

Master's thesis

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# Does Sustainable Building Technology Matter to Home Buyers?

Determinants of Passive House Purchase Decisions

Trondheim, May 2011

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Norwegian University of Science and Technology  
Faculty of Social Sciences and Technology Management  
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## Preface

The idea for the topic of this thesis evolved from attending several lectures and seminars that presented and discussed issues both within and beyond the boundaries of my master program Risk Psychology, Environment and Safety. The interdisciplinary angle has always interested me, and I wanted to try to include this in my thesis. The final decision of topic came at a seminar where several researchers from other fields within sustainable development participated. During the discussion someone stated “*sustainable building technology has existed for decades, but we don't really know why people don't use it*”. My reaction to the statement was: “*this is psychology!*”

This thesis would not be the same without the network of people that gave support and guidance in a process where I am learning, developing my skills and working as a researcher simultaneously. Therefore I would like to thank Erica Löfström at the Department of Interdisciplinary Studies of Culture for the discussion about potential angles of my topic. Similarly I have received very useful guidance from the research group working on the future carbon neutral settlement Brøset for directing me towards the already existing settlement that became my case. The real estate agency Heimdal Eiendomsmegling was very helpful in the quest for participants to interview, and I am of course forever thankful to the participants themselves.

My supervisor deserves special recognition for giving guidance all the way from an unclear and diffuse idea one year ago, to a finished result. There were always clear and logic answers on my strange questions and spontaneous emails. Finally, I have to thank my friends Henrik and Moira, as well as my dear sister Heidi for helping me improve my work and for lending me their fresh eyes.



## **Abstract**

The objective of this study was to explore what determines the decision of purchasing a passive house. Passive house projects are increasing in Norway, due to their energy saving potential, and an existing project in Trondheim was used as a case for this study. Exploring the determinants was done by interviewing people who had purchased a passive house, and asking what they focused on when deciding which house to buy. It was investigated to which extent the environmental aspect of passive houses influenced the purchase decision. Further, the study investigated if it was possible to distinguish different interest categories among the house buyers, based on economic, environmental or technological interest. Since passive houses are still within the earlier stages of diffusion, it was explored whether the buyers fit into the categories of innovators and early adopters, based on *diffusion of innovation theory*. If the passive house buyers showed environmental interest, the interest could be explained by the variables in the *value-belief-norm theory*.

Interviews and a questionnaire were used to survey the population of the case area and while it was a small sample, the results show that the passive house settlement is perceived more as a housing project in line with conventional projects than a technological innovation. The location, particularly in relation to distance to jobs, city centre and nature was the most important decision determinants. Additionally, limitations in the housing market determined the house choice. The sustainable feature of the passive house was not a determining factor, but was considered positive, mostly due to the long term economic benefit. This shows that the house choice was not guided by pro-environmental values, beliefs and norms. The buyers were not innovators/early adopters by their own choice, and expressed uncertainty about the technology.



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# 1 Introduction

An increased understanding of causes of climate change and environmental problems has created a need for both developing new sustainable technologies, and understanding of why and in what way the technologies are implemented in society. Behaviour change towards sustainable living is needed in both everyday actions and in high cost investments such as house purchasing. While a house purchase is not an everyday individual activity, it is a decision that has significant environmental consequences and is therefore important to address.

The International Energy Agency (IEA) calculated that the world primary energy demand will increase by 36% from 2008 to 2035 ([www.worldenergyoutlook.org](http://www.worldenergyoutlook.org)). In Norway buildings represent approximately 40% of the total energy consumption, 22% in the residential sector and 18% in the non-residential sector (Sartori, Wachenfeldt, & Hestnes, 2009). While this is important information to base future building strategies on, it is equally important to increase the knowledge about the users' perception, behaviour and preferences. As Johansen (2007) points out, introducing new technologies plays an important role in the process of making the building sector achieve a lower emission level of green house gasses. However, to successfully get these technologies adopted by potential users one has to understand how it is perceived, and how it spreads among people (Rogers, 2003).

