Psychological and structural facilitators and barriers to energy upgrades of the privately owned building stock

Christian A. Klöckner* & Alim Nayum

Norwegian University of Science and Technology

Published in Energy, 140, 1005-1017. (DOI: 10.1016/j.energy.2017.09.016)

Affiliations:

Prof. Dr. Christian A. Klöckner (*corresponding author)

NTNU – Norwegian University of Science and Technology

Department of Psychology

NO-7491 Trondheim

Norway

phone: (+47) 735 91977

fax: (+47) 735 91920

e-mail: Christian.Klockner@svt.ntnu.no

homepage: http://www.ntnu.no/ansatte/klockner

Alim Nayum

NTNU – Norwegian University of Science and Technology

Department of Psychology

NO-7491 Trondheim

Norway

e-mail: alim.nayum@svt.ntnu.no

Abstract

This article studies the psychological and structural determinants, barriers and drivers of the decision to upgrade the energy standard of privately owned residential buildings. A model is developed and tested on a sample of 2,687 Norwegian house owners. The intention to include energy efficiency upgrades in a rehabilitation project is determined by feelings of moral obligation to act, attitudes, and self-efficacy. The model shows also how these variables are linked to distal psychological variables like innovativeness, perceived consumer effectiveness, social norms, problem awareness, and value orientations. The impacts of structural barriers are channeled through the psychological variables. Important barriers are a feeling that the right time has not come yet to start the rehabilitation project, and being unsure about the economic saving potential. Important drivers are better living conditions in the dwelling and higher expected comfort, reduced energy costs and an increased market value of the dwelling, and perceiving the current building standard as a waste of energy. Limited economic resources seem to make people more interested in energy efficiency upgrades. Implications for policy-making are discussed.

Keywords: energy efficiency investments, private house owners, barriers, facilitators, psychology

Highlights:

- Psychological variables mediate almost all structural impacts on energy upgrades.
- Personal and social norms are an important driver of the decision.
- Being hesitant if the right time to act has come is a main barrier.
- Comfort and better living conditions are important facilitators.
- Limited economic resources seem to foster starting to think about energy upgrades.

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1 Introduction

Energy efficiency upgrades of existing buildings provide an opportunity to reduce the energy demand of housing and subsequently the CO_2 footprint of a country [1-4]. Even if a large number of dwellings are heated with electricity that is to a large degree based on hydropower, such as in the case of Norway, using energy more efficiently will free electricity for other purposes. This electricity can be used elsewhere, such as electric mobility or export to other countries where it can be substituted for electricity generated from fossil fuels [5, 6]. Whereas for new buildings energy use has decreased dramatically in Norway and other European countries due to new building regulations [1, 7-9], old buildings are characterized by high energy demands for heating in colder countries or air conditioning in warmer countries [10-12]. Thus, energy efficiency upgrades of buildings that do not fulfill today's standards are a priority in many countries [13, 14]. While older buildings are regularly renovated, energy efficiency upgrades are not always included in such projects, and if they are included, they are not always as ambitious as would be preferable from an energy efficiency perspective [15-17]. Many of the residential buildings that have potential for energy efficiency upgrades are privately owned, and the decision when to renovate and if so to integrate energy efficiency measures lies with the individual household [18, 19]. It is therefore crucial to understand the decision-making processes at the household level, not only including structural and economic variables but also the psychological mechanisms lying behind the (lack of) decisions [18, 20, 21]. Studies exploring this decision-making process are rare. Therefore, this study will explore the psychological structure of the decision-making process and barriers as well as facilitators of decisions for energy efficiency upgrades. With this paper, we aim to empirically underline the

argument, that decisions to invest in major energy efficiency measures in buildings for a private homeowner are often not primarily economic investment decisions, but more complex processes which also include moving from being indifferent about the topic to considering implementation of such measures.

Before we present the theoretical framework for this research, we define the key concepts used in our study, namely *facilitator* and *barrier*. According to the Merriam-Webster dictionary (https://www.merriam-webster.com/), a facilitator is "*someone or something that […] helps to bring about an outcome […] by providing indirect or unobtrusive assistance, guidance or supervision.*" In our case, we define facilitators as all factors that help house owners in making a decision to increase the energy efficiency of their homes in a renovation project. This includes structural factors, psychological cognitive factors, personality factors, social factors, and economic factors. Again, we like to point out that the process of starting considering such a project is in our view explicitly included, hence we are also interested in factors that help driving people out of indifference.

One of the definitions of a barrier in the Merriam-Webster dictionary is "*something immaterial that impedes or separates*", an alternative definition in the same entry is "*a […] structure that prevents or hinders […] action.*" Both definitions are useful in our case. In this study we define barriers as factors that hinder or impede the decision by a house owner to upgrade the energy standard of a house. Again, such factors include structural, psychological, personality, social, and economic components. There may be two possibilities of when a factor can be called a barrier: if it interferes between the wish of a *person* to energy upgrade and the implementation of that wish; or if a person does not even form the wish to energy upgrade and is indifferent about the topic. We decided to define barrier in the broader sense, to also include barriers between the *societal* need for more energy efficiency upgrades and the lack of homeowners participating in energy upgrades. In this research we study two types of barriers: (1) barriers

that interfere between the societal need and the individual's preferences, and (2) barriers that interfere after an individual has formed a wish to energy upgrade.

Based on these considerations, we will in this paper first introduce the empirical and theoretical background for the analyses conducted, then describe the methodological approach, before we focus on three research questions: (a) how strong are the barriers and facilitators perceived in the Norwegian context – which here is used as an example for comparable markets – and are there relevant differences with regard to socio-demographics and housing characteristics of the homeowners; (b) how much do these barriers and facilitators contribute to the general attitude towards energy efficiency upgrades; and (c) how do attitudes determine intentions to energy upgrades and upgrade behavior in the context of other psychological and structural variables. In other words, we will start with an analysis on the barrier/facilitator level, then lift the view to the broader context of decision-making.

2 Theoretical background

The following sections briefly introduce existing research on determinants of energy efficiency decisions in private renovation projects. We explore research on the relationship between attitudes and investments in such energy efficiency measures, as well as introducing more comprehensive psychological models of decision-making in environmental domains.

2.1 Structural impacts on energy efficiency decisions in private renovation projects

Typically, major energy efficiency upgrade measures (e.g. installing/upgrading: attic insulation and ventilation, more efficient heating, more efficient air-conditioning, and energy-saving windows) entail a medium to large amount of financial investment, which has been identified as a major barrier in a number of studies [18, 22]. Nevertheless, compared to non-investment measures (e.g. turning off the light in vacant rooms, turning down the thermostat) or measures

with minimal investments (e.g. changing to LED bulbs, sealing cracks around doors and windows), they offer higher potential for energy reduction with a one-time action [22-25].

As research regarding energy conservation in households suggests, structural or contextual factors, which are found in the economic, physical, and social environment within which potential energy efficiency upgraders act, strongly influence one-time costly investments [15, 18, 21, 22, 26]. For example, marketing campaigns, government policy regulations, and monetary instruments often act as incentives for potential energy efficiency upgraders by alleviating their financial burden at the time of the energy efficiency upgrade project [27-29].

Meanwhile, homeowners' preferences about energy efficiency upgrade measures are highly dependent on the physical environment and geographical location of the dwelling [18, 30]. Choices of appropriate energy efficiency upgrade measures are influenced by differences in climate that affect thermal energy exchange between the building envelope and the external environment, variations in temperature, wind, solar irradiation, precipitation and other meteorological variables in a given region over long periods of time [31, 32]. As such, the need for greater thermal comfort, better living conditions, and financial payoff may encourage people in colder climate to invest in measures like additional insulation of the roof, loft, outer wall, and foundation walls or the floor towards the basement or ground [18, 33], while people in warmer climates may find it attractive to install or upgrade air conditioning units if they believe the measure would lower their energy bill while providing them higher comfort and better living conditions [34, 35].

2.2 Barriers, facilitators and attitudes

Although structural impacts on energy efficiency upgrade measures are enormous, it is the homeowners' subjective evaluation of their magnitude that finally influences energy efficiency decisions in renovation projects [22, 36]. Annual heating costs, investment costs, and functional

reliability have for example been identified as important factors when deciding about new heating systems in Swedish households [44]. However, not all potential upgraders can fully utilize existing economic benefits since the type of the ownership (i.e. private or rental) and income level have a strong effect on which type of energy efficiency upgrade measures can be implemented [22, 38]. For example, major energy efficiency upgrade measures are more attractive to higher income potential upgraders who are owners rather than renters, as renters cannot determine energy efficiency upgrade measures and collect the financial incentives [20, 22].

