. This section will describe which existing options can facilitate the investment. This chapter describes known examples from the literature and options mentioned during interviews. The technical resources are already mentioned in the previous chapter.

5.2.1 Availability of financial resources

People have different amounts of financial resources available. One has many financial resources and could therefore be more willing to pay for energy saving measures then one who has less financial resources. Less research has been done to the willingness to pay for energy saving measures. A research done to the willingness to pay for energy saving measures in residential buildings in Switzerland showed that the willingness to pay, expressed as % of the purchase price, for enhanced façade insulation was 3% and a new window was 13% (Banfi, et al. 2005). Apparently the willingness to pay for windows is higher than for insulation. One possible explanation for this is described in section 5.1.3. Because the compatibility, relative advantage and observability of windows are likely higher than for façade insulation the willingness to pay for double glazing or high efficiency glass can be higher. Probably decisions are made with a ‘decision tree’. When investment costs are low and reduction in energy use is high then the incentive is the lower monthly energy bill; when investment costs are high than other aspects, such as comfort, are more important (Lalieu 2011). The willingness to pay for energy saving measures appears to be around €2000-€4000 (Schillemans, Rooijers and Benner 2006). This is also the reason why loans start at a minimum of about €2500 (Lalieu 2011) (Luigjes 2011).

5.2.2 Accessibility of financial resources

There are several financial resources to which an owner occupant can gain access.

5.2.2.1 Subsidies

A subsidy is a monetary assistance granted by the government. They can be divided into nationwide, provincial or municipal subsidies. There are several subsidies to enhance energy efficiency in buildings. For example, when improving the energy index an allowance of 300 to 750 Euros can be received, however this fund is exhausted. There is also a subsidy for sustainable energy, e.g. solar panels. This subsidy is coupled with generation of sustainable energy. Customers pay the investment and installation costs and receives a compensation for the generated energy. With this subsidy the payback time is reduced to 15 years. However, the regulation is perceived as too complex and the high investment costs are still a barrier to invest. There is also a subsidy for personalized advice; nevertheless there is also critique about this advice (Meijer and Visscher 2009). Subsidies are perceived as most popular among owner occupants as is shown in a research of Rooijers, Leguijt and Groot (Rooijers, Leguijt and Groot 2010). A disadvantage of a subsidy is that most of the time a limited amount of subsidy is made available. Therefore, most of the subsidies are exhausted in no time, which causes frustration among applicants (Hulshoff, 2010) (Boerbooms, 2010). Subsidies can result in 'free riders' which are owner occupants who would have applied energy saving measure even without subsidies. This results in high government costs (Rooijers, Leguijt and Groot 2010). This report tries to improve the energy efficiency of buildings without too much help of the government. As already mentioned the government is not able to finance everything on their own.

5.2.2.2 Loans

Loans are another possible solution to finance energy saving measures. The idea behind loans is that a lender, a financial institution, offers a loan with the intention to earn a return on financial capital. They lend the borrower money with an interest rate. Before they do this they require information about the income capacity of the borrower (T'Serclaes 2007).
Different financial institutions offer loans that are especially to finance energy saving measures. The energy saving credit developed by the government is to guarantee the loan. The advantage of this guarantee is that financial institutions can offer loans with lower interest rates.
Combining this guarantee with the loan 'Groenprojecten[21]' of the government the interest rates can further decrease (Meijer and Visscher 2009).

'Green loans' is an organization that finances sustainable investments of owner occupants. Private owners can get a loan with an interest rate of 6.2% when they apply energy saving measures. For example when an owner occupant lends the average investment costs of 12.5000 Euros, calculated in chapter 4, with a maturity of 72 months, the monthly payment is more than 200 Euros, whereas the monthly savings are 94 Euros (Tarieven ecolening 2011).

Another kind of loan is the loan offered by SVn[22]. This foundation controls revolving funds of 307 of the 431 municipalities, provinces and other organizations in the building sector. This revolving fund offers loans with low interest rates. Interest paid by lenders flows back into the fund, which can be used for new loans (Senternovem 2009).

SVn has a durability loan which is a loan specifically for energy saving measures to dwellings. Municipalities deposit money in a revolving fund which SVn manages. From this revolving durability loans are paid. This loan is introduced in 2009 and can be between €2500 - € 15000. Since July 2009 a 'Guarantee Energy Saving Credit' is available. This is a guarantee for credit institutions that offer a credit for owner occupants in favor of the realization of energy saving measures. Because of this guarantee the interest rate of such a loan is three percent below the normal limit for mortgage tariffs, at this moment the interest rate is around 2-3%. The percentage can differ in different municipalities. The availability of these loans is limited because only 45 municipalities offer this loan at this moment. The expectation is that next year 70 municipalities offer such a loan (Luigjes 2011). The first three years of the loan are redemption free thus only the interest rate has to be paid. Because many municipalities are

[21] This is a loan developed by the government for financing solar cells, solar collectors, heat pumps and improving the energy label with four or five steps (VROM 2010).

[22] SVn is an independent financial partner for municipalities, provinces, housing associations or other parties in public housing (SVn 2011).

participants in the fund, the interest rate can be seen as a subsidized interest rate (Vethman 2009). A remarkable condition to the durability loan is that repayment of the loan without a fine is possible. Another condition is that the total loan has to be paid back in case of removals (Vethman 2009).

An example of a municipality who offers such a loan is Eindhoven. This municipality started to offer a loan one year ago and nowadays has 140 requests and a fund of 1.3 million Euros (Luigjes 2011). The loans offered have an interest rate of 2% (Eindhoven 2011). Suppose that a loan of 12.500 Euros is given with a 15 years term. The first three years the annual expenses are just the interest rate which is 250 Euros. Whereas the annual energy savings are on average 1129 Euros, as is estimated in chapter 4. After three years the loan has to be repaid which results in annual expenses of 1182 Euros. At first sight this is not an attractive investment because the financial benefits are smaller than the financial costs. However, an increase in energy price is likely to occur. In the last ten years the energy price increased with an average of 8% a year (CBS 2010).

In Figure 5.2 the monthly expenses and savings are given when one has a loan of 12.500 Euros. The green bar represents the monthly repayment of the loan. The blue and red line visualize an increase in energy price of respectively three and eight percent. What can be seen is that because repayment starts after three years the first years are profitable. Since it is likely that there is an annual increase in energy costs the loan is also attractive after three years when repayment starts because benefits exceed costs.

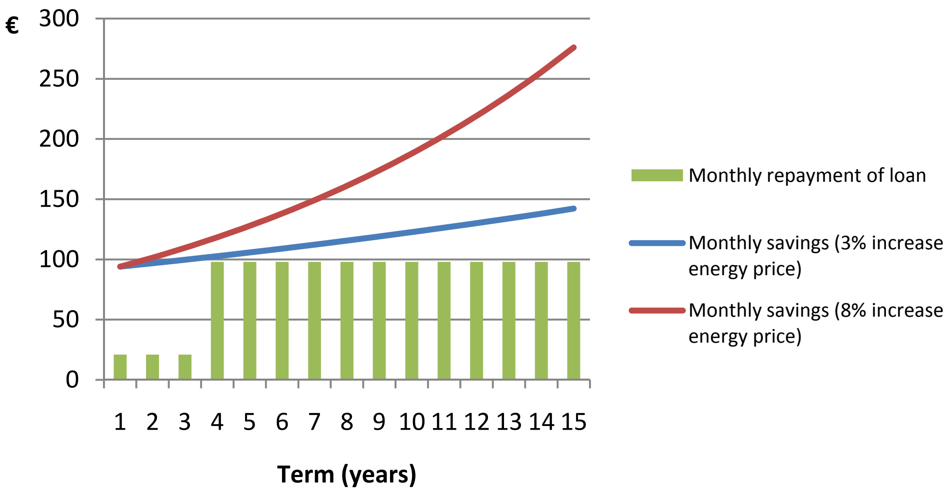

Figure 5.2: Calculated monthly expenses and savings of a loan

An annual increase in energy price of three percent results in monthly savings of 44 Euros after 15 years, then the loan is repaid and the monthly savings become 142 Euros. An increase of 8 percent results in higher monthly savings.

A possible disadvantage of a loan can be that owner occupants are reluctant to lend money. Several reasons for this are found by Koens (2006). More than 60% of the 910 respondents would prefer not to lend money. A second reason is that there is uncertainty about the time they live in their existing dwelling. The third reason is that it is uncertain what the actual savings will be and therefore they think the monthly expenses are too high (Koens 2006). Another reason why they are reluctant is because the government discourages lending money, e.g. with the campaign: ‘be careful, borrowing money costs money’ (Prast, Thomas and Tiemeijer 2009).

5.2.2.3 Mortgages

Since July 2008 energy saving measures, considered as home improvements, are also seen as ‘Groenprojecten’. Therefore owner occupants can finance energy saving measures with a ‘green mortgage’. This mortgage has a lower interest rate than other mortgages, but it requires a statement of AgentschapNL that it meets the requirements. In 2008 several financial institutions offered this mortgage. Another mortgage is the Climate mortgage. This kind of mortgage does not require a statement, thus is less time consuming. The interest discount is however lower than for a ‘green mortgage’. These mortgages are provided when it meets label or energy performance coefficient requirements. The administrative burdens for these mortgages are high because the improvements in energy performance should be measured. A risk for private customers is that there is uncertainty about the new interest rate tariff. The interest discount applies for ten years and after that financial institutions can set a new and higher interest rate (Vethman 2009). Despite the fact that those mortgages can unburden the investment costs, the popularity is disappointing. Several financial institutions, such as ING, Rabobank, ABN AMRO and Triodos, stopped offering those mortgages. This could be because the institutions had problems with the marketing of the product or because it became more difficult to obtain favorable provisions. As already mentioned in section 5.1.2 financial institutions should make a distinction between houses with a low energetic quality and a higher quality.

A mortgage which still exists is an ‘energy mortgage offered by ‘energie remmers’. This organization cooperates with Aegon. When one wants to finance energy saving measures with an Aegon mortgage a discount of 0.2 percent is offered on the mortgage interest rate. Those measures cause a reduction in monthly energy expenses as well as a reduction in mortgage expenses which is higher than the monthly investment costs (Energie remmers 2011).

5.2.2.4 Other options

Besides subsidies, loans or mortgages there are also other options to finance energy saving measures.

Energy Service Company

One possible option most mentioned in the literature is an Energy Service Company (Esco). An Esco is an organization who provides energy services, invests and is risk-bearing with energy saving measures. An Esco tries to earn the investment costs for measures back by the realized energy savings. Thus the compensation is linked with the actual realized savings. Esco’s are mainly aiming at business customers; therefore they are not offering financial solutions for private customers. Offering financial support for the owner occupant is seen as risky and difficult to control. Reasons for this are that energy performance contracts are more complicated in the residential building sector, homeowners are more suspicious against involving a third party financier in financing and projects in the residential building sector are generally too small (Vethman 2009).

District 'De Blokken' in Nijverdal

An innovative financial solution to overcome the investment costs is applied during a restructuring process in district 'de blokken'. This district is built during the 60s and almost halve of the 975 dwellings is property of a housing association. At the end of the 90s some of those dwellings were renovated but there were some doubts about the effectiveness of housing renovation alone for the future value of the district. The housing association decided to approach the renovation of the district in a more integral and interactive way. Arcadis accompanied and supported this process.