This study explores what aspects are most important to people when they are searching for and deciding which house to buy. Furthermore, this study investigates whether availability of sustainable features influence the house choice. Additionally it will be investigated whether a sustainable neighbourhoods attracts different types of people than conventional neighbourhoods, e.g. early adopters or environmentally interested. Research indicates (e.g. Jansson, 2009) that there are differences in determinants of behaviour when comparing high cost pro-environmental behaviour (eco-innovation) to low cost and curtailment<sup>1</sup> behaviour. Therefore this study also aims at

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<sup>1</sup> Changes by reducing things people already do

investigating adoption of high cost eco-innovation within the framework of diffusion of innovation theory (e.g. Rogers, 2003; Wejnert, 2002). The eco-innovation investigated in this thesis is the passive house technology; a low energy building standard, currently given much focus due to its resource saving potential. With this in mind, the following research questions were formulated:

- RQ1. What characteristics of a passive house do (potential) buyers focus on in the decision process?
- RQ2. Are house buyers who are interested in a sustainable housing project more focused on environmental aspects around the building than people interested in conventional houses?
- RQ3. Can different interest categories be identified among the buyers based on the characteristics they focus on?

These questions will be elaborated further, together with hypotheses and expectations in Section 1.6. However, first the concept of sustainability and sustainable building technologies is introduced and defined, together with the particular technology used as a case in this study, i.e. passive house technology. Further, previous research and theoretical foundations is presented.

Continuing in this thesis, Chapter 2 will present the method and the procedure of data gathering through interviews and a questionnaire. The results of the interviews and questionnaire will be presented in detail in Chapter 3, categorized according to the research questions. The implications of the study, discussion and suggestions for future research will be presented in Chapter 4.

## **1.1 Sustainable housing**

What characterizes a sustainable building? The definitions used when describing sustainable buildings and architecture vary, as do the definitions of the term “sustainable” itself. Mostly, when addressing sustainability in general, the definition in the “Brundtland report” (Our common future) is used to define sustainable development:

*"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p. 43).

### **1.1.1 Sustainability in the building sector**

Within the building sector the term “sustainable” has been discussed thoroughly, and has been defined as “*True sustainability, of course, means a house that produces as much energy as it consumes*” (Stang & Hawthorne, 2005, p. 13). This definition focuses only on the energy use. Stang and Hawthorne also present additional criteria that should be included in a sustainable building such as: it should be as small as possible, positioned to take advantage of sun and shade, and located close to public transportation, workplace, school etc.

Other definitions apply the sustainability concept to the building industry by using a broader approach. Gauzin-Müller and Favet (2002) state that three principles must be considered when achieving sustainable development: *social equity*, *environmental caution* and *economic efficiency*. For the building sector this means that a sustainable building should not only reduce the negative environmental impact, but also be affordable for the mass population. In effect, this leads to economic efficiency, according to Gauzin-Müller and Favet (2002), since the industry must provide the quantity of houses to the population and that, in turn, improves society’s economic growth.

By using sustainable architecture it is possible to reduce emissions, as well as to create a context for other pro-environmental behaviours (Sassi, 2006). As suggested by Sassi, sustainable buildings should have a small ecological footprint both during construction and usage, but also in the demolition phase. The buildings should be constructed in a way that they satisfy the residents’ practical needs, their psychological and physical well-being as well as being adjusted to the surrounding.

To provide sustainable buildings, different types of technologies are used. In Norway the heating necessities of buildings are most relevant with respect to energy use as, according to Statistics Norway (SSB), heating is responsible for approximately 50% of the total energy use of a household (Bøeng & Larsen, 2008). To achieve sus-

tainable development in the building sector, as well as respond to increasing electricity prices, there has been an increase in building projects involving low-energy houses. The term low-energy house is a widely used definition which means that houses have significantly lower energy use than houses built with traditional technology. However, a more specific definition separates low-energy houses and passive houses, since the technology is different. Passive houses require less energy for heating and hot water (Dokka & Hermstad, 2006). This study is focusing on passive houses.