Similarly, technical building characteristics such as age and physical structure (e.g. detached, semi-detached, or attached) also have a huge impact on the choice of energy efficiency upgrade measures as indicated by renovation choice modelling studies [39, 40]. While owners of older houses are more likely to adopt energy efficiency upgrade measures due to high running costs and increased market value of the property after upgrade [18, 39, 40], triggering events (such as building alterations and extension) can cause conflict with local or national building protection regulations [40]. For a specific type of renovation of privately owned residential buildings, homeowners not only need to seek permission of local authorities, but also need to inform and negotiate with neighbors [18, 40]. The degree of coordination with neighbors often depends on the physical structure of the building, ranging from full cooperation with neighbors for attached units to informing neighbors about the project for detached units [39, 41]. Furthermore, physical features of the building can make energy upgrade difficult or impossible e.g. a brick façade can make it difficult or impossible to add a layer of insulation, or space limitations can prevent certain technical solutions. Moreover, owners or tenants who expect to move soon might not make the best decision for the building, even though they may recognize that a specific type of energy efficiency upgrade measure better suits their personal circumstances [42]. Lastly, lack of trust in information regarding energy efficiency upgrades,

and previous uncomfortable experiences with renovation projects and contractors may hinder potential energy efficiency upgraders [15, 19, 43].

A number of studies have analyzed the barriers and drivers comprehensively. Mahapatra et al. [44] studied the market potential of a full-service energy renovation concept that combines counseling, energy auditing, financing, building work, and follow up, based on a thorough analysis of barriers to energy upgrades in Nordic houses. They identified barriers such as: a perceived lack of need for upgrades; the relatively small share that energy costs have in a household's budget; priority to other investments such as bathrooms and kitchens; insufficient information, knowledge or awareness; influence of installers or sellers that do not recommend energy efficient solutions; and a fragmented market with individual solutions for every step of the renovation project. Mortensen et al. [45] surveyed homeowners in Denmark and found that younger homeowners with children under 18 living in the household, and who had lived for relatively shorter times in their homes, are more interested in energy upgrades than older homeowners who had lived for a long time in their houses. They then analyzed how different socio-demographic groups differ in motivational factors that would encourage them to upgrade the energy standard of their houses. They found that younger age groups seem to be more receptive to architectural appearance, increased comfort, improved energy consumption, and better indoor environments, as compared to older age groups. An interesting perspective is taken in a paper by Tjørring [46] that analyzed energy renovation projects from a gender and practice theory perspective, finding that gendered energy practices and gender roles had a large impact on who is perceived to be responsible for energy renovation projects (often this responsibility is ascribed to men), but also on which measures are implemented and how. In the first part of this study, we will take a selection of the most central of these barriers and facilitators as a starting point for our analysis and determine, how strong they are perceived in

the context of the Norwegian market and how much they differ between subgroups of homeowners and housing types.

A more psychological way to look at the above-mentioned barriers towards, and drivers of, energy efficiency upgrading is to consider them components of attitudes, which are a main determinant in influencing intentions to perform a behavior. According to Ajzen [47, 48] attitudes are the composite of different beliefs about the behavior. Attitudes are assumed to be the sum of all beliefs about what would happen if the behavior is performed weighed up against the likelihood that they happen and the evaluation of that effect. Anticipated barriers and facilitators can thus be understood as such beliefs. Therefore, a number of potential barriers and facilitators can be related to general attitudes that can influence a homeowner's decision to upgrade their building's energy efficiency or not. This will form the second step of our analysis where the barriers and facilitators will be linked to a general attitude of energy efficiency upgrades.

2.3 Theoretical framework of this study

In the last step, we will put this attitude in perspective in a more comprehensive modelling framework. Psychological research about determinants of environmental behavior has moved beyond models that just include attitudes. The model analyzed in this study builds on environmental psychology behavior models [49]. We chose this discipline's models as we were interested in the individual's perspective as the core unit of our analysis. There are other theoretical traditions in the social science approach on energy decisions, with *practice theory* emerging as an interesting alternative framework to studying energy behavior. From a practice theory background energy behaviors, such as decisions to implement energy efficiency upgrades in a renovation project, are embedded in energy practices. These energy practices are determined by materials (e.g. physical structures and infrastructure, technologies), procedures

(e.g. frameworks, schedules, competences), and meanings (e.g. discourse, conventions) [50-52]. A person's behavioral pattern is determined by all three components, with practice theory giving a strong emphasis to the creation of meaning from the individual's practice. A number of interesting energy use related studies have contributed to making this perspective well recognized in energy research [e.g. 46, 50, 53-57]. Some practice theorists have strongly criticized the psychological perspective as too individualistic and as blaming the consumer [58-61]. While we agree that this criticism is valid to a certain degree, we strongly oppose the conclusion put forward by these authors that practice theory and psychological theory are fundamentally incompatible. We agree with other studies [62, 63] that assert the two theory traditions are surprisingly overlapping, if structural, technological and social components are properly represented in psychological theory. We assert the perspectives are complementary with a strong focus on the individual in psychology and on the social in practice theory. For our study, we chose the stronger focus on the individual, but that does not mean that we imply the practice approach would not be equally valuable.

The core of the model in this study is based on the Theory of Planned Behavior [47, 48]. Initially, the theory was developed to analyze and predict deliberate decisions and did not include any direct links to components outside the cognitive realm of the decision-maker such as structural barriers. However, later researchers have argued, that the representation of such external factors in extended versions of the theory and the study of their interaction with internal factors such as attitudes and perceived behavioral control or self-efficacy would benefit the applicability of the theory considerably [49]. Furthermore, it might be argued that the theory of planned behavior is not well suited to study decisions where the decision-makers are indifferent and do not really engage in decision-making. However, if factors can be identified that increase the decision-makers involvement, also that would increase the value of the theory in the larger context.

The theory of planned behavior assumes that the main determinant of an environmentally relevant behavior is the intention to perform it; in this case to implement an energy efficiency upgrade of a building within the next three years. This intention is, according to the theory, formed by the attitudes towards this behavior, the perceived social norms regarding the behavior, and perceived self-efficacy. An intention is an indicator of an individual's readiness to perform a certain behavior, in our case the willingness to include energy upgrades within a rehabilitation[1] project within a given timeframe.

The first of three aspects that determines the development of such an intention is attitude, which includes the subjective evaluation of the possible outcomes of the behavior (see also section 2.2). The second determinant, social norms, includes the impact of social pressure on a person's decision. If you perceive other people as supportive of a decision for energy efficiency upgrading, the likelihood for doing this will increase. Thøgersen [64] suggested separating social norms into what other people say they expect, and what they actually do, which he refers to as descriptive norms. We follow his distinction in this study, because social norms and descriptive norms do not always point in the same direction. The third determinant, self-efficacy, is if a person feels capable of performing the behavior; in the case of this research whether they know how to energy upgrade themselves or know which company to contact. Ajzen [48] argues that positive attitudes and positive social norms only lead to a positive intention if people feel capable of performing a behavior and feel they have control over the behavior. Furthermore, the more involved people are in a decision and the more salient the attitude and norm components are to them, the stronger and more stable the link between attitudes, norms, intention and consequently behavior are.

For behaviors that require extensive decision-making, such as big environmental investments, moral factors have been shown to have an important impact, which the theory of planned

[1] We use the term "rehabilitation" here to indicate renovation projects of a larger size, including a significant amount of the building's body.

behavior does not properly capture [49]. Models like the Norm-Activation Theory [65] and the Value-Belief-Norm-Theory [26] describe how moral aspects are included in such decision processes. These models assume that personal norms, which are a feeling of moral obligation to act, are a predictor of behavior in such cases. Different to attitudes, personal norms are the moral side of decisions. Attitudes refer to the rational or emotional-hedonistic side of a behavior ("would it be good/useful/beneficial to do this?"), whereas personal norms capture the moral evaluation ("would it be the right thing to do, given the values that I embrace?"). Personal norms are not always activated but need to be triggered by an interpretation of the situational stimuli that frame a situation as morally relevant. Such a trigger is usually the awareness that the given situation is causing effects that threaten something valued [49, 65]. In the case of this research, this could be interpreted as the wasteful energy standard of a building may be perceived as morally wrong. Over time such personal norms develop by internalizing and adapting social norms to the personal value system [64]. Within this process personal norms can become partly independent from social norms, although they often overlap to a smaller or larger extent.