During a 5 year process occupants of the district, together with the housing association, municipality and Arcadis, took decisions during special organized meetings about their home improvement and district facilities. Those meetings resulted in a broad support for a large restructuring project. The housing association wanted to improve the quality of their building stock; more specifically they wanted to renovate the roof with new insulation and roofing tiles. For them it was cheaper to restructure one building block as a whole than separately. However, to achieve this also owner occupants needed to cooperate with the project. Those owner occupants were not willing to pay for the high investment costs of roof renovation. The housing association decided to meet the demands of the private owners by paying the difference between actual investment costs minus value increase of the dwellings. The reason to do this is twofold. First, there arises an economy of scale. For the housing association it is cheaper to renovate one housing block of 8 dwellings at once than for example two by two. Another reason is that when their houses are renovated they increase in value, but when surrounding dwellings are still of poor quality this increase in value will be smaller than when the surrounding dwellings are also renovated. For private owners this proposal was attractive because they reduced their energy expenditures and their dwellings increased in value. The first housing block renovated was a block which existed of almost 80% of rental houses. Housing blocks with mainly owner occupied saw the results and also wanted to participate in this financial construction. The housing association was not able to finance this but the owner occupants decided to pay for new roofing tiles and install insulation on their own mainly because they were afraid to live in a dwelling which was of the worst quality in the neighborhood (Ogtrop 2011).

Several conclusions can be drawn from this project. The first is that during this project energy saving was not a leading topic. Improvement of the neighborhood was more important than energy savings. According to the project manager this project was successful because it approached the district in an integral and interactive way and the focus was not only on sustainability. Another finding is that this project was successful because of high participation of the occupants. The housing association financed a part of the investment costs for owner occupants because the value increase of the renovated houses had a positive effect on the rental property. Finally, visibility increased the rate of diffusion. Because the measures were visible for others the interest of owner occupants to take measures increased. Owner occupants started to invest in energy saving measures because they saw the results of the other houses which were renovated. Visibility was important in this project since this resulted in a value increase of the dwelling.

‘Building equities’

Another financial construction which is investigated by VROM and ECN is financing of energy saving measures by ‘building equities’ (Vethman 2009). With this construction owner occupants can get an interest and redemption free loan from investors to finance energy saving measures (Daalen de Jel 2005). The idea of this construction is that the realized surplus value after improvement of the dwelling is sufficient to pay off the loan after selling the house. Investors get a share in the realized surplus value. An owner occupant who invests in energy saving measures with ‘building equities’ has to give the investor a share of the surplus value after selling the house. This share depends on the increase in surplus value as well as the height of the lend amount (Vethman 2009).

A feasibility study is done to investigate the possibilities of ‘building equities’ for building improvements. A result of this study is that the concept of ‘building equities’ is fiscally and juridical feasible. This study also found that investors are interested in ‘building equities’ on condition that it concerns a project and area based approach with full support of the local government. The local government must manage the district in order to prevent that the investment costs are not earned back by the investor because the quality of the district decreases (Daalen de Jel 2005). Also owner occupants are interested in ‘building equities’ because they do not have to pay the investment costs for energy saving measures.

A disadvantage mentioned by owner occupants is that they have to pay a share of the realized surplus value to the investors (Daalen de Jel 2005). There is also the risk that the surplus value afterwards is insufficient to pay off the loan. In that case the owner occupant still has depts. And the investor loses the invested amount of money (Vethman 2009). Another disadvantage is that the costs to change the title deed and mortgage act are high. Furthermore it is possible that the mortgagee reject ‘building equities’ because a non-natural person becomes co-owner of the dwelling (Daalen de Jel 2005). Also the high contract costs between the investor and the owner occupant is seen as a disadvantage. Therefore ECN concluded that it is unlikely that the concept of ‘building equities’ is applied in practice (Vethman 2009).

5.2.3 Barriers

5.2.3.1 Resistance costs

A barrier with respect to enabling factors is the presence of resistance costs. Resistance costs are those extra costs that an occupant induces to take efficient measures. Examples of those extra costs are the transaction or opportunity costs which are already mentioned. Also the effort necessary to perform the measures is a barrier, e.g. floor insulation requires an empty living room, adjustment of doors and doorsteps. Those costs explain why the direct costs and benefits are only a part of the reason to apply energy saving measures (Rooijers, et al. 2006) (Blom, Cnossen, et al. 2006). The transaction or opportunity costs are non monetary costs but can be expressed as monetary costs by estimating the money needed to remove a barrier for people or by estimating how much money people want to receive for the amount of time they need to spend to search for information and contractors (Blom, Cnossen, et al. 2006). It appears that when people have to put a lot of effort in something they estimate the returns higher. The resistance costs can be decreased by the use of change agents or experts (Boerbooms, Hal and Diepenmaat 2010).

Resistance costs cannot be determined precisely. However, a minimum value can be given for profitable options because the benefits are higher than the costs and still these measures are not done. Apparently there is some resistance and this resistance is at least as large as the net benefit of the measure, otherwise this measure was already applied (Blom, Cnossen, et al. 2006). An example of the effect of resistance costs is given in Figure 5.3. The direct benefits are saved energy costs, intangible benefits are benefits that are difficult to express in monetary units, such as an increase in comfort. Technical costs are those cost necessary to purchase and install the measure.

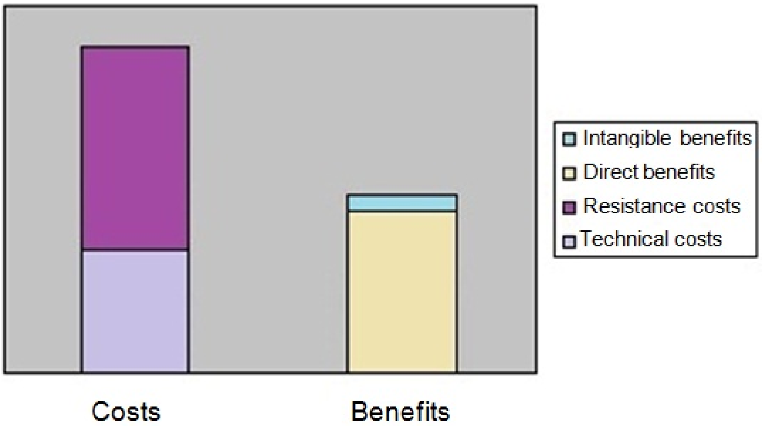

Figure 5.3: Example of costs and benefits for energy saving measures (Rooijers, et al. 2006)

5.2.3.2 Uncertainty

There always are uncertainties when a new technology is introduced or when a decision has to be made. Those uncertainties can be financial, but also uncertainty about comfort and energy savings exists. This uncertainty, together with the irreversible investment costs causes a greater risk aversion in adopting those efficient measures. According to Prast people have a risk aversion because the psychological effect of losing something is more than two times the effect of winning something. Thus formulating the effect of energy savings in terms of winnings causes people to choose for certainty while formulating something in terms of losses causes people to choose for the more risky solutions (Prast, Thomas and Tiemeijer 2009) (Rooijers, et al. 2006). An important finding of this is that energy savings should be formulated in terms of losses when not applying energy saving measures. For example, in chapter 4 the investment costs, annual savings and payback time is given. A payback time of 10 years seems to be a long time, but formulated in monthly savings has another effect, as can be seen in Table 5-1. Formulated in monthly savings people see what they lose when not applying measures and can be more willing to take measures.

Table 5-1: Payback time vs. monthly savings

Dwelling type	Building period	Payback time in years	Monthly savings
Detached house	< 1964	8,69	€ 149
	1965 - 1974	12,20	€ 115
Semi-Detached house	< 1964	10,76	€ 104
	1965 - 1974	13,86	€ 84
Terraced House	< 1945	9,33	€ 103
	1946-1964	11,08	€ 59
	1965 - 1974	16,62	€ 45

Another finding is that people better can get an incentive before, which they have to pay back when not applying measures, than an incentive afterwards (Prast, Thomas and Tiemeijer 2009). Therefore rewarding people with good behavior has a better effect than punishing people who do not perform that behavior (Boerbooms 2010).

Uncertainty always exists because of the following reasons. Energy saving measures is very location specific; therefore it is difficult to estimate the costs and benefits. For example, cavity wall insulation can be very beneficial if there is no wall insulation at all and when there is no rubble or no excess of mortar in the cavity wall. However, when there is already cavity wall insulation which is inferior or when there is rubble or excess of mortar the expenses to execute cavity wall insulation increases. The benefit of insulation also depends on the gas usage of the occupant, e.g. insulation would be more beneficial for large households in detached houses than for one person living in a small terraced house. Another reason for uncertainty is the uncertainty about the global energy prices. Energy prices increased rapidly the last 10 years, but it is uncertain what the future prices will be (CBS 2010). This has an effect on the monthly savings and the estimated payback time.

Furthermore there is uncertainty about the annual energy consumption, which causes difficulties in estimating the payback time of certain measures. Every year something changes in energy consumption. This can be the result of seasonal differences in temperature but also in family composition. Another reason for this uncertain annual energy consumption is known as the ‘rebound effect’. Several researches have pointed out the importance of the rebound effect. “*A rebound effect refers to an (unanticipated) counterbalancing or even a complete disappearance of initial energy efficiency gains*” (Abrahamse 2007). There are basically two types of rebound effects. The first is when people spend their money, saved from reducing energy use, on energy intensive goods, e.g. buying an extra television (Abrahamse 2007). Another rebound effect is related to technological innovations. For example, when light bulbs become more energy efficient people leave them burning longer (Goorden 2005). Or when people think their house is energy efficient they also think that they can leave doors or windows open (Luigjes 2011) (Goorden 2005). Therefore the calculated savings can differ from actual savings.

At last, there is also the lack of experience, with the application of innovative and sustainable techniques, by contractors and suppliers. This lack of experience means a lack in skills, which can result in delays and implementation errors. This results in conventional solutions in which occupants and suppliers have experience (Hoppe 2009).

5.2.4 Conclusion

This section gave an overview of possible financial solutions that are available to finance investments in energy saving measures. It started with estimating the available resources one has or what one is willing to pay. According to several experts interviewed the willingness to pay is about 2000-4000 Euro for energy saving measures. The willingness to pay for double glass or high efficiency glass seems to be a bit higher. However, the investment costs are in general higher than the willingness to pay. Therefore several financial resources are offered to which owner occupants have access to.

Financial resources, such as subsidies, offered by the government are most popular among owner occupants. Many subsidies are exhausted which causes frustration among applicants. Subsidies are not the solutions to overcome the investment barrier because the government is not able to finance everything. Several financial institutions offer financial constructions to finance energy saving measures. An example is the durability loan offered by SVn which is an attractive option to finance energy saving measures. The monthly expenses to repay the loan are lower than the monthly benefits provided that the energy price increases annually. At this moment the loan is relatively unfamiliar among owner occupants because only 45 of the 431 municipalities offer such a loan. Owner occupants are also reluctant to borrow money. In addition there is uncertainty about the actual savings which makes it difficult for the lender to guarantee the calculated benefits. Nevertheless a durability loan has a high potential to motivate owner occupants. Another financial construction which can finance energy saving measures is a mortgage. A mortgage requires a notarial deed which requires additional costs. Also many mortgages to finance energy saving measures do not exist anymore because of low popularity or tightened regulations of the government. A mortgage can create opportunities to finance energy saving measures, especially if financial institutions make a distinction between dwellings with different energetic quality.

Also some innovative financial constructions are discussed in this chapter. An energy saving company and 'building equities' are not likely to be successful because of high organizational costs. A financial construction used in Nijverdal can be an option for district restructuring when there is fragmented property. Several conclusions can be drawn from this project. The first is that energy saving was not a leading topic in this restructuring process. The value increase of the houses was an important factor that caused the housing association to pay a share of the investment costs for owner occupants. Furthermore visibility of the measures and peer pressure seems to be important.