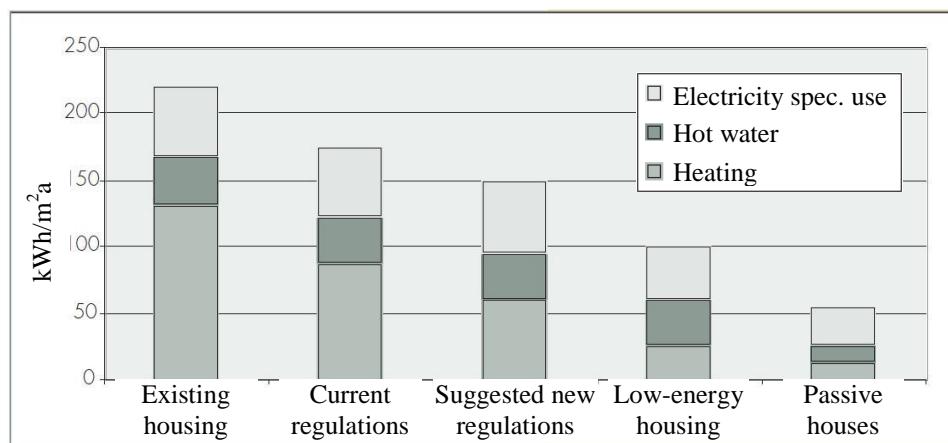
### **1.1.2 Passive houses**

The term passive house refers to the minimal need to actively heat and cool the house, without reducing the quality of indoor climate (Passive House Institute, n.d.). While it is most common to implement passive house standards to new buildings there are projects to refurbishing old houses (Elswijk & Kaan, 2008). This is possible where e.g. the outer walls are constructed in such a way that insulation can be added and where it is possible to upgrade the ventilation system. The Passive House Institute has provided guidelines for the basic features of passive house construction:

- Energy used for heating should not exceed 15 kWh/m<sup>2</sup>a (a= annually).
- Compact form and good insulation
- Southern orientation and shade considerations
- Energy-efficient window glazing and frames
- Building envelope air-tightness, i.e. defining the allowed air leakage through unsealed joints
- Passive preheating of fresh air
- Highly efficient heat recovery from exhaust air using an air-to-air heat exchanger
- Hot water supply using regenerative energy sources
- Energy-saving household appliances

Most existing houses in Norway use approximately 130 kWh/m<sup>2</sup>a (Dokka & Hermstad, 2006). By using passive house technology it is thus possible to save a large amount of energy, in particular energy used to heat the house. Depending on the location and climate one can reduce the energy consumption to 25% of conventional houses, and in some cases even down to just 10%, see Figure 1.

The main strategy to reach these reductions is to reduce the heat leakage by increasing the insulation in walls, floor and ceiling and usage of super insulated windows, often triple glazed. Heating is achieved by maximizing the utilization of the sunlight. Additional heating is gained from electrical appliances and body heat from the residents (Dokka & Hermstad, 2006). Due to the climate in Norway there is usually a need for an additional heating system, e.g. electrical ovens or water borne heating, even if the best available insulation is provided (Elswijk & Kaan, 2008).