Ellen, Wiener and Cobb-Walgren [48] suggest considering not only the individual's self-efficacy for a behavior, but also analyzing the general feeling that the individual has towards their ability to make a difference to environmental problems. People might be convinced that it would be good, beneficial, morally right and even socially supported to perform energy upgrades, but still decide not to if they believe that their effort is just a 'drop in the ocean', compared to other actors such as business and industry. This was also found repeatedly in focus group discussions reported by Klöckner, Sopha, Matthies and Bjørnstad [67]. Thus, perceived general consumer effectiveness was included as an additional variable in the model.

Finally, Diffusion of Innovation Theory [68] predicts that the general innovativeness of a person relates positively to the likelihood that this person takes up new technology or societal trends

faster than other people. General innovativeness (a positive evaluation of things that are new and the willingness to try them) has been described as a central element supporting uptake. Mahapatra and Gustavsson [69] studied diffusion of energy efficient heating technology in Sweden and found that innovativeness was a driver of a switch from electric resistance heating to more efficient heating systems. This led us to also include this variable in the analyses regarding the larger decision-making context.

A comprehensive model comprising of the factors described above will be tested in the last part of this study, which builds on previous work [70-72]. Its core is the theory of planned behavior, but extended to moral aspects and their activation, and linking to basic value orientations as well as more general traits such as perceived consumer effectiveness and innovativeness. In line with the theory of planned behavior, an intention to upgrade energy standards is assumed to be the direct predictor of implementing energy efficiency upgrades. This intention is generated from attitudes, self-efficacy and personal norms, which mediate the two components of social norms (other people's expectations and behavior) and are triggered by problem awareness as assumed in the norm-activation theory. Personality variables (innovativeness and consumer effectiveness) are assumed to partly determine an individual's perception of self-efficacy in the context of energy efficiency upgrades. It is assumed that more innovative people feel that consumers have a larger influence and this then leads to higher feelings of being in control with respect to energy efficiency upgrades. Finally, basic value orientations are expected to determine how high the awareness of the problem is (which might be fueled both by hedonistic and altruistic motives), and how effective consumers perceive their actions to be. More hedonistic people may see their impact as a consumer as limited. The model will be tested in a version purely focusing on psychological variables, as well as an extended version that also includes external barriers.

3 Methods

3.1 Sample

For this study, a large survey was conducted between January and March 2014. The sample for the study was recruited from members of TNS Gallup's Panel in Norway. Two different subsamples were recruited for the study from the panel members: (a) a representative population sample randomly selected from the panel (N=2,605) and (b) an additional sample of people that either recently conducted a deep rehabilitation or are planning to do so within the next three years (N=1,182). This was done to get a rich dataset for people in these categories, which were expected to constitute only a small fraction of the population. The additional respondents were recruited by addressing randomly selected panel members and screening them with a question asking if they had recently conducted a building rehabilitation or were planning to do so in the next three years. If they answered "yes", they were included in the study. For the analyses in this study, both samples were combined. For all analyses in this paper, respondents were excluded if they did not own their dwelling or were living in a multifamily building, which both made rehabilitation measures conducted by them very unlikely. This reduced the sample for this study to a total of N=2,687.[2]

[2] We are aware that the sample does not constitute a random sample from the population of Norwegian households for three reasons:

- We did not sample directly from the Norwegian population but from an online panel which is assumed to be representative for the Norwegian population.
- Within this online panel, we did a random sampling, but then oversampled people that either are planning to conduct a major rehabilitation project or just have finished.
- Not all potential participants sampled replied.

We further agree that this is a challenge for all inference statistical analyses. A true random sampling would have eliminated this problem, but we would have suffered from a much higher non-response bias, as response rates in general surveys sent out to random samples are extremely low in Norway. Thus, we decided to use an online panel, which reduced non-response bias but introduced a selection bias, since members of an online-panel are not the same as the population of all Norwegians. However, analyses of the panel quality by TNS Gallup show that the panel is representative for the Norwegian population with internet access (97% of Norwegians) with respect to the most important socio-demographics. The panel is operated in lines with ISO-standard 26362:2009. That being said, the doubt about which population the study speaks for remains to a certain degree. However, inspired by reviewer comments, we also conducted a number of sensitivity analyses testing if the results were different if the random sample from the panel was compared with the additional sample; analyses showed no significant differences. Furthermore, we also conducted all analyses a second time with Bayesian estimators which do not use assumptions about distributions and find the same results. This makes us confident that the reported results are robust. Within the parameters that we were able to test, we also believe that the online panel

The population from which the representative sample was drawn was defined as Norwegian households with members of 18 years and older. It was stratified for sex, age, education and geography to be representative for the Norwegian population. 5,589 members of the panel were asked by an invitation e-mail to participate in the study and 2,605 persons participated (45 % response rate). 50.2% of the main sample were male, 49.8% female. 21.5% were 18-29 years old, 28.5% were 30-44 years, 26.7% were 45-59 years, and 23.3% were older than 59 years. 27.4% were living in the region Oslo and Akershus, 27.1% in the remaining eastern Norway, 28.7% in south-west Norway, and 16.9% in mid-north Norway. Younger people and people renting their dwelling were under-represented in the sample as compared to the population, and consequently a weight adjusting the main sample for this bias was calculated and used in all analyses.

The additional sample was recruited to provide better data coverage for people in building rehabilitation situations (recently finished, ongoing or planned) for the behavior modelling and barrier/driver analysis. For this purpose, members of the TNS panel were contacted by mail and screened if they fitted the conditions for the additional sample. As representativeness for this sample was not relevant no weighting was applied. 54.1% of the additional sample were male, 45.9% female. 11.0% were 18-29 years old, 24.1% were 30-44 years, 32.7% were 45-59 years, and 32.2% were older than 59 years.

In the final sample used for the analyses we found the following socio-demographic composition: 52.3% of the sample were male, 47.7% female. 7.2% were 18-29 years old, 23.6% were 30-44 years, 36.2% were 45-59 years, and 33.0% were older than 59 years.

sample is a good approximation of the Norwegian population of house owners, but given the sampling procedure this needs to be interpreted with an acknowledgment of the limitations of the sample .

3.2 Measures

The survey contained the following sections relevant to this study: (1) living situation with respect to the dwelling, (2) psychological determinants of intentions to upgrade (see below), (3) value orientations and innovativeness, (4) measurement of barriers to, and drivers of, including energy upgrades in rehabilitation projects, (5) plans to implement four specifically described types of energy upgrades within the next three years, and (6) socio-demographics of the household.

The measures of the psychological determinants, value orientations, and innovativeness were adapted from established measures of the constructs [48, 64-66, 71, 73, 74] which were identified in a literature study [75] and tested in a pilot study [72]. To keep the questionnaire as short as possible, the number of questions per variable was restricted to as few questions as deemed possible. A confirmatory factor analysis shows good fit for the measurement instruments (Chi^2=3355.59, *df*=409, p<.001; *RMSEA*=.044 [.042 .045]; *CFI*=.93; *TLI*=91; *SRMR*=.042). Table 1 shows the number of questions per variable and the internal consistency of the resulting scales. For the different variables the internal consistencies were deemed good to acceptable, while problem awareness and general consumer effectiveness have low consistencies as measured by Raykov's Rho [76].

Only a selection of the items from the innovativeness scale [74] was used for the analyses in the behavioral models, as the internal structure of the scale was not detected as one-dimensional. An analysis of the measurement instrument showed that there was a dimension on which all positively formulated items were loading and a second dimension with the negatively formulated items. Both dimensions were reasonably correlated, but not identical. To avoid complicating the model analysis only one of the two dimensions was used (skepticism against innovations). Only the questions that loaded on the negative dimension of the scale were used, but reverse coded.

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One of the research questions for this paper asked which barriers to, and drivers of, including energy efficiency upgrades into rehabilitation projects impact attitudes to energy upgrades. This raises the question of how can barriers and drivers be measured in a reliable and valid way. We decided against directly asking the participants for barriers and drivers to avoid people answering strategically in a questionnaire that came from the National Energy Efficiency Agency that is also responsible for subsidy schemes. Instead we stated a number of barriers and drivers as statements and asked for the participants' agreement. The survey recorded a total of 10 potential drivers of energy upgrade decisions and 13 barriers (for a list of barriers and facilitators included in this study see Table 2). The statements were presented randomly, and were asked between other questions measuring psychological variables. By doing this we hoped that the participants would focus less on stating barriers as justifications for inaction, and that they would not be tempted to strategically overrate financial drivers. The list of barriers was derived from previous studies based on qualitative input from members of the target group and a thorough literature study [49, 72].