This section discussed the financial resources available and accessible. It appears that there are financial resources available to finance the investment. However, lack of knowledge about those financial resources among owner occupants results in low popularity of those resources. Furthermore, the investment costs are perceived higher because of resistance costs. Those are lowest on natural moments or when change agents are involved. Formulating energy savings in terms of losses has more effect than formulating in savings. Uncertainty causes a reserved attitude among owner occupants. More experience with energy saving measures can reduce this uncertainty. It is difficult to give certainty because external factors such as temperature and family composition changes. Also several rebound effects causes uncertainty in actual savings. All those uncertainties make it difficult for a financial institution to guarantee that the calculated savings, at least, equal the actual savings.

Recommendation 1: Inform owner occupants about the available financial resources and try to increase the knowledge concerning monthly savings (with annual energy price increase included)

Recommendation 2: Give owner occupants advice about energy saving measures on 'natural moments'

Recommendation 3: Financial institutions should make a distinction between dwellings which are different in energetic quality

Even when one has the intention to apply energy saving measures (section 5.1) and has the financial resources available (section 5.2) there is still another factor which can influence behavior. This is described in the following section.

5.3 Reinforcing factors

Reinforcing forces are defined by Green and Kreuter as "*those consequences of action that determine whether the actor receives positive or negative feedback and is supported socially afterwards*" (Green and Kreuter 1999). Reinforcing factors include feedback from peers and advice from experts. Also regulations from authorities can reinforce behavior. This section will describe which kinds of feedback, advice and regulations can be effective to motivate owner occupants to take energy saving measures.

5.3.1 Feedback

The factors described in section 5.1 can form the intention to make a change in specific behavior. Often such change can be followed by social reactions from the environment. The individual seeks for confirmation about the decision by feedback from the environment. Positive feedback can directly strengthen the chosen behavior, while negative feedback can stop the behavior. There are different kinds of feedback. Feedback can be electronic or written, but feedback can also be face-to-face. Both are explained below.

5.3.1.1 Electronic or written feedback

Electronic feedback can be continuous; for example a monitor which gives the electricity use. According to Abrahamse et al. continuous feedback is effective in reducing gas and electricity use. They concluded that the more frequent the feedback was given the more effective it was (Abrahamse, Steg, et al. 2005). What was not tested however was how long the feedback would be effective. Essent also experimented with continuous feedback using special meters. A result of that research was that people were interested in those meters for two or three months but after that they lost interest (Lalieu 2011).

Another kind of feedback is comparative feedback. In this case individuals get feedback relative to the performance of others. This can create a feeling of competition which can be effective when relevant others are used as reference group (Abrahamse, Steg, et al. 2005). This kind of feedback can have a direct effect on changing a norm but can also influence attitude and behavior. What has to be kept in mind is that the right message is send. According to Prast, Thomas and Tiemeijer several feedback mechanisms brought about the opposite effect because the message was formulated wrong (Prast, Thomas and Tiemeijer 2009) . For example, it appeared that when households received information about the energy use of others in their neighborhood the energy usage of those using less than the average increased after receiving the message. The message focused on undesirable behavior and that behavior became the social norm (Prast, Thomas and Tiemeijer 2009).

5.3.1.2 Face-to-face feedback

Also interaction between different people can provide feedback. Interaction and feedback from peers is important because marketing campaigns and other media promotions can spread the amount of information about energy saving measures but it's the experience and conversation about it that really spreads adoption (Rogers 2003). Therefore this paragraph will describe the different target groups that exist according to the diffusion theory of Rogers.

The first category is the innovators or the technology enthusiasts. This group is the first and smallest segment (2.5%) to adopt a new technology because they appreciate the new technology and see the relative advantage of the product. For example, innovators are those who buy an iPad when it costs well over a thousand dollars. They have the interest to learn about the product and are willing to talk about their experiences using that new product. The speed of adoption can be increased when those innovators are found and they are provided with support and publicity for their ideas (Moore 2006). The 'SEV[23]' is experimenting with innovators and extreme energy saving measures. According to them extreme energy saving measures are necessary to reach the climate goals set by the government. They try to form a community of practice. A community of practice is a group of people who have the same ideas and share the same interests. A competition element is created because individuals can share their ideas and performance with other like-minded. A community of practice can reinforce the diffusion of extreme energy saving measures (Munckhof 2011). Competition in a community of practice is an effective way to motivate owner occupants, because of social pressure and the competition element people are more willing to apply energy saving measures (Boerbooms 2010) (Essens 2011). According to the SEV a small segment is willing to take extreme measures but is not aware of the fact that others are also willing. When they form a community and communicate through a forum they can exchange information and experiences about their ideas. When they took measures their experiences are documented and spread to reach the second group of people (Munckhof 2011).

The second group is the early adopters or visionaries. This is the group who adopt a new technology when the benefits become clear. In most cases social prestige is a motivator to adopt. Visionaries tend to be more socially respected because they are seen as trendsetters while innovators are more seen as specialist or experts (Rogers 2003). According to Moore the difference between a visionary and a technology enthusiast is that "*a visionary derives value not from a system's technology itself but from the strategic leap forward it enables*" (Moore 2006). If early adopters are convinced of the advantages and necessity they will adopt. They are always looking for social or financial benefits. Therefore, they are easy to reach, for example, when a discussion meeting is organized to discuss energy saving measures they are the ones that are present. Visionaries like a project orientation. They are willing to cooperate with a pilot project. They can fulfill an important role in persuading others in the neighborhood to apply energy saving measures. In a research of McKenzie-Mohr it is shown that 'community block leaders', people who are respected and have influence in the neighborhood, are effective to persuade others to adopt sustainable behavior (McKenzie-Mohr and Smith 1999). Visionaries as well as innovators are not price-sensitive. The first is willing to take the risk because they see potential and are enthusiastic to experiment with the technique and the second is interested in the product because of its technology irrespective of price (Moore 2006).

The early majority or pragmatists are, according to Rogers, represented by 34% of the population. They will not change behavior until there is solid proof that there are benefits. They are, unlike early adopters, sensitive for the source of information (Rogers 2003). Community block leaders or celebrities can influence the behavior of the early majority (Boerbooms, Hal and Diepenmaat 2010). This is also confirmed in a research of van Hal to "*the diffusion of environmental innovations in*

[23] SEV is a Dutch organization which develops innovative answers for social problems in the housing sector.

housing". In that research it is found that when "*at least one member from the project team of the demonstration project acts as innovation champion (= a charismatic person who throws his weight behind the innovation)"* it has a significant positive effect on the diffusion of that innovation (A. v. Hal 2000). This also applies to energy saving measures. When one is satisfied about energy saving measures and is willing to take other measures, one can serve as ambassador by sharing their experiences with others in their environment. Therefore it is important to involve those at the start of a renovation process (Boerbooms, Hal and Diepenmaat 2010).

The fourth group is the late majority or the conservatives. This group is as large as the previous group according to Rogers (Rogers 2003). They will also change behavior if the benefits are clear but their main driver is that they are afraid to not fit the mainstream market. They will change behavior because others do. It is therefore, more effective to focus on social norms than on benefits (Moore 2006).

The last group described by Rogers is the laggards. This is a group of people who are skeptic about every new innovation. For them regulation and enforcement is necessary. They need examples of other laggards who have adopted the innovation and they also want to familiarize with the product, for example by an example house which has applied energy saving measures (Rogers 2003). In general model houses are an effective way to let owner occupants experience the advantages of energy saving measures (Boerbooms 2010).

In theory the first group serves as reference group for the second and the second can influence the third group etc. However, sometimes it is argued that between the second group and the third, the early majority, a gap exists. This so called 'chasm' is caused by different interest between the early adopters and early majority. This 'chasm' can explain why some products are popular in the beginning but do not reach the mass market (Moore 2006). This aspect is illustrated in Figure 5.4, where also the different adoption groups and their 'share in the population' are summarized.

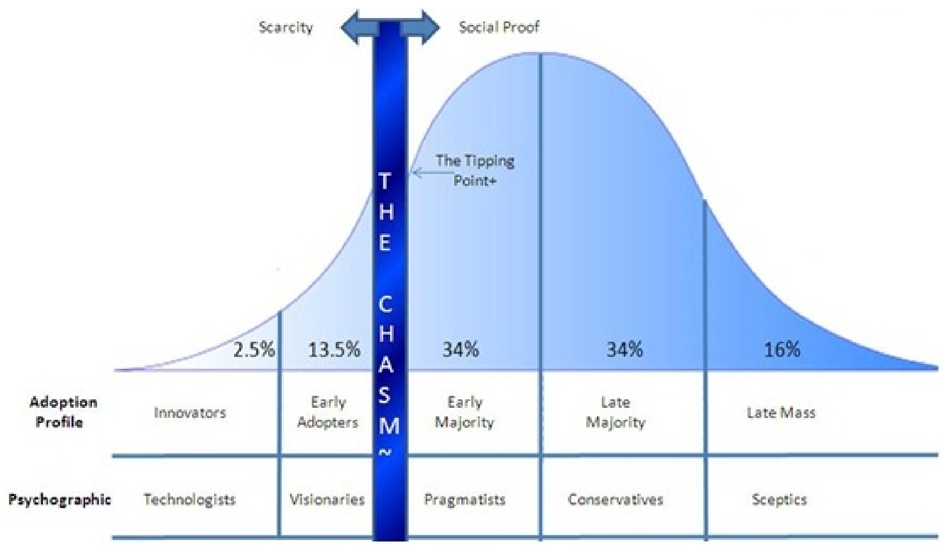

Figure 5.4: Diffusion of Innovation Adoption Curve (Maloney 2010)

It is argued that when this ‘chasm’ is crossed a tipping point is reached resulting in adoption of the innovation by the mass market. To increase the adoption of energy saving measures different owner occupants have to be motivated in a different way. The innovators and early adopters adopt a new technology irrespective of the price. They adopt it because it is a scarce product and they get recognition of others. The other group wants to know the benefits and advantages of the innovation before they will adopt. In other words they want social proof or advice and feedback of those who have already adopted the technology. Therefore the different groups need to be approached in a different way. The first groups should for example be approached with the message that energy saving is important and that they can be the first to adopt this new technology, think for example of a photovoltaic panel. The second group should be approached with the message that it is a proven technology which has clear advantages and benefits (Maloney 2010). For example, they should receive positive messages about the experiences with façade insulation of early adopters.

To summarize, to motivate owner occupants to take energy saving measures feedback can be an effective tool. Especially experiences of peers seem to be effective. There are different kinds of adopters which have to be approached in a different way. Those who already have adopted energy saving measures could serve as ‘ambassadors’ to share their experiences with those who are still in doubt. The diffusion of innovation adoption curve can also explain why some people have, for example, installed photo voltaic panels while others have not.

5.3.2 Advice

Besides feedback from monitors or peers, advice from experts is also an important factor that can reinforce behavior. As has already been described, there is a lack of knowledge about which energy saving measures are available and there is a lack of self-efficacy to execute the measures. Workshops and personal advice can increase the knowledge about energy saving measures and can maybe change the attitude one has (McKenzie-Mohr and Smith 1999). It can also decrease the resistance costs which are described in section 5.2.

5.3.2.1 Workshop

Geller (1981) studied the effect of advice about energy saving measures given in a workshop. Participants participated three hours in each workshop where they learned about energy saving measures that could reduce the amount of energy used in their dwelling. Geller measured the knowledge and beliefs about energy saving before the workshop and after the workshop. He concluded that the awareness about the energy crisis, knowledge and willingness to take energy saving measures increased. After the workshops participants received a free low-flow shower head to install. Home-visits conducted a few weeks after the workshops showed however that although the knowledge and willingness to install measures was increased behavior did not change. Only eight of the 40 participants who received a free low-flow shower head had installed them, compared to two of the control group. No differences where found between the participants of the workshops and the control group. None of the participants had taken energy saving measures such as insulation (McKenzie-Mohr and Smith 1999). An important lesson learned from this experiment is that information influenced some determinants of energy saving but it did not actually change behavior.