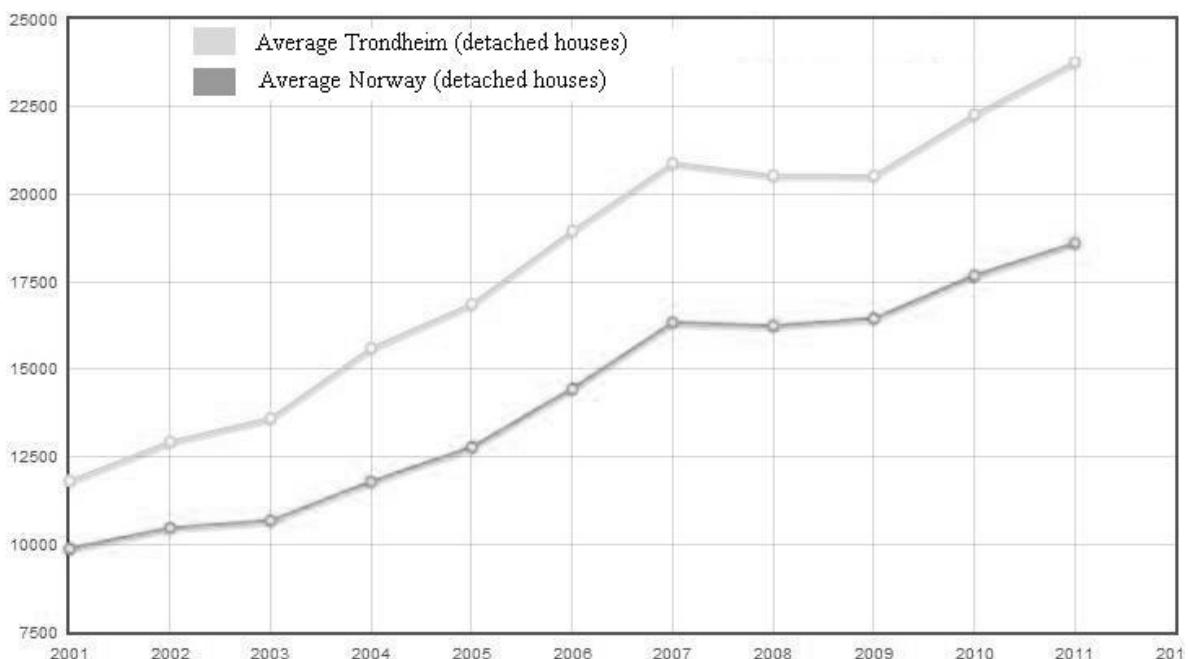


**Figure 1. Annual energy use in kWh/m<sup>2</sup> divided by electricity specific use, hot water and heating.**

Source: (Dokka & Hermstad, 2006, p. 7)

## 1.2 Housing market in Trondheim

To understand the context where the decision for a house purchase is made, it is important to analyze the local market conditions. Local and national newspapers recently reported that the housing market in Trondheim has been under increasing pressure in recent years, with house prices above average (Mathisen & Toning, 2011, January 14). At the same time the number of houses for sale is decreasing (Sved, 2011, March 07). The reason, according to Sved, is that fewer people are selling their houses, and there are fewer new houses being built. The statistics support these claims, showing that the average price per m<sup>2</sup> for a detached house in Trondheim is NOK 23654.22 in 2011, whereas the price in 2000 was NOK 11823,82, see Figure 2.



**Figure 2. Development of prices/m<sup>2</sup> for detached houses in Trondheim compared to Norway.**

Source: Norges Eiendomsmeglerforbund ([www.nef.no](http://www.nef.no))

The number of detached houses being built has decreased from 1990 to present, see Table 1. Additionally, there has been an increase in the population in Trondheim by 24604 people between 2000-2010 (SSB, [www.ssb.no](http://www.ssb.no)). The influence this development might have on the decision process of house purchase will be elaborated in the Chapter 4.

**Table 1. Number of detached houses in Trondheim categorized by building year**

Building year	Number of houses
1961-1970	4382
1971-1980	3609
1981-1990	5298
1991-2000	2073
2001-	1350

Source: Statistics Norway (SSB)  
([www.ssb.no/boligstat](http://www.ssb.no/boligstat))

## 1.3 House buyers' preferences

The decision to buy a specific house is shaped both by characteristics of the house itself and of the buyer. In general there are some criteria that a house must fulfil in order to be considered suitable by a potential buyer. These criteria will be elaborated on in the next section. Additionally, the buyers must consider potential limitations that are more difficult to control, e.g. income level, mortgage limitations, or the possibility to travel to and from work (Anglin, 1997). Within these limitations, the desired characteristics are considered.

### 1.3.1 Important determinants of house choice

A house purchase involves several decisions and factors, both situational factors and personal preferences (Sirgy, Grzeskowiak, & Su, 2005). It is a process that requires both information gathering and involvement (Koklič & Vida, 2009). In a study by Saaty (1990) the house purchase decision was used to illustrate that when there are several factors to consider in a decision, the factors are arranged in a hierarchical structure. Saaty's study is relevant for this study for two reasons. Firstly, it shows the process behind the decision making, and how the criteria for house choice differ between persons. Secondly, it is interesting to investigate the criteria themselves. The

combination of location, available public facilities, and house characteristics within the financial boundaries were the most important determinants of the decision.

Saaty (1990) showed that the overall criterion for which house to choose was “*satisfaction with house*”, but that this was determined by several underlying criteria that influenced the final decision. Saaty identified eight different variables that were important:

- *size of house* – suitable size according to needs
- *location to bus lines* – convenience of public transportation
- *neighbourhood* – traffic conditions, security and condition of the neighbourhood
- *age of house*
- *yard space* – size of outside space and distance to neighbours
- *modern facilities* – waste separation system, adapted for new appliances etc.
- *general condition* – need for renovation
- *financing available* – e.g. mortgage and savings

In Saaty’s study, the participants were presented with three hypothetical houses, having the task to decide which of them to choose in a purchase. Since the participants were presented with pre-chosen houses, and it was hypothetical, the location of the houses was not given much focus. According to Saaty (1990) the eight criteria are considered and weighed against each other, giving a personal hierarchical order where some criteria are prioritized over others.