The plans to implement specific energy efficiency upgrades in a renovation project were measured by asking which of the following measures the participants plan to take within the next three years:[3]

- Additional insulation of the roof or loft (at least 10cm additional insulation)
- Additional insulation of the outer walls (at least 5cm additional insulation)

[3] We are aware that «cm of insulation» is a rough and fuzzy measure since insulation products with the same thickness can have very different insulation capacity. However, this way of measuring substantial insulation upgrades was chosen in close discussion with the Norwegian Energy Efficiency Agency, which funded the study, to make it practical for participants to answer the questions without necessarily having the technological expertise.

- Changing to extra energy-saving windows (U-value 1,0 or lower or 3-pane windows)
- Additional insulation of the foundation walls or the floor towards the basement or ground (at least 5cm additional insulation)

These measures were decided upon, after discussions with the Norwegian Energy Agency Enova and a thorough literature review, as they were deemed substantial enough to determine improvements in energy efficiency. A measure was then calculated based on how many of these actions were planned within the next three years (0-4 of the abovementioned actions), indicating how ambitious the planned energy efficiency upgrade was.

3.3 Analysis strategy

The analyses for this study were conducted in three independent steps. As a first step the degree to which each barrier and facilitator was embraced by the participants was calculated and differences between subgroups of homeowners and housing types were calculated.[4] These analyzes address the research question of how salient and important different types of barriers and facilitators are perceived in the target group. The second step was an analysis of how the different barriers and facilitators were related to the strength of the general attitudes to upgrade. This analysis addressed the research question of how people form their general attitudes towards energy efficiency upgrades. The analysis was conducted both with an ordinary least square regression and the least angle regression method [77] to test for potential confounding effects of multicollinearity. In a second step, a structural equation modelling approach was chosen to test the theoretically derived model of energy upgrading intentions on the data; first without, and then with, additional structural conditions included. To reduce model complexity, the building components of the general attitudes identified in step one were no longer included,

[4] Because of the high number of significance tests run for these analyses, the significance level for them was adjusted to $p<.001$ to avoid false positive results.

and only general attitudes as measured by the combined evaluation of the barriers and drivers were included. Theoretically, the barriers and facilitators can be assumed to be contained within the attitudes.

4 Results

4.1 Importance of barriers and facilitators in the Norwegian context

Table 2a and 2b display the perceived importance of the tested barriers and facilitators in the Norwegian sample. The barriers most strongly embraced are the feeling that the right point in time has not come yet and being unsure about saving potentials. Fearing to have to supervise contractors and expecting too much disturbance are also important. The least relevant barriers on average are building protections, which only apply to few houses, needing to agree with neighbors, which most Norwegians in the sample do not need because they own a single family home, and plans to move soon. The most strongly embraced facilitators named are easily accessible information, higher expected comfort levels and trustworthiness of the available information. Less prominent is the feeling of the current building standard as a waste of energy.

--- INSERT TABLE 2A AND 2B ABOUT HERE ---

With regard to sociodemographic differences, it appears that women deem lack of economic resources and time for supervision of contractors as more important barriers, whereas lack of competence for contractors and negative previous experiences are less important. Payoff within reasonable timeframes, positive health effects and trustworthy information are deemed more important facilitators for women as compared to men. Economic resources appear to be a stronger barrier for younger homeowners, whereas disturbance of everyday life and supervision needs for contractors are especially important for the oldest age group. The youngest age group

especially values higher comfort and better living conditions as facilitators, as well as that they perceive more often than older homeowners the energy consumption of their home as a waste of energy. Innovativeness is quite strongly related to perception of barriers: The least innovative participants are more unsure about saving potentials, less able to make a decision, feel more bound by building protection regulations, find it more difficult to find and trust information, fear more disturbance of their everyday life and report more negative experiences from previous projects. The amount of realistically investible money (which was measured as the money that was potentially available through savings and loan) had – as expected – an impact on the lack of economic resources as a barrier. Also the need to coordinate with neighbors is higher for people with less available resources, most likely because they live more often in attached single houses. Finally, education levels have an impact on perceiving disturbance of everyday life and supervision of contractors as a barrier, which is highest in the most highly educated group of the sample. On the other hand, they also score highest in perceiving the energy standard as a waste of energy and perceiving suitable subsidy schemes available.

With regard to house related characteristics, the type of house (single-family house, semi-detached house, or terraced house) affects some of the barriers. Owners of single-family houses are less concerned about disturbance of their everyday life or the need for supervision of the contractors. Furthermore, for them lack of economic resources, not being able to make a decision, being unsure about the saving potentials, and – not surprisingly – the need to coordinate with neighbors is less of an issue, as compared to owners of a terraced house. Most likely related to this, owners of smaller houses are more likely to embrace lack of economic resources as a barrier, report more need to coordinate with neighbors, and report more often having problems making a decision. It is likely that smaller houses are more often terraced houses. The age of the house shows some interesting effects, so are people owning houses in the two middle age categories more unsure about saving potentials than the two most extreme

groups (likely because the owners of old houses are sure about the potential being evident, whereas the owners of newer houses are sure that the potential is low. Also the inability to make a decision is strongest in the second most old houses group. That the right point for a rehabilitation project has not come yet is – not surprisingly – a barrier that is more relevant for owners of newer houses, whereas building protection regulations (as expected) and economic resources are more relevant barriers for owners of older houses. With respect to facilitators, so are reduced energy costs, increased market value, pay-off within reasonable time, positive health, better living conditions, and higher comfort levels are all perceived strongest in the oldest houses. Owners of the oldest houses are also more likely to perceive the current insulation standard as a waste of energy. The differences between different regions in Norway are not very distinct, but there are some: The barrier to having to consult with neighbors is strongest in Oslo as compared to all other regions, likely due to the higher population density. In addition, the demand to supervise contractors is perceived a stronger barrier in Oslo, likely, because fewer house owners in Oslo take on the insulation job themselves. All economic facilitators (reduction of energy costs, increased market value of the house, pay-off within a reasonable time frame) are perceived stronger in the most northern regions of Norway, especially as compared to the south and west (which is not surprising, taking the climate differences between those regions into account).

4.2 Components of the attitudes towards energy upgrades

For the second step of the analysis, the attitudes measure was regressed on all 13 barriers and 10 drivers included in the study to explore how important each of those factors is for the general attitude to upgrade the insulation standard. Because multicollinearity can become a problem with so many interrelated predictors, a second regression was conducted utilizing the least angle regression method [77], which is regarded a more reliable method of selecting relevant

independent variables as compared to stepwise regression. This method provided results displayed in the last column that overcome the multicollinearity problem, with six barriers and facilitators excluded from the analysis. The two analyses yield almost the same results (see Table 3).[5]

Attitudes are significantly related to many of the barriers and drivers. These explain 51% of the variance in attitudes, with more drivers than barriers determining attitudes. The strongest driver is the expectation that an energy upgrade will improve living conditions in the dwelling. Also influencing positive attitudes to energy upgrades are the perceptions that the energy use in the dwelling before the upgrade was wasteful, that there is a potential monetary saving, and that there is a potential increase in the market value of the dwelling. Perception of higher comfort in the dwelling is another contributing determinant, and anticipated positive health effects make a small but significant contribution. Interestingly, existing funding schemes are weakly negatively related to attitudes, potentially indicating an effect of attributing the cause of positive evaluation to an outer source, meaning that you would conclude to conduct an energy efficiency upgrade primarily because the subsidy, not because of positive attitudes.

Compared to the drivers, most barriers are irrelevant for attitude formation. Two of the significant barriers contradicted what we expected in our research: insecurity about the saving potential and lack of economic resources. A negative relation of barriers on attitudes were found for: strict building protection regulations, perceived lack of contractors' competences, doubt in the trustworthiness of information, and the feeling that the right point in time had not come yet.

[5] The numbers on the table are to be read as follows: Each number is a standardized regression weight, which reflects the influence one of the predictor variables in the table has on the attitudes when the influence of the other variables is controlled for. The numbers can fall between -1, which is a perfect negative relation indicating that one predictor completely predicts the attitudes and in a negative direction (the higher values on that predictor the lower values on attitudes), and +1, which is a perfect positive relation (the higher the values on that predictor the higher values on attitudes). 0 indicates no relation. Values around +/- .10-.20 are considered weak effects. Statistical significance indicates the estimated probability for finding an observed value in a predictor given that the true value in the population was 0.

--- INSERT TABLE 3 ABOUT HERE ---

4.3 The psychological structure of decision-making

In the final step of our analysis, we were interested which role attitudes (which – as we found in step three are a good representation of the barriers and drivers) play in the larger context together with other variables. To test the proposed model structure derived from the theoretical models presented in Section 2.3, a structural equation model was specified as displayed in Figure 1.[6] It received acceptable empirical support according to the rules proposed by Hu and Bentler [78] as can be seen in the model fit indices displayed in the figure.