5.3.2.2 Personal advice

Energy saving measures one can take is very dependent on the situational context. Owner occupants do not always know if there is already insulation in their dwelling, therefore it is necessary to receive personalized information (Schalkwijk and Mulder 2009). Green and Kreuter called this "*tailoring or the principle of individualization*" (Green and Kreuter 1999). According to Abrahamse the advantage of individual information is that participants only receive relevant information instead of getting a large amount of general information (Abrahamse 2007). An example of personal advice with respect to energy saving is the so called 'energie prestatie advies' (EPA). This is an advice given after a home energy audit which is "*a home visit by an auditor who gives households a range of energy-saving options…based on their current situation*" (Abrahamse 2007). After such an advice households know which kind of energy saving measures are applicable to their dwelling as well as the related investment costs, gas and electricity savings and the time it takes before the measures are earned back (EPA 2011). The research of Abrahamse found that home energy audits with personal advice had a positive effect on the energy use of households (Abrahamse 2007). Another research also found that feedback about energy consumption is an effective way to improve energy efficiency (Ayers, Raseman and Shih 2009). This can be explained by the fact that some people may want to adopt energy saving measures but they simply do not know where to go to (Boerbooms 2010). The common belief of a personal advice about energy saving measures is in general positive (Schalkwijk and Mulder 2009). A disadvantage of this advice can be that owner occupants have to pay an expert to analyze the house. Paying 200-400 Euros in advance while it is still unclear which measures are applicable is considered as a risk. As already described in 5.2.3.2 people have a risk aversion. This could cause reservation to request a personal advice (Boerbooms 2010).

To summarize, organizing workshops about energy saving measures influence some determinants such as knowledge and awareness, but does not change behavior. Personal advice seems to be an effective way to motivate owner occupants to take energy saving measures because it gives opportunities to act.

5.3.3 Regulations

Regulations made by the government can reinforce behavior. An important condition is that the regulations made "*have maximum opportunities for supportive feedback for new behavior*" (Green and Kreuter 1999). This paragraph will describe some existing regulations and will conclude with those regulations that can motivate owner occupants to take energy saving measures.

5.3.3.1 Energy label

As already mentioned in the introduction energy reduction is becoming more and more an issue. Reducing energy use is one of the main goals of the European Union. For that reason there are several regulations made. For the newly built houses there are building codes such as the energy performance coefficient. Some argue that those building codes are mildly effective in achieving the policy goals (Aroonruengsawat and Auffhammer 2009). Therefore mandates and stricter energy efficiency standards were introduced. The Energy Performance of Buildings Directive (EPBD) introduced by the European Union in 2003 is an example of this. The goal of this directive is to enhance energy performance in buildings. One of the results of the directive is the implementation of energy certificates or energy labels for utility buildings and residential dwellings (Brounen and Kok 2010).

An energy label shows the energy efficiency of that specific dwelling. When determining the label several aspects are taken into account. These are, among others, the thermal characteristics of the building, the heating installation and hot water supply and the building type. All aspects are given in appendix A. The label is based on a simple indicator of energy consumption, the energy-index (EI)[24]. This energy-index is determined by "*modeled primary energy consumption under average conditions*" (Brounen and Kok 2010). Thus the actual energy consumption given on the energy bill can be different from the indicated energy consumption. The energy-index is translated into different categories, A++ to G, wherein A++ means energy efficient and G is energy inefficient. Professionally trained advisors issue the certificate after they have physical inspected the dwelling and calculated the energy index with a standardized model (Brounen and Kok 2010).

This label is introduced in 2003 as follows: According to article 7 of the EPBD "*…Member states shall* ***ensure*** *that, when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be. The validity of the certificate shall not exceed 10 years*" (EU 2003). Those member states were free to decide how they implemented the directive. However the necessary laws, administrative provisions and regulations to meet this directive had to be brought into force at the latest on 4 January 2006. The Directive permitted a delay of three years for those states that have a lack of qualified and/or accredited experts that grant a label (EU 2003). The Netherlands implemented the energy label in January 2008. This means that one should have an energy label when one sells or rents a house. An energy label is, however, not fully mandatory in the Netherlands. Sellers may not have an energy label while still able to sell their house. Homebuyers have to sign an exemption which overcomes the obligation of the seller to label the dwelling. Without obligation the diffusion of the energy label in the Netherlands is slow. This is going to change, because of the Recast EPBD in 2010. This recast states that: "*…Member states shall* ***require*** *that, when buildings or building units are constructed, sold or rented out, the energy performance certificate or a copy thereof is shown to the prospective new tenant or buyer and handed over to the buyer or new tenant. …The provisions of this Article shall be implemented in accordance with applicable national rules on joint ownership or common property*" (EU 2010). The deadline to implement this obligation to show an energy label will be on 9 January 2013. If a dwelling does not have an energy label in 2013 then the title deed cannot go through. The recast also has some changes that increase the transparency of energy consumption. For example, it may include additional information such as energy use and it requires that an "*energy performance indicator is stated in the advertisement in commercial media*" (EU 2010). There are some exceptions to this new directive. Dwellings younger than 10 years have no obligation to have an energy label because for those dwellings the energy performance coefficient is calculated. If one has carried out an energy performance advice (EPA)[25] by a certified advisor between 1 July 2002 and 1

[24] In 2012 the energy index will be replaced with a new calculation methodology (EPG) (Rooijers, Leguijt and Groot 2010).

[25] The difference between an energy performance advice and an energy label is that an EPA is more elaborated. It is possible to receive a label based on representativeness. A label gives a list of possible improvement measures whereas an EPA gives specific advice based on family situation and behavior and it gives an indication

January 2008 an energy label is not necessary. Also monuments do not have the obligation to have an energy label. An energy label is valid for a period of 10 years (MilieuCentraal 2011).

There are some disadvantages with an energy label. When the label was first introduced in 2002 there were poorly defined label requirements and insufficient professionally trained advisors. A television program 'Radar' examined the quality of the advisors. Three advisors investigated the energetic quality of one house and granted three different kinds of energy label (Radar 2008). Another disadvantage is that the label is not mandatory and that it is possible to sign a waiver which makes it possible to circumvent the obligation to have a label when selling the house (Brounen and Kok 2010). The intention of the recast EPBD is to remove these disadvantages. Another disadvantage is that an energy label requires an investment of the seller of about €200. The advantages of an energy label are not clear for the owner occupant and because it is not mandatory one is not willing to pay €200 for an energy label because one has risk aversion (Boerbooms 2010). There is also a large unfamiliarity with the energy label. Research from 'MilieuCentraal' showed that only 16% of almost two thousand responds knew what an energy label implied, knowledge about an EPA advice was only 7% (Schalkwijk and Mulder 2009).

An energy label also has advantages which can motivate the owner occupant to take energy saving measures. Firstly, the next occupant knows with this label if it is an energy efficient home and if there are possibilities to enhance the energetic quality of the dwelling. Another advantage is that an owner occupant is sensitive for feedback and an energy label can provide that feedback.

There is some evidence that houses with a higher energy label have a higher selling price. In a research of Brounen and Kok they investigated the selling prices combined with energy labels for the residential sector in the Netherlands (Brounen and Kok 2010). They found that the labels given to residential dwellings are declining because of negative publicity in the media. Another result is that households with a lower monthly income are more likely to have a label. Some of the labeled dwellings "*have a relation with less competition in the local housing market*" (Brounen and Kok 2010). Another result is that home buyers are willing to pay more for houses that have a higher energy label and thus are more energy efficient. Home buyers are willing to pay two to three percent more for a higher label. This depends on the height of the label (Brounen and Kok 2010). Also Meijer and Visscher found that one is willing to pay more for a house with energy efficient facilities (Meijer and Visscher 2009).

5.3.3.2 White certificates

White certificates guarantee a certain amount of realized energy saving. They are comparable with the clean development mechanism of the Kyoto protocol (Rooijers, Leguijt and Groot 2010). The idea is that one specific party, for example energy suppliers, have the obligation to let their customers take energy saving measures. Therefore they should offer products and services. Customers have to pay a little more for their energy (Lalieu 2011). The government can obligate the energy suppliers to achieve

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of the investment costs and savings. EPA uses actual energy consumption and not modeled energy consumption.

a specific annual amount of white certificates. When the supplier does not achieve this objective a penalty has to be paid (Rooijers, Leguijt and Groot 2010). In 2006 the principle of white certificates was proposed by the government but there was too much resistance of the energy sector. As a result of this the agreement 'Meer met minder' was formed (LaCroix 2011). In the UK white certificates were implemented quite successful. In the beginning the expenses of the investment costs and advertising etc were low. After that the relatively cheap, easy and profitable measures were done the expenses increased because of higher investment costs as well as higher costs to motivate owner occupants (Rooijers, Leguijt and Groot 2010). Eventually it resulted in a wait-and-see attitude because customers waited until energy suppliers came up with an attractive financial proposal (Lalieu 2011). It is unlikely that this instrument will be successful in the Netherlands because the energetic quality of the building stock in the UK was of poorer quality and therefore more benefits could be achieved (Lalieu 2011) (Rooijers, Leguijt and Groot 2010).

5.3.3.3 Fiscal instruments

Research has been done to several fiscal instruments to enhance the energetic quality of dwellings. For example, Vethman 2009 compared numerous financing instruments. He concluded that an instrument which seems to be most suited is differentiation of the 'transfer tax' (OVB) (Vethman 2009). Also 'Stichting Spaar het Klimaat' concluded that differentiation of the OVB is promising (klimaat 2010). Therefore only this fiscal instrument is more elaborated.

Transfer tax or OVB has to be paid when a person becomes owner of a dwelling. This tax is 6% of the purchase price plus additional expenses that have to be paid. Differentiation of the OVB can stimulate owner occupants to take energy saving measures because it can give a financial incentive when one buys a new dwelling. For example, suppose it costs 10.000 Euros to get a B label and that one percent of the OVB is given back to the occupant if this is achieved. If someone purchases a house of 200.000 Euros a financial reward of 2.000 Euros is given (Rooijers, Leguijt and Groot 2010). Receiving the financial reward afterwards causes risk aversion which is described in section 5.2.3.2. This instrument has a small effect on the short term because it only has influence on mutation. Because on average annually one out of 20 owner occupants moves, the instrument influences 5% of the total stock (klimaat 2010). Furthermore a disadvantage is that higher income households who can afford to buy a more expensive dwelling receive a higher financial reward.

5.3.4 Barriers

An important barrier concerning reinforcing factors is the unstable policy of the government. To start, several subsidies described in section 5.2 are perceived as being too complicated and time-consuming. Also the percentage of free riders is very high; several reports estimate the percentage of free-riders at 50-60%. This can be explained by the difference in adopters (Egmond 2006).

Furthermore unstable policy causes uncertainty and frustration among the owner occupants but also among suppliers of energy saving measures or installations. The government can create certainty by setting a clear term for subsidies or policy. According to Boerbooms, Hal and Diepenmaat setting clear deadlines increases the chance of success (Boerbooms, Hal and Diepenmaat 2010). The Clean Energy Group state that energy programs should focus on progress and shorten the decision process. Following a decreasing stimulating program would be very effective according to them. Every year the financial incentive decreases this increases, according to them, the decision process (Sinclair and Rosoff 2009).