Sirgy et al. (2005) state that there is a need for a dual approach to understand the house choice decision. Sirgy et al. include both functional and symbolic aspects when explaining determinants of house choice. Functional aspects involve the quality of the home in relation to the needs of the residents, e.g. the floor plan and structure of the house related to the residents routines and behaviour. A positive match between the residential functions and the residents’ needs increases the likelihood of choosing the house (Sirgy et al., 2005). In addition to functional aspects, a house reflects the self-image. According to Sirgy et al., the more the image of the house matches the buyers’ self-image, the more motivated the buyers are to choose the house. However, there

might be interfering factors, such as time pressure and (in)experience of house purchase, that could influence the choice.

Other studies point to the importance of place identity and how the place corresponds with the residents' values (Lindstrom, 1997; Proshansky, Fabian, & Kaminoff, 1983). Potential buyers intentionally seek the housing and location where their values and their preferences are confirmed (Lindstrom, 1997). The values and preferences vary between different locations, e.g. preferring a quiet neighbourhood, closeness to nature, or creating a sense of belonging through similarity to the neighbours. According to Proshansky et al. (1983) preferences vary from house specific features, such as design or colour, to landscape or geographical preferences. The latter is determined by place identity characteristics.

It has been shown by Koklič and Vida (2009) that determinants of the house choice are both internal and external. The participants of the study were buyers or potential buyers of pre-fabricated houses. The decision on where to build was made before the decision of which house to choose. Hence, location was not discussed in the study. The findings show that the house choice was related to people's self-concept and as a way to express their lifestyle. The internal factors that were shown to influence house purchase were emotions, self-confidence, experience, prior knowledge, and involvement. External influences were factors such as family, marketing communication, reference groups, and income.

### **1.3.2 Sustainable house buyers' preferences**

There is an increasing number of neighbourhoods with sustainable building technologies in Europe (Schnieders & Hermelink, 2006), as well as in Norway (Lassen, Fylling, & Mysen, 2009). In some cases there have been studies evaluating the residents' experience of living in such areas, analyzing both the experience of living there, as well as the reasons for moving there (e.g. Isaksson & Karlsson, 2006; Löfström, 2008; Ornetzeder, Hertwich, Hubacek, Korytarova, & Haas, 2008). This gives important knowledge of whether the sustainable aspect is important, and, if so, to what extent it becomes a determining factor influencing the decision to move there. Four cases

of sustainable neighbourhoods are described in the following sections, including conclusions that can be drawn on a more general level.

### **Anneberg, Sweden**

The neighbourhood Anneberg is located in Danderyd, close to Stockholm, Sweden and consists of 50 residential units (Lundh & Dalenback, 2008). It was built in 2000-2002, with the purpose of having a pro-environmental profile, mainly by waste separation, improved sewage system and the use of renewable energy sources (Löfström, 2008). The energy system used was a solar heating system with a borehole storage system in the underground granite rock maintaining low-temperature space-heating (Nordell, 2000), mainly by floor heating (Löfström, 2008).

The residents were interviewed regarding their experience of living in the area, as well as the main characteristics they found important when choosing to move there. As with buyers of traditional houses, the main reason for choosing to buy in Anneberg was the location and comfort of the houses. The sustainable technology was considered positive by all participants of the study, but not a determinant of house choice.

The evaluation of the sustainable technology was further investigated, and Löfström (2008) found three different aspects that were considered important with respect to the sustainable feature of the houses: *financial, ecological and technological interest*. While three interest categories were found, it does not mean that the residents were only focused on one of the three. It merely shows that they differ in what the residents perceive as most interesting about the sustainable features. The financial aspect involves the positive effect of saving money from the energy saving heating system. The financial benefit was reported as positive, but some of the interviewees also specifically stated that it was not a determining factor. Several of the interviewees that had a positive view of the financial benefit also had a positive view of the reduced environmental impact. It was found that most of the respondents who had a positive view of the environmental effect of the sustainable building technology, were pleased with saving money from lower energy consumption. Those interested in the technological feature of the house were themselves engineers. They were thus highly interested in

the technology used and were the only ones who stated that the technology in itself had some influence on the decision to buy in that neighbourhood.