--- INSERT FIGURE 1 ABOUT HERE ---

The analysis shows that the intention to upgrade the energy standard of a dwelling within the next three years is determined by personal norms, positive attitudes towards an energy upgrade (for components of attitude see also the analyses in section 4.1), and the individual's perception of self-efficacy. Personal norms have the strongest influence on intention to energy upgrade, followed by attitudes and self-efficacy. For making such a big investment, a general feeling of "this is the morally right thing to do" (personal norms) is therefore a relevant aspect which is not the same as developing positive attitudes.

Even though personal norms and social norms are not identical, a personal norm is generated mostly from social norms; in other words what relevant other people say about this behavior. However, problem awareness also has an impact on the development of personal norms that

[6] The numbers in figure 1 are standardized model estimates, which are interpreted in the same way as the standardized regression weights in Table 2 (see footnote 3). R^2 is the amount of explained variance in a variable by the predictors included in the model. This number lies between 0 (no variance explained) and 1 (all variance explained). Model fit estimates reported under the figure indicate how well the model reproduces the observed relations between the variables in the raw data. For further information about their interpretation, please see Hu and Bentler [78].

goes beyond the mere impact of other people. The impact of descriptive norms (what other people do) on personal norms is not significant. Both social norms and descriptive norms are related to problem awareness, meaning that one is more likely to recognize what other people do or say with respect to energy efficiency upgrades if one is aware of the problem. Developing problem awareness is more likely for people with an altruistic value orientation, thus caring for the well-being of other people, other beings or the environment. Even though hedonistic values (embracing what suits my own well-being) are also positively related to problem awareness, this impact is so weak that it does not reach statistical significance.

Self-efficacy is related to personality variables of the person deciding. Having the perception that it is easy to implement energy efficiency measures is more likely if a person in general thinks that consumers can make a difference to environmental problems with their actions. This feeling of general consumer effectiveness is negatively related to a hedonistic value orientation. If people care mostly about their own well-being, they are less likely to think that their actions can make a difference. Another personality aspect that impacts general consumer effectiveness is the general innovativeness of a person. The more a person embraces new technologies and new societal trends, the more likely is it that this person also feels that consumers have relevant power with their actions.

In a second step, the model was applied to predict the plans to conduct specific energy efficiency upgrades within the next three years. Only participants that had not performed a substantial energy upgrade in the last three years were included in the analysis (N=1,885). Four structural variables that were identified in the theory section (see Section 2.2) as particularly relevant were also included in the model: (1) available economic resources, (2) plans to move soon, (3) building protection regulations, and (4) the need to coordinate with neighbors. The impact of these four variables was modelled both directly on the number of plans and indirectly via attitudes, social norms and consumer effectiveness.

Figure 2 displays the resulting model, which again is deemed an acceptable fit (see model fit indices in Figure 2). Intentions to energy upgrade are a good predictor for level of ambition of upgrade plans for the next three years. The relationships in the psychological model are mostly unchanged by restricting the sample to people who have not conducted an energy efficiency upgrade already in the last three years. The links from problem awareness to personal norms, social norms and descriptive norms are slightly weaker, but the link from descriptive norms to personal norms is now slightly stronger and statistically significant. Of the structural variables, most impacts are mediated by the psychological variables. This means that they have a significant effect on one or more psychological variables included in the model, while only weakly or not at all being related to the behavior directly after controlling for the psychological variables.

--- INSERT FIGURE 2 ABOUT HERE ---

Lack of economic possibilities is negatively related to the perception of consumer effectiveness and thus also indirectly to self-efficacy. Interestingly, it also has a positive impact on attitudes (as shown above already) and a small positive impact on the level of ambition of plans, indicating that people with limited economy have more positive attitudes to energy upgrades and also more ambitious plans.

To be moving soon has a negative effect on consumer effectiveness and ambition of the intended upgrade. Having to coordinate with neighbors reduces the ambition level for energy upgrade plans directly and also general consumer effectiveness. Being bound by building protection regulations has a negative effect on consumer effectiveness and ambitions directly. Social norms are positively related to three of the four structural barriers.

5 Discussion

The results of the study of barriers and drivers of energy investments in privately owned houses show a number of interesting aspects: Not being sure if the right point in time for a rehabilitation project has come and being unsure about the saving potentials are the barriers that are embraced the most, and they are also among the more important components forming the general attitude. Accessible information, higher expected comfort and available subsidy are the drivers, that are perceived as strongest, but in context of all other drivers and barriers, better expected living conditions and perceiving the current insulation standard as a waste of energy are the strongest independent predictors of general attitudes. (2) Not surprisingly, barriers and drivers do not apply in the same way to all population and housing groups. Neighbors and supervision of contractors are more important for people living in smaller, often terraced houses and more in cities. Monetary benefits are expected to be larger in the harsher northern climate as compared to the moderate climate at the west coast or in the south; also older houses are expected to benefit more from rehabilitation. Interestingly, the owners of the next oldest houses are most unsure about what they would save and are most unsure about how to make a decision. For most of such houses an energy upgrade would make sense, so this target group needs to get special attention. As expected are innovative house owners less prone to see barriers, so they could be a relatively easy group to convince. Females seem to trust information and contractors more.

The study further shows that attitudes to energy efficiency upgrades are more influenced by facilitators than barriers, which is interesting as it provides opportunity for positive motivational strategies. Economic facilitators and barriers (e.g. expected payoff, reduced energy costs) seem not to be dominant. Limited economic resources have been shown by this study to be more motivating than limiting in the initiation of an energy efficiency project, perhaps because of the economic benefits that would be particularly welcome. In the final step of the analysis, we could

demonstrate that the structural model received good support by the data and shows that many structural barriers impact decisions to upgrade the energy standard of a dwelling indirectly, filtered through psychological variables. Furthermore, the model test showed that general attitudes which capture the barriers and drivers are an important, though not the most important factor determining the intentions to start a rehabilitation project.

Before exploring the implications of the results, the limitations of the study need to be discussed to put the results into perspective. Even though the study has a large sample, it might be debated for which population the survey is representative. Since the sample was not randomly sampled from the population of Norwegian house owners but from an online panel, the question remains if the results can be generalized to the whole population. The provider of the online panel has built the panel to be representative for Norwegian households with internet access (which covers 97% of all households), but still there may be differences that we cannot control. Furthermore, we oversampled respondents who either just finished a major building rehabilitation project or were planning to start one within the next three years. This will have biased the sample further. However, we conducted an analysis of the differences between the two groups in the sample and did not find any differences. Another weakness of the survey is that it builds on self-reported measures (especially about energy measures taken), which cannot be objectified. It might thus be possible that respondents adapted their answers to be consistent or within social expectations. Some readers might identify the theoretical background in psychology a substantial weakness of the study. We agree that alternative theoretical frameworks might have produced other interesting insights, but we consider our results a valid contribution if the limitation of the perspective is taken into account (which is true for every theoretical perspective chosen).

In spite of these limitations, the results have several implications for policy measures. The structural model shows that personal norms are a main driver of the intention to invest in energy

upgrades. These norms are in turn influenced by descriptive and social norms (in figure 2 both components have a significant influence), but the influence of social norms (what other people expect) is much stronger. If a household is targeted by other people or institutions communicating the importance of energy upgrades, this obviously does not go unnoticed, given that the opinion of these people or institutions are considered relevant for this decision. With regard to personality variables, more innovative people and people more convinced of the consumers' market power over environmental actions are more prone to energy investments in their dwellings. Furthermore, they are less prone to perceive barriers as important. Thus, if it needs to be decided which kinds of households to target first, then the more innovative and the ones believing in the effectiveness of consumer actions are the more promising.

Considering the barriers that prevent people from engaging in building rehabilitation, some of the study's conclusions are not surprising: building regulations are a structural barrier that prevents people from even starting to think about energy upgrades. Not being able to make a decision, however, is a main barrier for deciding which energy efficiency measure(s) to include in the rehabilitation project, which goes beyond the structural barriers. A clear recommendation for this study is to develop creative ways of making people realize when this point in time has actually come. This applies particularly to owners of newer houses, who might think that their house is still in good enough shape and owners of houses of medium age who are most unsure about if they should rehabilitate or not. The right time for energy upgrades is probably when people plan a major rehabilitation project, so campaigns may need to focus on getting the energy efficiency considerations implemented at that point in time. Based on discussions of the research team with market actors, another "right point in time" may occur when emergency rehabilitation measures have to be implemented (e.g. the façade is leaking and needs to be replaced). In such cases it appears to be up to the contractors to promote energy efficiency measures, so here the contractors should be addressed to encourage that.