An example of unstable Dutch policy which resulted in frustration and uncertainty was the abolishment of the ‘Energie Premie Regeling’ (EPR) in 2003. This was a subsidy for insulation, high efficiency boilers, solar boilers and photo voltaic panels (Boonekamp, et al. 2003). Before the abolishment the Netherlands was a leading player in the solar energy market, but after the abolishment the market for photo voltaic panels collapsed. Because of this the Netherlands now has to catch-up with respect to solar energy (Roofs 2011).

The German policy is much more stable. Their government introduced in 2000 the ‘einspeisegesetz’ to promote renewable energy. Customers who installed a solar panel for example received a feed-in compensation for generated solar energy. This compensation is fixed for 20 years; therefore customers get certainty about the payback time of solar panels. Energy suppliers have to pay this compensation but they pass this on to the customers, households have to pay about 35 Euros annually. Because of this policy the market for photo voltaic panels in Germany increased, the purchase price decreased and it resulted in additional employment for ten thousand people (Baal 2007).

5.3.5 Conclusion

This section described several reinforcing factors that can reinforce the motivation to take energy saving measures.

The first reinforcing factor described is feedback. Comparative feedback can create competition which reinforces behavior. A drawback of comparative behavior is that when the wrong feedback is given it does not motivate but can achieve the opposite.

Recommendation 1: Create competition by giving comparative feedback. This increases energy savings, provided that the right message is send

A more effective way of feedback is experience and conversation about energy saving measures with peers. Those who have already adopted energy saving measures could serve as ‘ambassadors’ to motivate those who are still in doubt. In motivating owner occupants the different adopter categories should be kept in mind. The first two are mostly motivated by the innovativeness and scarcity of the product. The majority are motivated when it is proven that energy saving measures have advantages and benefits. The strategy to motivate those two categories should be different. Another finding of the evaluation of the target groups is that the element of competition can increase the rate of adoption.

Recommendation 2: People who have already adopted energy saving measures should act as ‘ambassadors’ to share their experience with those who have not

Recommendation 3: Send a different message to each adopter category to motivate them

Workshops and personal advice by experts are other reinforcing factors. Experiments have shown that workshops increases awareness, knowledge and willingness to take energy saving measures but that an actual action to take measures does not occur. Combining workshops with personal advice gives them opportunities to act.

Recommendation 4: Give personal advice about energy saving measures, the related investment costs and benefits to increase the rate of adoption

Recommendation 5: Combine workshops with personal advice to give owner occupants opportunities to act

Several regulations made by the government can also reinforce behavior. An example is an energy label which can give a better understanding of the energetic quality of the dwelling. Until 2013 it is not mandatory to show an energy label. This is a disadvantage at this moment. Another disadvantage is the lack of experience among experts who assess the energetic quality of a dwelling. Besides the lack of experience a disadvantage is that owner occupants have to invest about €200 to receive such a label. However, an energy label has also some advantages. It can give opportunities to act and there is some evidence that houses with a higher energy label have a higher selling price.

Recommendation 6: Regulations about the energy label should be made more clear and obligatory

Recommendation 7: Indicate a possible value increase of a dwelling after applying energy saving measures

The principle of white certificates was a successful instrument in the UK but is unlikely that it will be successful in the Netherlands. The average energetic dwelling quality in the Netherlands is higher than in the UK and the principle of white certificates was only successful for relatively cheap measures. Eventually it created a wait-and-see attitude of owner occupants and did not motivate owners to take energy saving measures.

The government can also offer several fiscal instruments to reinforce the motivation of owner occupants. In this section only the most promising instrument, OVB, is discussed. This instrument can create a financial incentive that can motivate owner occupants; however this incentive is only created on mutation moments. Therefore it has a small effect on the short term. Since the financial reward is given afterwards it causes uncertainty. Because people are risk averse it is not likely that it will be a very successful instrument, also because of the unstable policy of the government.

Stable policy can result in faster adoption of energy saving measures, as is explained with the example of the German ‘einspeisegesetz’. The Dutch policy causes uncertainty among owner occupants but also among suppliers. The government should make long term goals and make clear policy to achieve those goals. For example, the government should make a stricter policy for an energy label. It can, for example, forbid that houses with a low energy label are sold, until they are energetic improved. By tightening the norm it can increase the energetic quality.

Recommendation 8: The government/ municipalities/ project developers must formulate clear goals and deadlines

To optimally reinforce behavior changing instruments are needed which is visualized in Figure 5.5, were Figure 5.4 is modified with instruments to motivate owner occupants. The first step is agenda and goal setting by the government or municipality. Making clear goals, deadlines and stable policy increases the chance of success. The innovators and early adopters can serve as ambassadors to cross the ‘chasm’ and to share their experiences with others. In the category of the early majority and the late majority several barriers exists, which have to be remove. Those barriers are already described throughout this report. The late mass is skeptic to take energy saving measures and will not adopt measures until regulations and standards are made.

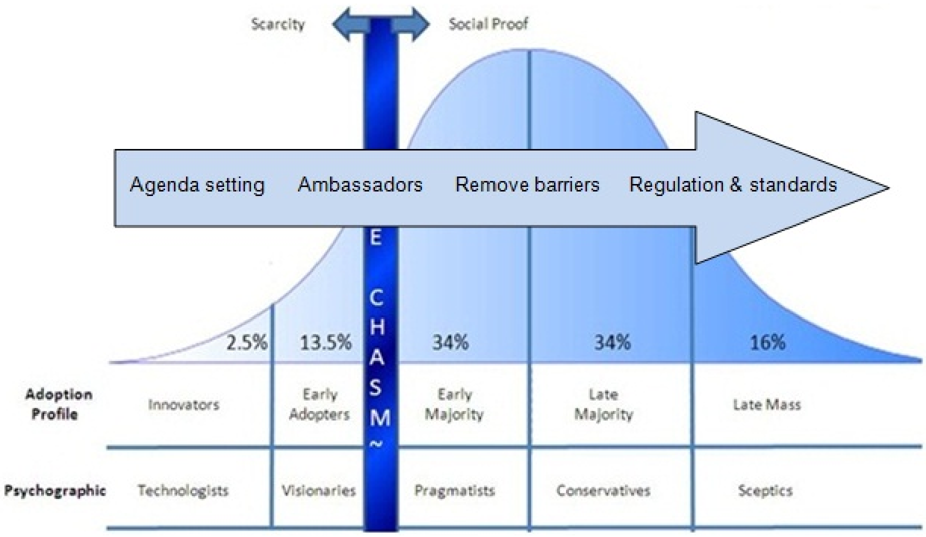

Figure 5.5: Adopter categories with policy strategies

6 Survey among owner occupants

The qualitative research discussed in the previous chapters came up with several barriers for owner occupants to apply energy saving measures. To verify these barriers and to find underlying motivations for taking some measures, an online questionnaire has been sent to owner occupants. This chapter describes the goal of the questionnaire, and discusses the variables and the results of the questionnaire. At the end of the chapter the results of the questionnaire are linked to the findings of the previous chapter about influencing factors for energy saving measures.

6.1 Survey goal

The questionnaire has been sent to the employees of Arcadis ‘s Hertogenbosch. The goal of the survey is to find influencing determinants that encourage owner occupants to take energy saving measures. As well as, to find which measures are popular to take. The results of the questionnaire contribute to evaluating and determining different strategies to motivate an owner occupant to take energy saving measures.

6.2 Respondents

As mentioned, the survey was spread using an online questionnaire and it was sent to about 200 employees. The employees had a period of three weeks to complete the questionnaire. At the end of this three week period, 95 employees had started the questionnaire of which 75 actually finished it. The high response rate could be explained by the fact that it concerns an internal research[26].

6.3 Variables

The survey consists of different components. The first part asks for general information on for example dwelling type and building period (before 1975 or after). The second part asks the respondents about their knowledge of the energy bill and whether the respondents think that they live in an energy efficient dwelling. These questions should give an indication about their awareness of and sense of urgency for energy saving measures. The third part focuses on which measures are popular to take and whether the respondents have applied energy saving measures and if so, for what reasons. The final part of the questionnaire tests the knowledge of the respondents about several measures. The respondent estimates the cost and benefits of the investment for several measures. At the end of the final part, the respondents are asked whether they would invest in the measure.

6.4 Results

In Figure 6.1 the results of the different dwellings are compared with the research performed by AgentschapNL. As already mentioned in chapter three, the research of AgentschapNL gives a good reflection of the total building stock.

[26] Several employees responded that they did not start the questionnaire because they were no owner occupant. Therefore it is plausible that many employees intended to answer the questionnaire and sending a reminder will not increase the number of respondents that much.

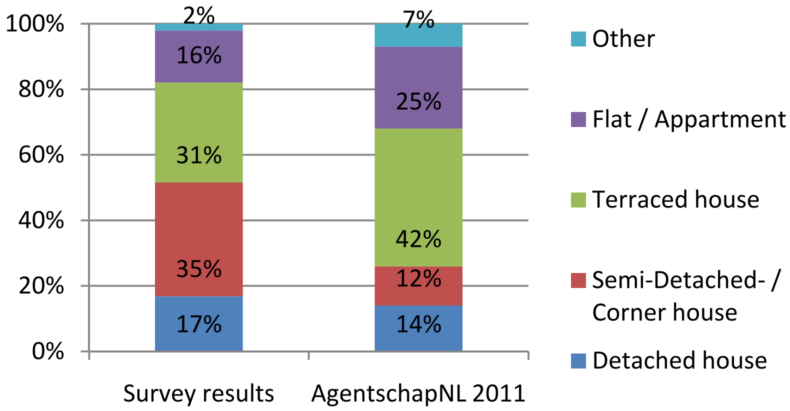

Figure 6.1: Dwelling types survey compared with AgentschapNL

The percentage of detached houses (17%) is just slightly higher in the survey than the research of AgentschapNL (14%). Remarkable differences are found for the categories terraced houses and semi-detached houses. First, this is because, the survey uses different dwelling categories than the research of AgentschapNL. In the latter, corner houses are grouped with terraced houses. In the survey, semi-detached houses and corner houses are grouped together because both dwellings are on one side attached to another dwelling, resulting in quite similar energy consumption. A second explanation for the remarkable differences could be that 80% of the respondents to the survey are owner occupant. According to AgentschapNL only 60% of the building stock is owned by owner occupants. Semi-detached and corner houses have a higher percentage of owner occupants than terraced houses, which generally have a high percentage of tenants. This can also explain the difference in the category flat / apartment.

Apparently most of the respondents live in dwellings build after 1975 because almost 64% of them answered that the building period of their dwelling was after 1975. This is high compared to the average of 42%. On average 58% of the inhabitants in the Netherlands live in dwellings build before 1975. This variation can be explained by the difference in income. In general lower income households live in older houses (building period 1945-1975) of poorer quality which are cheaper to buy, e.g. sold rental property (Klerks, et al. 2009).

As already mentioned in section 5.1 there needs to be a sense of urgency or awareness to do something to reduce the amount of energy used. To test this, the respondents were asked to give their opinion about the energy efficiency of their house. If they think their house is energy inefficient it is arguable that their willingness to increase the efficiency is higher. Most of the occupants think their dwelling is average efficient or energy efficient. Occupants of houses build before 1975 think their dwellings are less energy efficient than occupants of houses build after 1975, as can be seen in Figure 6.2. It seems to be that the group of occupants with a house before 1975 is aware of the fact that they live in an energy inefficient house. It appears that most occupants can estimate the energy efficiency of their dwelling.