Interestingly, lack of economic resources is not a barrier for *starting* to think about energy efficiency upgrades; it seems to rather be a driver because it makes potential savings relevant. It appears that people with limited resources are *more* willing to consider energy upgrades, anticipating potential savings in the end, which for them would be significant. They even make more ambitious plans than people with better financial resources. During the planning process, however, they may come across barriers as they realize that they cannot implement their ambitious plans. It appears that for such people alternative ways of financing the planned energy efficiency upgrades would be a path that should be followed.

In regarding drivers, the picture is even more diverse. Relevant drivers for considering energy efficiency upgrades come from different categories, some of them comfort related, some of them economic (lower energy costs, higher market value), some health related, and some more on the moral side, namely a feeling that the energy use of the building is a waste. Drivers related to comfort and living conditions appear to be at least as important as economic drivers. From a marketing perspective the message is rather clear. The focus should be on three aspects: increased comfort and better living conditions, economic savings and payoff through a higher market value for the building, and framing the overuse of energy as a loss.

Acknowledgements:

This research was funded by the Norwegian Energy Agency, Enova. This paper is based on an internal, unpublished report to Enova [79]. A second paper from the same project but with a different scope and independent analyses has been published recently [80].

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APPENDIX

Items used in the analyses in this paper

Intention to energy upgrade

Coded 1 (“not true at all”) to 7 (“completely true”).

- I realize that something has to be done about the insulation standard and intend to find out more what I could do within the next twelve months/the next three years.
- I have decided how I want to improve the insulation standard of my dwelling and intend to arrange the necessary details with contractors within the next twelve months/the next three years.
- I have very concrete arrangements with contractors about the upgrade of the insulation standard of my dwelling and intend to implement them within the next twelve months/the next three years.

Attitudes

In general, do you think that increasing the insulation standard of your dwelling would be …

… worthless (coded 1) to valuable (coded 7)

… unpleasant (1) to pleasant (7)

… harmful (1) to beneficial (7)

… bad (1) to good (7)

Descriptive norms

Expressed as percentages.

- Approximately, how many of the people you know have upgraded the insulation of their home?
- Approximately, how many of your neighbors have upgraded the insulation of their home?

Social norms

Coded 1 (“I do not agree at all”) to 7 (“I agree completely”).

- People who influence my decisions think I should upgrade the insulation standard of my dwelling.

- People who are important to me think I should upgrade the insulation standard of my dwelling.

Problem awareness

Coded 1 (“I do not agree at all”) to 7 (“I agree completely”).

- I worry about environmental problems caused by the energy used because of bad insulation standards.
- Bad insulation standards are a problem with respect to climate change.

Personal norm

Coded 1 (“I do not agree at all”) to 7 (“I agree completely”).

- Due to my values/principles, I feel obliged to upgrade the insulation standard of my dwelling.
- I feel personally obliged to upgrade the insulation standard of my dwelling.

Self-efficacy

Coded 1 (“I do not agree at all”) to 7 (“I agree completely”).

- I know what to do to upgrade the insulation standard of my dwelling.
- I know who to contact to get a professionally executed upgrade of the insulation standard of my dwelling.

General consumer effectiveness

Reverse coded 1 (“I do not agree at all”) to 7 (“I agree completely”).

- I feel personally helpless to have much of an impact on a problem as large as the environment.
- Since one person cannot have an effect on the solution of environmental problems, it does not count what I do.

Altruism

Now we ask you to read some descriptions of a person. How much is each of these descriptions like you or not like you? Coded 1 (“not like me at all”) to 7 (“very much like me”).

- It is really important for me to help people around me. I care about how they are doing.
- Justice and equality are important values. I think everybody should have the same opportunities in life.
- People should care more about nature around them. It is important for me to protect the environment.

Hedonism

Now we ask you to read some descriptions of a person. How much is each of these descriptions like you or not like you? Coded 1 (“not like me at all”) to 7 (“very much like me”).

- I like to show my abilities. I want that people admire what I do.
- It is important for me to have a good time. I like to “spoil” myself.
- It is important for me to be rich. I want to have a lot of money and expensive things.

General innovativeness

Coded 1 (“I do not agree at all”) to 7 (“I agree completely”).

- I enjoy trying new ideas.
- I frequently improvise methods for solving a problem when an answer is not apparent.
- My friends and colleagues often ask me for advice or information.
- I consider myself to be creative and original in my thinking and behavior.
- I enjoy taking part in the leadership responsibilities of the group I belong to.
- I feel that I am influential towards my friends and colleagues.
- I find it stimulating to be original in my thinking and behavior.

Table 1: Internal consistencies and number of questions for the different psychological variables.

Variable	Number of items	Raykov's Rho [95% CI]
Intention to energy upgrade	3	.91 [.91 .92]
Attitudes towards energy upgrades	4	.94 [.93 .94]
Descriptive norms	2	.75 [.69 .81]
Social norms	2	.75 [.73 .76]
Problem awareness	2	.57 [.54 .60]
Personal norm	2	.78 [.77 .79]
Self-efficacy	2	.63 [.60 .66]
General consumer effectiveness	2	.50 [.46 .54]
Altruism	3	.69 [.67 .70]
Hedonism	3	.62 [.60 .64]
General innovativeness	7	.83 [.82 .84]

Table 2a: Differences in barriers and drivers between different socio-demographic groups (N=2,687). The agreement was measured on a 7-point scale (1=do not agree, 7=completely agree); bold numbers indicate a significant difference at the p<.001 level between at least two numbers, the highest and the lowest number are marked; age, innovativeness, and available free investment money were divided into three to four groups of equal size.

		gender		age respondent				Innovativeness				available free investment money			education				
	Total	male	female	<43	43-53	54-63	>63	lowest quartile	next lowest quartile	next highest quartile	highest quartile	<150001	150001-500000	>500000	basic	higher	vocational	university <5yrs	university 5yrs+
Barriers																			
Unsure about the saving potential for energy costs after an upgrade	4,17	4,18	4,16	4,25	4,24	3,97	4,20	**4,43**	**4,08**	**4,03**	**3,98**	4,13	4,17	3,98	4,11	4,08	4,18	4,19	4,38
Plans to move soon	1,83	1,90	1,75	1,84	1,74	1,77	1,97	1,85	1,98	1,66	1,78	1,91	1,83	1,72	2,00	1,80	1,84	1,85	1,72
I cannot manage to make a decision about what to do	2,47	2,51	2,44	2,49	2,42	2,38	2,60	**2,69**	**2,62**	**2,53**	**2,07**	2,57	2,50	2,11	2,67	2,47	2,41	2,45	2,55
The right point in time has just not come to upgrade	4,58	4,46	4,72	4,48	4,57	4,67	4,61	4,65	4,47	4,62	4,52	4,56	4,38	4,16	4,85	4,64	4,65	4,52	4,23
Building protection regulations prevent me from upgrading	1,50	1,52	1,48	1,59	1,45	1,43	1,54	**1,52**	**1,66**	**1,46**	**1,32**	1,47	1,43	1,37	1,60	1,48	1,52	1,44	1,63
Not enough economic resources	3,13	**2,93**	**3,36**	**3,71**	**3,20**	**2,82**	**2,76**	3,24	3,20	3,09	2,87	**3,64**	**2,71**	**2,16**	3,13	3,26	2,97	3,06	3,32
Contractors that could do the job lack the necessary competencies	2,11	**2,28**	**1,90**	2,09	2,12	2,05	2,18	2,30	2,24	2,05	1,95	2,18	2,03	1,97	2,21	2,05	2,17	2,01	2,32
Dependent on agreement with neighbors	1,66	1,60	1,72	1,84	1,70	1,52	1,55	1,62	1,82	1,54	1,54	**1,80**	**1,49**	**1,26**	1,78	1,67	1,60	1,61	1,78
Difficult to know if information about energy upgrades can be trusted	3,32	3,29	3,36	3,34	3,29	3,20	3,45	**3,49**	**3,44**	**3,31**	**2,99**	3,27	3,23	2,87	3,31	3,33	3,34	3,24	3,46
Too much disturbance of everyday life throughout such a project	3,94	3,83	4,08	**4,07**	**3,84**	**3,67**	**4,18**	**4,15**	**4,12**	**3,86**	**3,55**	3,88	3,87	3,74	**3,82**	**3,75**	**3,89**	**4,03**	**4,44**
Information about upgrading is difficult to find	2,67	2,63	2,72	2,77	2,68	2,51	2,72	**2,98**	**2,78**	**2,52**	**2,28**	2,70	2,49	2,34	2,79	2,74	2,59	2,57	2,82
Demands much time to supervise the contractors	3,98	**3,81**	**4,18**	**3,88**	**3,83**	**3,92**	**4,27**	4,07	4,10	3,95	3,73	3,96	3,82	3,87	**3,88**	**3,80**	**3,88**	**4,09**	**4,44**
Negative experience from previous projects	1,99	**2,12**	**1,84**	1,98	1,97	1,96	2,04	**2,08**	**2,18**	**1,89**	**1,83**	2,00	1,90	1,77	2,12	2,01	2,02	1,95	1,87
Facilitators																			
Reduction of energy costs expected after upgrade	4,49	4,49	4,48	4,55	4,50	4,41	4,48	4,36	4,57	4,52	4,42	4,50	4,68	4,44	4,50	4,46	4,54	4,48	4,43
Increased market value of the dwelling expected after upgrade	4,76	4,77	4,74	4,69	4,72	4,68	4,94	4,64	4,66	4,82	4,74	4,85	4,94	4,76	4,86	4,71	4,83	4,70	4,77
Payoff of the investment within a reasonable time frame	4,64	**4,48**	**4,83**	4,67	4,67	4,66	4,58	4,52	4,69	4,69	4,64	4,71	4,75	4,43	4,77	4,67	4,61	4,59	4,70

Positive health effects expected after upgrade	4,47	**4,26**	**4,73**	4,70	4,39	4,39	4,40	4,36	4,49	4,52	4,47	4,59	4,52	4,35	4,59	4,59	4,38	4,40	4,42
The building standard of the dwelling is perceived as a waste of energy	3,14	3,25	3,02	**3,59**	**3,15**	**2,86**	**2,96**	3,21	3,19	3,06	3,06	3,47	3,31	3,32	**2,77**	**3,04**	**3,02**	**3,27**	**3,61**
Better living conditions in the dwelling expected after upgrade	4,60	4,62	4,58	**4,91**	**4,60**	**4,40**	**4,48**	4,48	4,54	4,57	4,66	4,87	4,83	4,70	4,41	4,60	4,59	4,58	4,77
Higher comfort levels expected after upgrade	5,07	4,99	5,15	**5,33**	**5,09**	**4,99**	**4,84**	4,87	4,98	5,13	5,18	5,32	5,23	5,15	5,08	5,05	5,04	5,07	5,15
Information about energy upgrade is easily accessible	5,32	5,32	5,30	5,14	5,36	5,46	5,30	**4,83**	**5,34**	**5,41**	**5,60**	5,27	5,42	5,44	5,43	5,32	5,38	5,30	5,15
Information about energy upgrade is trustworthy	4,84	**4,66**	**5,06**	4,83	4,83	4,88	4,83	4,69	4,85	4,85	4,95	4,94	4,97	4,68	4,90	4,72	4,71	4,96	5,09
There are subsidy schemes in place supporting the upgrade	5,01	4,99	5,05	4,70	4,93	5,16	5,17	4,77	4,98	5,01	5,04	4,94	5,04	5,30	**5,12**	**4,72**	**4,95**	**5,11**	**5,47**

Table 2b: Differences in barriers and drivers between different house type groups (N=2,687). The agreement was measured on a 7-point scale (1=do not agree, 7=completely agree); bold numbers indicate a significant difference at the p<.001 level between at least two numbers, the highest and the lowest number are marked; house size and age of the house were divided into three to four groups of equal size.

	house type			house size			age of the house				Part of the country					
	single family	semi-detached	terraced house	<131m²	131-180m²	>180m²	<1960	1960-1975	1976-1985	>1985	South	East	West	Central	North	Oslo
Barriers																
Unsure about the saving potential for energy costs after an upgrade	**4,08**	**4,27**	**4,58**	4,22	4,22	3,99	**4,05**	**4,34**	**4,32**	**3,94**	4,17	4,15	4,22	4,09	4,15	4,29
Plans to move soon	1,78	2,02	1,99	1,92	1,81	1,76	1,81	1,89	1,82	1,75	1,93	1,89	1,73	1,64	1,85	1,60
I cannot manage to make a decision about what to do	**2,39**	**2,55**	**2,85**	**2,66**	**2,43**	**2,27**	**2,56**	**2,65**	**2,49**	**2,15**	2,51	2,49	2,48	2,26	2,54	2,44
The right point in time has just not come to upgrade	4,53	4,82	4,71	4,55	4,61	4,56	**4,00**	**4,33**	**4,63**	**5,43**	4,55	4,65	4,58	4,39	4,45	4,60
Building protection regulations prevent me from upgrading	1,48	1,46	1,63	1,56	1,50	1,40	**1,72**	**1,45**	**1,36**	**1,41**	1,59	1,54	1,45	1,33	1,43	1,57
Not enough economic resources	**3,02**	**3,33**	**3,58**	**3,30**	**3,15**	**2,79**	**3,37**	**3,33**	**2,89**	**2,80**	2,94	3,22	3,02	2,92	3,27	3,19
Contractors that could do the job lack the necessary competencies	2,07	2,12	2,34	2,25	2,12	1,95	2,15	2,22	2,05	1,96	2,09	2,12	2,14	1,96	2,03	2,41
Dependent on agreement with neighbors	**1,24**	**2,28**	**3,52**	**2,11**	**1,61**	**1,22**	1,62	1,62	1,62	1,71	**1,74**	**1,63**	**1,57**	**1,62**	**1,50**	**2,40**
Difficult to know if information about energy upgrades can be trusted	3,25	3,44	3,62	3,42	3,35	3,14	3,35	3,36	3,28	3,20	3,46	3,33	3,34	3,10	3,19	3,42

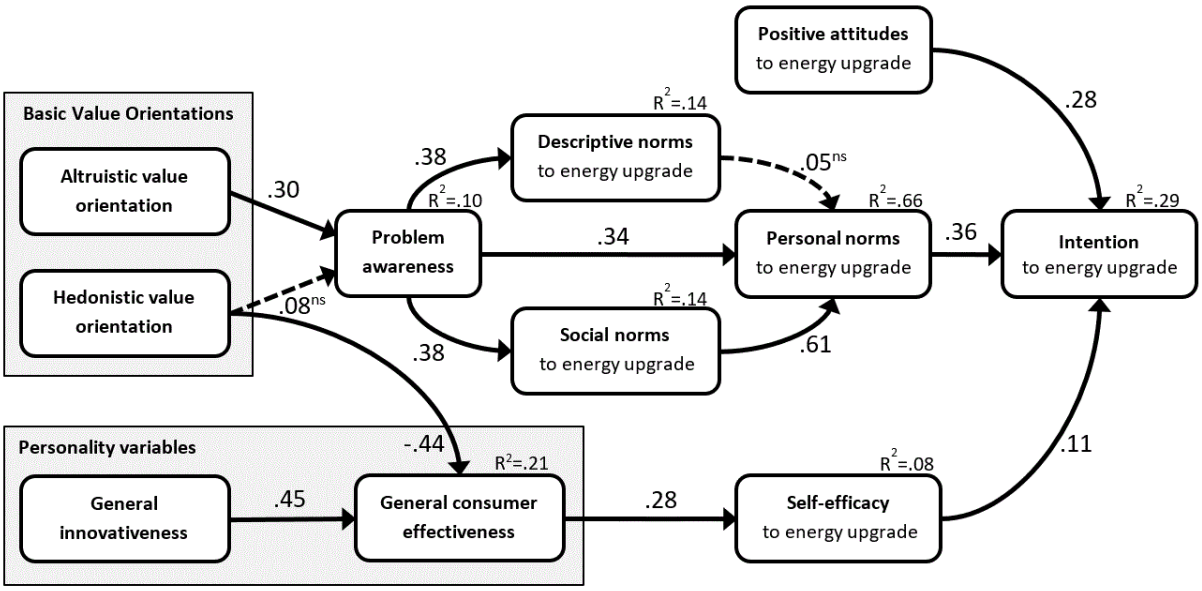
Too much disturbance of everyday life throughout such a project	**3,84**	**4,16**	**4,35**	3,94	4,12	3,75	4,03	3,99	3,96	3,74	4,19	3,95	3,87	3,75	3,73	4,32
Information about upgrading is difficult to find	2,60	2,84	2,94	2,72	2,65	2,54	2,72	2,72	2,65	2,49	2,81	2,60	2,70	2,67	2,62	2,97
Demands much time to supervise the contractors	**3,86**	**4,23**	**4,43**	4,00	4,00	3,90	4,01	3,85	4,05	3,94	**3,92**	**3,98**	**4,05**	**3,93**	**3,63**	**4,71**
Negative experience from previous projects	1,97	1,91	2,11	2,06	1,94	1,91	2,08	1,90	2,01	1,92	2,00	2,01	2,03	1,80	1,93	2,08
Facilitators																
Reduction of energy costs expected after upgrade	4,48	4,31	4,61	4,52	4,44	4,40	**5,04**	**4,86**	**4,35**	**3,57**	**4,37**	**4,48**	**4,19**	**4,82**	**4,82**	**4,59**
Increased market value of the dwelling expected after upgrade	4,73	4,72	4,90	4,88	4,79	4,52	**5,30**	**5,19**	**4,62**	**3,77**	**4,47**	**4,74**	**4,64**	**4,97**	**5,25**	**4,59**
Payoff of the investment within a reasonable time frame	4,63	4,66	4,72	4,74	4,59	4,54	**4,99**	**4,87**	**4,46**	**4,19**	**4,32**	**4,62**	**4,44**	**4,91**	**5,13**	**4,81**
Positive health effects expected after upgrade	4,41	4,56	4,71	4,58	4,45	4,32	**4,74**	**4,65**	**4,21**	**4,22**	4,27	4,48	4,35	4,63	4,68	4,54
The building standard of the dwelling is perceived as a waste of energy	3,10	3,35	3,29	3,20	3,14	3,05	**3,71**	**3,47**	**3,06**	**2,22**	3,33	3,12	2,92	3,36	3,18	3,26
Better living conditions in the dwelling expected after upgrade	4,56	4,65	4,76	4,69	4,61	4,42	**5,32**	**5,05**	**4,40**	**3,52**	4,41	4,62	4,43	4,89	4,78	4,65
Higher comfort levels expected after upgrade	5,05	5,07	5,15	5,12	5,07	4,96	**5,58**	**5,31**	**4,88**	**4,37**	4,83	5,13	4,84	5,29	5,21	5,19
Information about energy upgrade is easily accessible	5,37	5,11	5,11	5,29	5,32	5,43	5,29	5,31	5,37	5,36	5,21	5,29	5,38	5,24	5,58	5,13
Information about energy upgrade is trustworthy	4,84	4,87	4,82	4,83	4,86	4,84	4,82	4,81	4,89	4,89	4,71	4,90	4,63	4,95	4,89	5,04
There are subsidy schemes in place supporting the upgrade	4,99	4,93	5,15	5,03	4,94	5,13	4,95	4,91	4,86	5,36	5,07	4,93	4,87	4,92	5,14	5,75