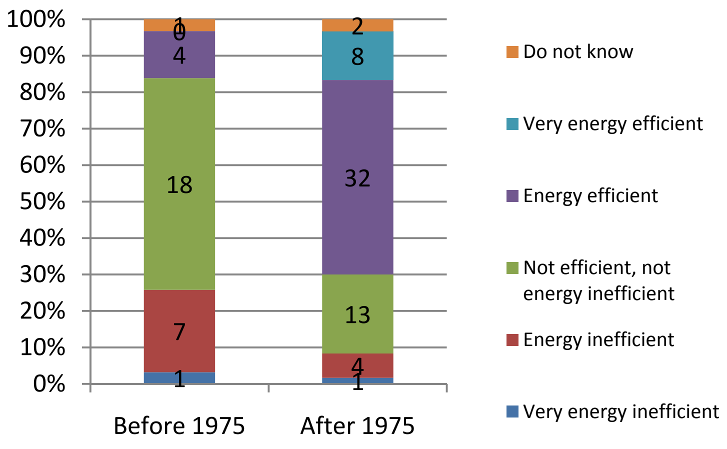

Figure 6.2: Opinion of occupants about the energy efficiency of the dwelling

The respondents were asked if they knew their energy consumption on a monthly basis. Almost 85% of the respondents answered that they knew their energy consumption roughly or not at all. This is in line with the results of a research of Milieu Centraal where 87% answered to know their energy consumption roughly or not at all (GfK 2009). Occupants can estimate if their house is efficient or not but their knowledge should still be increased because many do not know their energy consumption. If they know the consumption, energy saving measures are useful and possible. The respondents were also asked if energy efficiency of a house was taken into consideration to purchase the house or not. More than 70% of the respondents answered that the current energy efficiency of the property was not taken into consideration. When they were asked if energy saving was important 80% answered that they find energy saving important. No difference is found between age of the buildings. Thus many find energy saving essential but this is not an argument when buying a new property. Subsequently the respondents were asked why they think energy saving was important. The argument that it could save money was a more important argument then that is was good for the environment. It seems that motivation is driven by financial reasons. Other researchers also found that environment is an inferior motivator (GfK 2009) (Horst 2008). Energy saving is important for households. They are able to estimate if they live in an energy efficient house, but their precise energy consumption is unknown. When buying a house energy efficiency is not taken into account. This is remarkable because saving money is an important argument to save energy and an energy efficient house has lower monthly expenses.

As already mentioned, many respondents find energy saving important. 56% of them took energy saving measures in the last 5 years. As can be seen in Figure 6.3 almost two third of the occupants of dwellings before 1975 took measures compared to more than 50% in the other group. However, when this data is tested using statistics, the building period does not influence the decision to take measures. Also the current energy efficiency of the dwelling does not influence the decision to take energy saving measures.

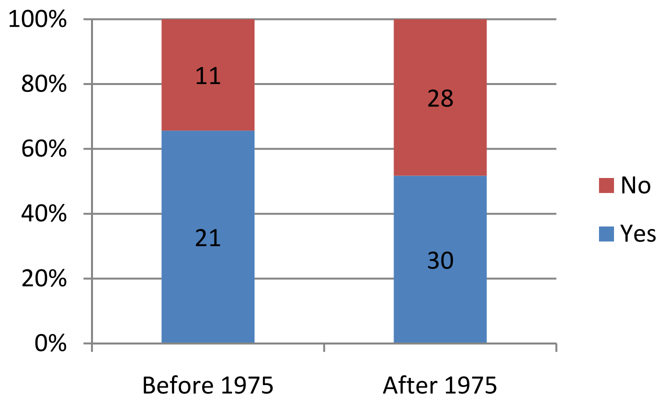

Figure 6.3: Are there during the last five years energy saving measures done?

To those who have applied measures, is asked what measures they have adopted. The results are shown in Figure 6.4.

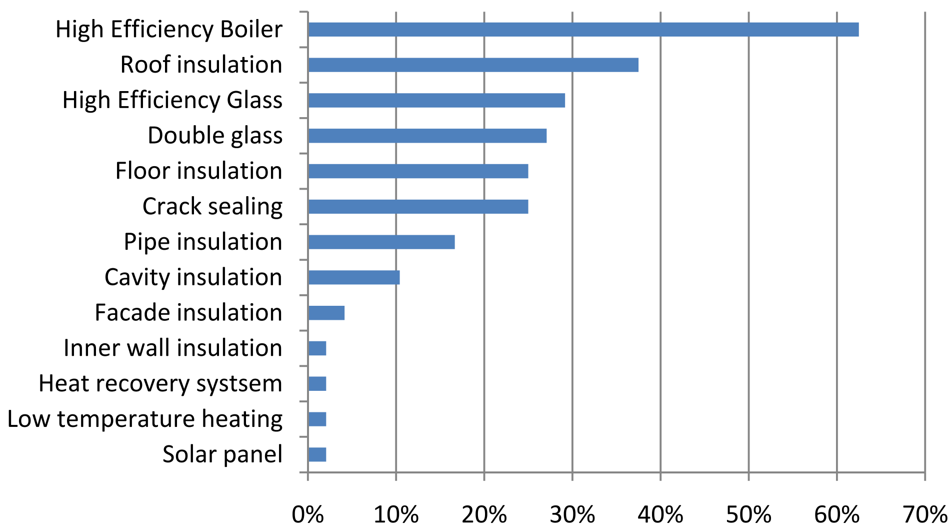

Figure 6.4: Measures taken by respondents

Installation of a high efficiency boiler is mentioned by over 60% of the respondents. Also high efficiency glass, double glass and crack sealing are popular measures. In other researches of research institute OTB and 'Vereniging Eigen Huis (VEH)[27]' quite the same measures are found. Installation of a high efficiency boiler is the most popular measure. Replacing regular light bulbs with energy saving light bulbs is another popular option, as well as, installation of double glazing or high efficiency glass. The solutions are mainly sought in improvements of installations. Placing solar panels is also a popular measure according to research of VEH (Oel, et al. 2010) (Meijer and Visscher 2009). The results of the researches show that solutions to save energy are sought in improving installations and not in improving insulation, except for double glazing. This is quite remarkable but an explanation could be that installations can relatively easy be replaced when it is not functioning anymore. In that

[27] VEH did a survey among 1565 owner occupants about the intention to invest in energy efficiency.

case most people choose for an installation with a higher quality e.g. a high efficiency boiler instead of a conventional boiler; LED lighting or energy saving light bulb instead of a regular light bulb. Replacing glass by high efficiency glass occurs when glass is broken, but more likely is the case when the occupants have nuisance of cold whereby the comfort decreases or when window frames are firm rot and they choose to install new window frames as well as high efficiency glass. Insulation of facade, roof or floor can also increase the comfort but are somehow less popular than double glazing. There are some problems with installation of these measures. For example insulation of the inside of the façade or floor insulation requires high effort of the occupant because the inside of the building must be empty and power points and/or doorsteps must be replaced[28]. Natural moments[29] are suitable for this kind of renovations, but the consumers must be made aware of the options. This can be an explanation for the high percentage of roof and floor insulation mentioned in the questionnaire. Because the target group are employees of Arcadis, which is an engineering and consultancy office, it could have knowledge that is above average about insulation measures. Another explanation can be that the age of the target group is younger than average and therefore have a higher turnover rate. The combination of knowledge and natural moments can cause a higher percentage of roof and floor insulation.

Intomart performed a research, commissioned by MilieuCentraal, on energy savings in households and the willingness to take measures[30]. The questionnaire asked the respondents which measures they knew to save energy. The measures most mentioned are first more LED or energy saving light bulbs, turning down the heating and on the third place insulating the house. In that research of Intomart measures which have to do less with behavior and more with investment are mentioned more by owner occupants then by tenants. This is a result which was expected but a remarkable finding was that for the installation of double glass no difference was found. Apparently, tenants are willing to invest in double glass but not in insulation while insulation is more cost effective. Another finding from this research is that double glass (12%) and replacement of the conventional boiler (8%) are less mentioned as energy saving measures, but are popular measures to take. Probably those measures are not associated with energy savings (GfK 2009). The respondents of Arcadis who have taken measure were asked why they have taken those measures. Most of them answered that it increased the comfort (27%) or that it needed to be replaced (27%). A lower energy bill was a third reason to apply measures (23%). Only 8% of them answered that they did it because it was good for the environment. Again this shows that environment is an inferior motivator. This is in line with the research of OTB and VEH. In those researches saving money on the energy bill and increasing the indoor comfort were the two most important reasons to adopt energy saving measures. Spare the environment and tackle moisture and ventilation problems are less important reasons. The reason least mentioned is to save energy because it can increase the value of a building (Oel, et al. 2010) (Meijer and Visscher 2009).

Thereafter all the respondents were asked which measures they would adopt in their dwelling. Simple measures such as crack sealing and pipe insulation are most mentioned, but also placing of double

[28] Note that when a crawl space is available this disadvantage does not apply for floor insulation.

[29] Natural moments are removals, leaks, or defects in house.

[30] The research was done among 400 tenants and 418 homeowners using an online questionnaire

glass or high efficiency glass. Insulation of façade or inner wall are not popular, while floor and roof insulation are. A research of 'Milieu Centraal' investigates what the reasons are for private owners to not use façade insulation in their dwelling. Special attention is given to the target group of residents of houses built before 1976. It appears that four out of ten house owners had an insulated façade. Only 11% of the 1863 respondents who have no façade insulation take it into consideration (Schalkwijk and Mulder 2009). General unfamiliarity exists with insulation on the outside of the façade (GfK 2009).
Complex and technical measures such as a heat pump, low temperature heating or micro CHP boiler are also measures which are not popular. One measure which has to be noticed is the installation of photo voltaic panels. 37% of the respondents will maybe install such a panel and 15% answered probably or certainly.

To determine which variables are relevant to apply energy saving measures 19 questions have been asked. A factor analysis is done to identify a number of factors that can explain most of the variance observed. Almost 70% of the variance is explained by six factors. The first factor is energy related. It includes the variables 'current energy efficiency' and 'energy label'. The second factor includes the variables 'increase of comfort', 'current comfort' and 'healthier indoor climate', this factor is comfort oriented. Another factor identified is the inconvenience or difficulties one has when taking energy saving measures. Also knowledge is a factor which is found to be important. Financial aspects such as payback times, monthly savings and insight in costs/benefits are the fifth factor found. Financial opportunities and energy awareness is the last factor found.

The respondents were asked to give their opinion about several propositions. They were asked to estimate the costs for different energy saving measures. There appeared to be a large difference in estimation of investment costs. In general the respondents underestimate the costs. This is a remarkable result, because it was expected that the costs were overestimated. If the high investment costs were a barrier to invest in energy saving measures they would have overestimated the costs. There are two results that are further discussed below. The investment costs for cavity wall insulation are highly overestimated. Some respondents thought the investment was higher than 5000 Euros, while the actual investment cost for cavity wall insulation in a simple terraced house is between 500 and 1000 Euro[31]. Only 15% of the respondents estimated the costs close to the real costs, as can be seen in Figure 6.5, where the green bar represents the category of the estimated investment costs that matches the real investment costs. When the respondents were asked to estimate the monthly savings, they underestimated the savings, as can be seen in Figure 6.6. An explanation for this result can be a lack of knowledge among occupants.

[31] The costs for cavity wall insulation is very situation dependent. The investment costs for cavity wall insulation of detached houses is higher, however the return on investments are also higher.