Table 3: Regression of attitudes on barriers and drivers (N=2,687). A positive regression weight implies that the more a respondent agrees with the statement, the more positive are the attitudes; a negative weight implies that more agreement with this statement is associated with more negative attitudes.

Barriers towards energy efficiency upgrades	**Standardized regression weights**	**Standardized regression weights (LAR)**
Unsure about the saving potential for energy costs after an upgrade	.049 **	.053 ***
Plans to move soon	-.013 ns	-.012 ns
I can not manage to make a decision about what to do	.008 ns	*Excluded*
The right point in time has just not come to upgrade	-.134 ***	-.132 ***
Building protection regulations prevent me from upgrading	-.038 *	-.036 *
Not enough economic resources	.073 ***	.076 ***
Contractors that could do the job lack the necessary competencies	-.039 *	-.037 *
Dependent on agreement with neighbors	-.025 ns	-.024 ns
Difficult to know if information about energy upgrades can be trusted	-.047 *	-.042 **
Too much disturbance of everyday life throughout such a project	.011 ns	*Excluded*
Information about upgrading is difficult to find	.020 ns	*Excluded*
Demands much time to supervise the contractors	-.016 ns	*Excluded*
Negative experience from previous projects	-.028 ns	-.028 ns
Drivers of energy efficiency upgrades		
Reduction of energy costs expected after upgrade	.132 ***	.125 ***
Increased market value of the dwelling expected after upgrade	.149 ***	.139 ***
Payoff of the investment within a reasonable time frame	-.037 ns	*Excluded*
Positive health effects expected after upgrade	.048 *	.037 *
The building standard of the dwelling is perceived as a waste of energy	.191 ***	.196 ***
Better living conditions in the dwelling expected after upgrade	.211 ***	.212 ***
Higher comfort levels expected after upgrade	.114 ***	.109 ***
Information about energy upgrade is easily accessible	.022 ns	.015 ns
Information about energy upgrade is trustworthy	.009 ns	*Excluded*
There are subsidy schemes in place supporting the upgrade	-.052 **	-.051 **

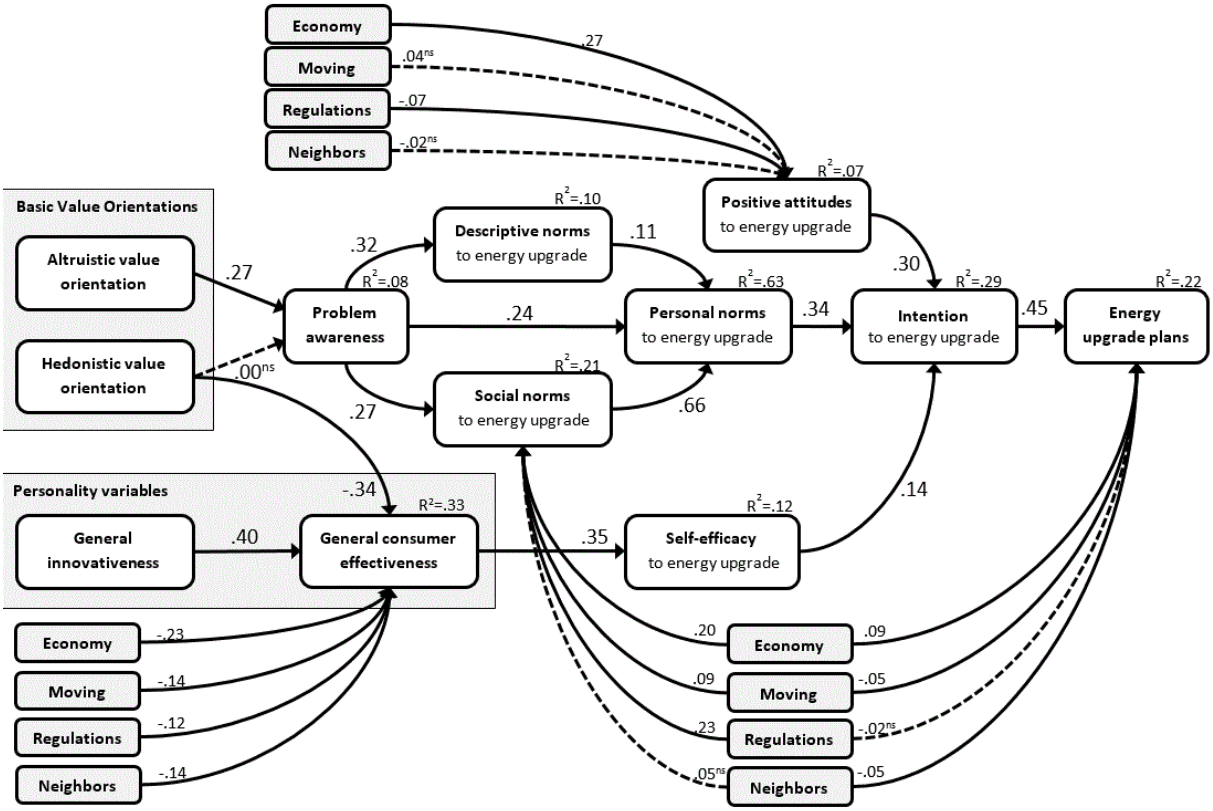
****p<.001, **p<.01, *p<.05, ns = not significant*

Figure 1: Psychological determinants of intentions to energy upgrade within the next three years.



Model fit: *N*=2,676; *Chi*^{2}=3,025.32, *df*=443, p<.001; *RMSEA*=.047 [.045 .048]; *CFI*=.90; *TLI*=.88; *SRMR*=.067

Figure 2: Modelling the ambition level in plans for future energy efficiency upgrades with psychological and structural predictors.



Model fit: *N*=1,885; *Chi*^{2}=2,275.21, *df*=580, p<.001; *RMSEA*=.039 [.038 .041]; *CFI*=.91; *TLI*=.89; *SRMR*=.058