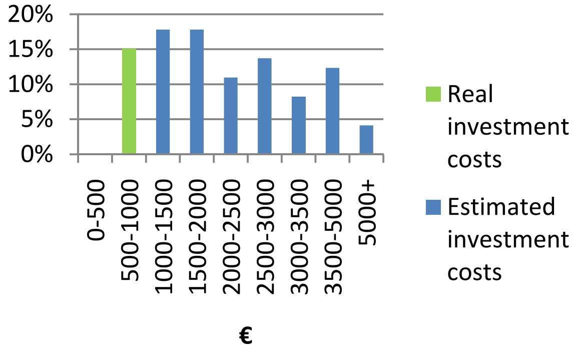

Figure 6.5: Estimated investment costs cavity wall insulation

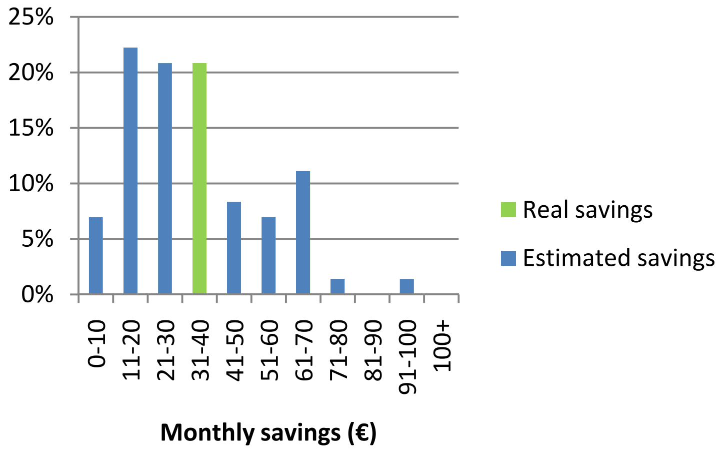

Figure 6.6: Estimated savings cavity wall insulation

From Figure 6.7 can be derived that the investment costs for photo voltaic panels are underestimated. Almost 80% of the respondents estimate the costs for 8 m² of PV-panels below 3000 Euros. The actual costs are higher at this moment[32]. The actual 'savings' are overestimated as is illustrated in Figure 6.8. Almost 80% of the respondents estimate a monthly saving of more than 20 Euros. After the opinion of the investment costs and returns the respondents received the real investment costs and the real savings. Many found photo voltaic panels very unattractive to invest in. 60% of the respondents would not invest in it, whereas 52% answered before that they were willing to invest. This indicates that there is lack of knowledge or lack of information.

[32] Based on research of PRC, reference date April 2010

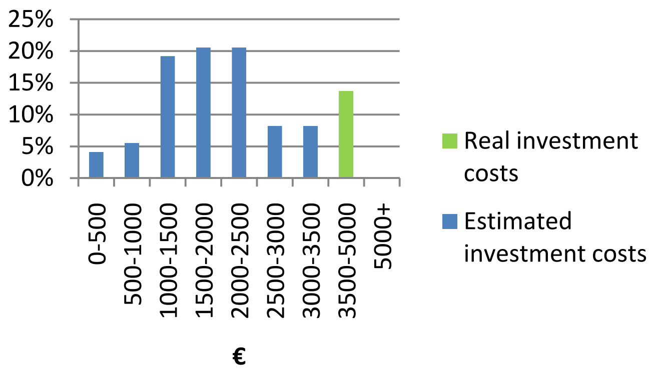

Figure 6.7: Estimated investment costs PV (8m²)

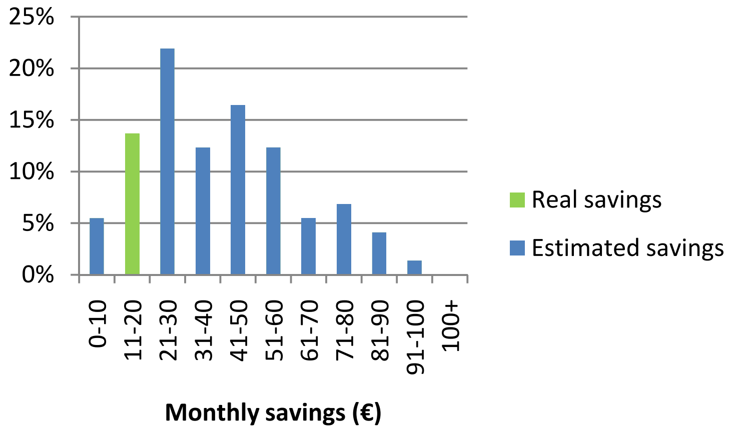

Figure 6.8: Estimated 'savings' PV[33]

The outcomes for the estimations of cavity wall insulation and photo voltaic cells are opposite. The investment costs for the first are overestimated while the costs for PV panels are underestimated. The same applies for the estimated savings. It is difficult to draw a conclusion from these results. It could be that there is more information about photo voltaic panels and, as a reason of that people underestimate the costs. Also visibility of the panels can have an effect on the underestimation. Because the panels are visible people can unconscious form an opinion about the costs. Besides visibility it can be that photo voltaic panels has a positive image whereas insulation of a cavity wall has a negative image because of moisture problems.

6.5 Conclusion

This chapter tried to find underlying motivations to take energy saving measures. It also tried to verify some barriers found in the previous chapter.

There appears to be a lack of knowledge about the energy consumption and energy saving measures. This knowledge should be increased because this results in uncertainty about the actual savings and payback times. Owner occupants can estimate the energetic quality of their dwelling quite well.

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[33] The savings are based on a sloped roof positioned north-west with an angle of 36°. If the dwelling is positioned south the monthly savings are higher

However they do not take energetic quality into account when purchasing a dwelling. They should take this into account because energy saving measures are most profitable on natural moments.

Owner occupants take energy saving measures, but those measures are quite simple. Measures they intend to take within five years are again simple measures; a remarkable result was that many indicate that they will install photo voltaic panels. When the respondent were asked why they have taken energy saving measures, increase in comfort, needed to be replaced and a lower energy bill were the main reasons to take energy saving measures. Only a small group answered that they took energy saving measures because it was good for the environment. Several propositions about energy saving measures showed that comfort, knowledge, financial aspects, current efficiency and self-efficacy are factors that influence the decision to take measures. A lack of knowledge exists about the investment costs and savings. As already mentioned, increasing this knowledge is important because owner occupants then can estimate their benefits.

7 Conclusions and Recommendations

In this chapter the conclusions of the research will be given as well as recommendations that are important to enhance energy savings in existing residential buildings of owner occupants. This chapter will answer the research question "**How can owner occupants be motivated to take energy saving measures?"**

In order to be able to answer the research question this chapter is structured by the model of Green and Kreuter. The conclusions are summarized in this chapter and also recommendations are given which are already mentioned in the previous chapters.

7.1 General conclusions and recommendations

Single family houses built before 1975 are poor insulated, mainly due to the lacking of regulations during that period. Therefore, dwellings built before 1975 have a high savings potential. Many technical measures to increase the quality are available and some are already adopted but those are not always the most effective ones. In general, measures done are the replacement of conventional boilers with high efficiency boilers, the replacement of single glass with double or high efficiency glass and other simple measures such as crack sealing and to a lesser extent roof insulation. Insulation, such as façade, roof and floor insulation, is most effective and profitable but is not a popular measure to invest in. Because the whole unit functions only as well as the least effective component one must adopt an energy saving package. In chapter 4 the average investment costs are estimated to be about 12.500 Euro.

Conclusion: **Single family dwellings built before 1975 are poor insulated and have a high saving potential**

Conclusion: **Many technical measures to enhance the energetic quality of dwellings built before 1975 are available. Insulation is most effective and profitable, but other measures such as installation and high efficiency glass are most popular. The average investment costs to make a dwelling more energy efficient are about 12.500 Euro**

There appear to be several barriers with respect to energy saving measures. This is also called the efficiency gap. Several factors can be responsible for this. The first factor is predisposing and can form the purpose for making the decision to start behavior. It is argued that the purpose starts with awareness of a problem or need. People are aware of the importance to be careful with energy use but the felt need to do something about it seems to be low. High efficiency boilers and double glazing seem to be measures of which the problems are solved in a routine way. The sense of urgency to increase the efficiency of a dwelling is low, also because the percentages of people's income spend on energy costs seem to be small. Energy saving has not a high priority compared to aspects such as dwelling type and comfort. Furthermore a finding of this research is that there is a lack of knowledge about actual energy use and potential savings.

Conclusion: **People are aware of the importance to be careful with energy use. However the felt need or sense of urgency to do something about it seems to be low because there is a lack of knowledge about the actual energy use and potential savings. There is also lack of self-efficacy because adoption of insulation is a decision made once in a lifetime**

Conclusion: **Energy saving measures does not have a high priority for owner occupants compared to contextual aspects, such as orientation of the dwelling and emotional aspects, such as comfort and status**

Recommendation: **Increase the sense of urgency with information and visualization**

Recommendation: **Point out the relative advantage by linking energy saving with other aspects that have a high priority, such as comfort**

Recommendation: **A ‘model dwelling’ can increase the relative advantage, compatibility, trialability and observability which positively influence the attitude of a person towards energy saving measures**

Recommendation: **Increase knowledge about energy saving measures**

Recommendation: **Make energy saving measures visible to increase the rate of adoption because it can give social reward**

Recommendation: **Unburden the owner occupant by helping searching for suitable energy saving measures**

The second factor which is important is the availability and accessibility of financial resources. Those resources are only used if owner occupants have the motivation to adopt energy saving measures. If owner occupants want to take energy saving measures it is estimated that they are willing to pay around €2000-€4000. Therefore loans start at a minimum of about €2500. It is argued that the high initial investment costs are a barrier for owner occupants. This barrier is perceived higher because there are resistance costs. Those resistance costs can to a large extent be removed when energy saving measures are done on natural moments. There are several financial instruments available that can help owner occupants to finance energy saving measures. Subsidies offered by the government are most popular but cause frustration because they are exhausted frequently. A durability loan offers an attractive solution to finance energy savings. With increasing energy prices a durability loan is very profitable, however this loan is relatively unfamiliar and people are reluctant to borrow money. It is also uncertain if the calculated savings are enough to finance the investment. Mortgages can offer solutions to finance energy saving measures but also this kind of instrument is relatively unfamiliar.

Conclusion: **There are financial resources available to finance investment. Lack of knowledge about those resources among owner occupants results in low popularity. The investment costs are perceived higher because of the existence of resistance costs. Uncertainty about the actual savings make owner occupants reluctant to invest in energy saving**

Recommendation: **Inform owner occupants about the available financial resources and try to increase the knowledge concerning monthly savings (with annual energy price increase included)**

Recommendation: **Give owner occupants advice about energy saving measures on 'natural moments'**

Recommendation: **Financial institutions should make a distinction between dwellings which are different in energetic quality**

The third category in evaluating the determinants that can motivate owner occupants to take energy saving measures are reinforcing factors. Electronic feedback, such as 'smart meters', are proven to be effective in reducing gas and electricity use. Also feedback relative to the performance of others is useful but the right message has to be given. According to Rogers the most effective tool to spread innovation is communication. Experience of and conversation between peers about energy saving measures can motivate others to adopt energy saving measures. There are different adopter categories which should be approach in a different way. The first category is motivated by the scarcity and innovativeness of the measure while the other is motivated by social proof. Workshops and personal advice are an important tool to motivate owner occupants because there is a lack of knowledge about the available measures and financial opportunities and personal advice can give them opportunities to act. A final reinforcing factor is regulation made by the government. If the government has the right policy set it can reinforce behavior to adopt energy saving measures. However the Dutch government does not have clear policy goals. Several tools, such as an energy label, do not work optimally while they have the potential to motivate owner occupants.

Conclusion: **Experience of and conversation between peers about energy saving measures can motivate others to adopt measures.**

Conclusion: **Clear and stable policy towards energy saving measures can create certainty and increase the rate of adoption**

Recommendation: **Create competition by giving comparative feedback. This increases energy savings, provided that the right message is send**

Recommendation: **People who have already adopted energy saving measures should act as 'ambassadors' to share their experience with those who have not**

Recommendation: **Send a different message to each adopter category to motivate them**

Recommendation: **Give personal advice about energy saving measures, the related investment costs and benefits to increase the rate of adoption**

Recommendation: **Combine workshops with personal advice to give owner occupants opportunities to act**

Recommendation: **Regulations about the energy label should be made more clear and obligatory**

Recommendation: **Indicate a possible value increase of a dwelling after applying energy saving measures**

Recommendation: **The government/ municipalities/ project developers must formulate clear goals and deadlines**

It can be concluded that there is no single silver bullet that will remove all the barriers and eventually can motivate owner occupants to take energy saving measures. It is essential that the three categories that influence the decision are evaluated to indicate what owner occupants find important. Those categories should be considered all at once and not just one. For example, do not focus only on financial aspects, because people often make irrational decisions. Projects that are financially focused have small chance of success. Furthermore it is important to start with evaluating the predisposing factors, because if the motivation to adopt energy saving measures is not present additional financial resources or subsidies will only work for those who already have the intention to adopt energy saving measures.

A recurring theme in several recommendations is the lack of knowledge. Knowledge about energy saving measures is absent. Because owner occupants do not know their actual energy use potential savings are not known. When they want to adopt energy saving measures low self-efficacy causes another barrier. Owner occupants are reluctant to invest in energy saving measures because returns on investment are uncertain. More experience with applying measures in dwellings of owner occupants can give more knowledge about the resulted energy savings. There should be more information for owner occupants on energy savings. For example, a municipality can offer a ‘house purchasing course’ where potential dwelling purchasers receive information about the impact of bad energetic quality of a dwelling and the options to do something about it. This course fits with the recommendation to connect on a natural moment. It can give an owner occupant opportunities to act and it can offer financial instruments if the investment costs are perceived as being too high. Financial institutions can offer a loan or a mortgage with a low interest rate. If there is uncertainty, occupants who have already adopted measures can share their experiences during such a workshop.

An interesting tool to measure whether the energetic quality of a dwelling is increased is an energy label. This label gives, in combination with personal advice, the opportunity to get insight in the energy saving potential of the dwelling. It gives the owner occupant information about the possibilities. There is some evidence that dwellings with a higher energy label have a higher selling price, thus owner occupants get a part of their investment costs back when they sell the dwelling. There are of course external factors which can influence the selling price and therefore there is uncertainty if owner occupants get a part of their investment costs back when they sell the dwelling. An energy label can also be connected with several fiscal instruments such as transfer tax or mortgages. Those reasons mentioned above indicate that the obligation of an energy label should better be at the purchaser instead of the seller because it has more advantages for the potential buyer. The government should more clearly define the label requirements and the advisors should give a more uniform advice about the energetic quality. If an energy label is more optimized the government can make requirements that forbid for example the transaction of dwellings which have a poor label.

7.2 Recommendations for Arcadis

As mentioned at the beginning of this report this research is conducted at Arcadis. Arcadis gives advice to, among others, municipalities. This research has several recommendations about motivating owner occupants to take energy saving measures. First of all, Arcadis and a municipality should make clear policy goals with deadlines. It is important that a field research, e.g. a questionnaire among owner occupants, is done to know the needs of the target group. After this field research owner occupants that are interested in energy saving measures should become ambassadors to persuade others. They should be involved in the project and decision process. When the needs of the occupants is known try to come up with solutions that fit with those needs. Cooperation with brokers is necessary to fit with a natural moment. If the high investment costs are a problem loans or mortgages can be offered to finance the measures. Furthermore the project of 'Nijverdalse wijk de blokken' showed that energy saving is not a leading argument to adopt energy saving measures. Improvement of the neighborhood was more important. This project was successful because of high participation of occupants. Because the results were visible to others the interest of owner occupants to take energy saving measures increased.

8 Discussion and further research questions

Throughout this report it is made clear that many factors can influence the motivation or decision of owner occupants. There are numerous strategies available to enhance energy saving. To determine successful strategies and to better understand the issues involved a multidisciplinary approach is used. An assumption made at the beginning of this report was that motivating owner occupants requires a behavioral change. Now that the research is completed it is possible to determine if this Precede-proceed model was the most appropriate model to use in this research. Motivating owner occupants to take energy saving measures requires indeed a behavioral change, because many are stuck in habitual behavior. Using the model of Green and Kreuter allowed getting insight in the various factors influencing behavior. This multidisciplinary approach considered both the internal factors of behavior, the predisposing factors, as well as external factors of behavior, the enabling and reinforcing factors. Furthermore, this framework also provided a foundation for a model or working plan that can motivate owner occupants to take energy saving measures.

The multidisciplinary approach of Green and Kreuter gave several insights in the problems concerned with energy saving measures and the goals set by the government to achieve CO_2 reduction. Chapter three and four mentions the quality of the building stock and the measures that are available to improve the energetic quality. During interviews it became clear that no consensus exist about which measures to take. There are basically two different beliefs. The first is that small energy saving measures are effective because the investment costs are small and the occupant can experience the effect of the measure. Others belief that large radical measures are necessary. There are several arguments why radical measures have potential. The first is that to achieve an energy neutral municipality existing buildings must reduce their energy use significantly and with simple measures such as cavity wall insulation this is not achievable. Another reason is that radical innovations, for example a new façade with insulation, increases the visibility and has the potential to become a routine with removals. Nowadays the first things occupants replace when refurbishing their dwelling are in general double glazing and/or roof insulation. If there are façade products available that can increase the energetic quality it can be that this measure is also done. Those two beliefs are different in approach, but the ultimate goal is the same. The goal of both is to achieve, for example, an annual energy reduction of two percent. The first tries to achieve this by an energy reduction of two percent for all dwellings whereas the latter tries to achieve this by making two percent of the total building stock energy neutral. This discussion can be further investigated in another research.

Further research question: Which approach is more effective, an incremental or a radical with respect to energy saving measures?

Related to the above formulated research question is a question related to suppliers. This research focused on the demand side but the suppliers of energy saving measures can also influence this energy related problem. Quite a lot of interviews indicated that there is also lack of experience and knowledge among suppliers. If owner occupants want to refurbish their dwelling they should also be encouraged by suppliers to take energy saving measures. Therefore another research question is.

Further research question: How can suppliers in the building sector be motivated to encourage energy saving measures among owner occupants?

This report described that three important factors influence behavior. The first is the predisposing factor which can motivate an owner occupant to take energy saving measures. Analyzing this factor raised several questions. It appeared that energy saving is not to everyone's concern. They are therefore not willing to pay the high investment for energy saving measures. This research often encountered this problem. People spend their money rather on a new car or a vacation than on energy saving measures. Some experts argued that this is due to different norms, beliefs and priorities. If there is no positive perception about energy saving measures financial instruments will only work for those who already are positive about energy savings. The first step is to create such a positive perception or a different mindset. There are some ideas to do this by linking energy saving measures with emotional aspects such as health, safety and quality. Another possibility is to formulate energy savings in a different way, as is described in Table 5-1 section 5.2. In other words a more marketing or decision theory oriented approach is needed, or to quote Godin again: "*It's a lot easier to sell something that people are already in the mood to buy*".

Further research question: How to link energy saving measures with personal needs and emotional aspect such as health, safety and quality?

The enabling factors described showed that there are several financial opportunities to finance energy savings. Payback time, actual savings and return on investment are all aspects that influence the decision to adopt energy saving measures or not. It would be a valuable addition or deepening to this research if an analysis is done about the total benefits. Thus, several scenarios can be made which include the calculated savings, the estimated value increase, the increase in comfort and the estimated increase in energy price. This 'total life cycle' cost can influence the decision of owner occupants to adopt energy saving measures.

Further research question: What are the 'total life cycle' costs and benefits of energy saving measures over a certain period of time

Several organizations try to finance energy saving measures with the achieved lower living expenses; an example of this is an Esco. Especially in the rental sector integrated living expenses are proven to be successful (Blom, Cnossen, et al. 2006). A living expenses guarantee can offer possibilities for financing energy saving measures in owner occupant dwellings. More research has to be done to this topic. There are several arguments why this is difficult to achieve in practice. The first is which actor will bear the financial risk if the savings are not achieved. Another is that rebound effects exist and there is uncertainty about family composition and external influences. What could be possible is that the older energetic worse insulated dwellings serve as back-up to bear the financial risks.

Further research question: How can integrated living expenses finance energy saving measures in owner occupant dwellings?

As mentioned in this report rewarding people with good behavior has a better effect than punishing people who do not perform that behavior. Rewarding owner occupants for a low energy bill has a better effect than punishing those who have a high energy bill. There are several advantages by doing this. First, people do not have to take energy saving measures but can for example lower the thermostat; this does not involve high investment costs. Second, owner occupants who get a reward can be motivated to take energy saving measures in order to get a higher reward. However how this should be done is not elaborated in this report.

Further research question: **How can a reward on a lower energy bill motivate owner occupants to take energy saving measures and how should this reward look like?**

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Appendices

Appendix A - General framework for the calculation of energy performance of buildings

Common general framework for the calculation of energy performance of buildings

(Referred to in Article 3)

1. The energy performance of a building shall be determined on the basis of the calculated or actual annual energy that is consumed in order to meet the different needs associated with its typical use and shall reflect the heating energy needs and cooling energy needs (energy needed to avoid overheating) to maintain the envisaged temperature conditions of the building, and domestic hot water needs.

2. The energy performance of a building shall be expressed in a transparent manner and shall include an energy performance indicator and a numeric indicator of primary energy use, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on- site production.

The methodology for calculating the energy performance of buildings should take into account European standards and shall be consistent with relevant Union legislation, including Directive 2009/28/EC.

3. The methodology shall be laid down taking into consideration at least the following aspects:

(a) the following actual thermal characteristics of the building including its internal partitions:

(i) thermal capacity;

(ii) insulation;

(iii) passive heating;

(iv) cooling elements; and

(v) thermal bridges;

(b) heating installation and hot water supply, including their insulation characteristics;

(c) air-conditioning installations;

(d) natural and mechanical ventilation which may include air-tightness;

(e) built-in lighting installation (mainly in the non-residential sector);

(f) the design, positioning and orientation of the building, including outdoor climate;

(g) passive solar systems and solar protection;

(h) indoor climatic conditions, including the designed indoor climate;

(i) internal loads.

4. The positive influence of the following aspects shall, where relevant in the calculation, be taken into account:

(a) local solar exposure conditions, active solar systems and other heating and electricity systems based on energy from renewable sources;

(b) electricity produced by cogeneration;

(c) district or block heating and cooling systems;

(d) natural lighting.EN 18.6.2010 Official Journal of the European Union L 153/29

5. For the purpose of the calculation buildings should be adequately classified into the following categories:
(a) single-family houses of different types;

(b) apartment blocks;

(c) offices;

(d) educational buildings;

(e) hospitals;

(f) hotels and restaurants;

(g) sports facilities;

(h) wholesale and retail trade services buildings;

(i) other types of energy-consuming buildings

Appendix B - List of interviewed experts

List of interviewed experts	
Organizations	**Interviewee**
Arcadis	A. Elbers
	B. van Ogtrop
	J. Frohling
	P. Brouns
	V. Rijsdijk
	N. van Geenhuizen
	P. Nouwen
	T. Koks
AgentschapNL	A. Hulshoff
	C. Egmond
	F. Lacroix
TU/e	J. Lichtenberg
	E. Blokhuis
Vereniging Eigen Huis	C. Umlauf
SEV	J. van den Munckhof
SVn	R. Luigjes
Stichting 'Meer met Minder'	M. Boerbooms
Essent	L. Lalieu
Gemeente Eindhoven	M. Essens