### **Vienna, Austria**

Other studies show that the environmental concern can be a motivator for the choice of the house. In a study by Ornetzeder, et al. (2008) the motivating factors behind the house choice in a car-free neighbourhood was compared with a reference settlement. There were differences between the two settlements, see Table 2. Interestingly, the most significant difference was *generous common areas and facilities*. 81% of the car-free settlement residents stated that as an important motivator to buy in that area, while 17% of the reference settlement stated the same. Closeness to the *recreation area ‘Alte Donau’* also differed between the two groups. 85% of the respondents from the car-free settlement stated closeness to Alte Donau as a motivator for choosing the housing, whereas 58% of the reference settlement stated the same. Both these criteria involve outdoor activity close to the home, and do not require car use. This indicates that when the household does not own a car, the desire to have outdoor activities closer to home increases.

**Table 2. Motivators to move to a settlement – comparing car-free and reference settlement.**

<b>Most important motivations to move to the settlement</b>	<b>Car-free area (%)</b>	<b>Reference settlement (%)</b>
Recreation area ‘Alte Donau’	85	58
Generous common areas and facilities	81	17
To live in a ‘green’ and healthy environment	73	61
Quiet site/no noise pollution	71	61
Bright, sunny apartment	68	54
Good floor plan	46	63
Need for more living space	44	61

Source: (Ornetzeder, et al., 2008)

### ***Lindås, Sweden***

Lindås is a neighbourhood of 20 terraced passive houses, located 20 kilometres south of Gothenburg, Sweden, built in 2001 (Isaksson & Karlsson, 2006). It is, as most passive houses, mainly heated by the electrical appliances, body heat and effective use of sunlight. 16 of the 20 households were interviewed approximately a year after moving in. It was reported that the main reason for moving to the neighbourhood was the location, as it is close to nature and the sea, and at the same time not too far from Gothenburg. It was also perceived that the terraced houses were good value for the money compared to other houses in the same area.

As with a non-sustainable house purchase, Isaksson and Karlsson (2006) found that it was the location and the financing that were perceived as the most important aspects. The sustainable feature, i.e. low energy use, was perceived as adding positive value to the houses. It was, however, not among the determinant factors. When asked about concerns regarding the new technology, most responded that they trusted the researchers and the building proprietor and did not express any specific concern about the technology.

### ***Kassel, Germany***

In Kassel, Central Germany, the first multi-story passive house was built in year 2000, which consisted of 40 apartments for low-income tenants (Schnieders & Hermelink, 2006). In this study it was found that the most valued aspect of the apartments was the balcony, and the least important was the fact that it was a passive house. Interestingly, in the advertising campaign, marketing the characteristics of passive house and low energy use did not attract many tenants. When the marketing campaign focused on attractiveness, balcony and that it was a new building, the response increased.

#### **1.3.3 Importance of the sustainable aspect**

The four cases presented above gives an indication that the determinants of buying a sustainable house are very similar to house purchase in general. The location, size and indoor planning were the most important features. Some of the residents in these settlements reported environmental reasons for choosing to move there. However, as was

shown in the marketing campaign in Kassel, there are other features that are more important. The sustainable feature of the houses was perceived as positive, both for personal financial benefit and environmental concern.

## **1.4 Determinants of the decision process**

So far, the house buyers' preferences and the characteristics that are important for choosing which house to buy have been reviewed. However, it is also important to find the determinants of the decision process when buying a house, and how they might differ from other types of potentially pro-environmental behaviour. In the following section, the differences in the decision process between high cost purchase and other pro-environmental behaviour will be presented. Further, the adoption process of innovations, through Rogers' (2003) diffusion of innovation theory will be discussed. Finally, the possible influence of values, beliefs and norms on high investment purchase and early adoption of innovations will be elaborated using the value-belief-norm theory (Stern, Dietz, Abel, Guagnano, & Kalof, 1999).

### **1.4.1 High cost purchase behaviour compared to everyday behaviour**

Research in the area of sustainable behaviour has suggested that it is necessary to have different approaches to high cost purchases than to everyday behaviour (Ölander & Thøgersen, 1995). With high cost decisions the level of involvement and information search is more extended than with low cost purchase (Laurent & Kapferer, 1985). It also requires more cognitive effort (Jansson, 2009).

Three different types of pro-environmental behaviour have been identified that each have different influence strategies to be successful: curtailment, maintenance and investment (or efficiency) behaviour (Ritchie & McDougall, 1985). Curtailment behaviour is based on modifying or reducing the already existing behaviour and its consequences, e.g. lowering indoor temperature or reducing car use (Ölander & Thøgersen, 1995). Curtailment behaviour requires little information seeking, other than gaining knowledge of the need for behaviour change (Ritchie & McDougall, 1985). It does sometimes require a change in lifestyle, e.g. taking the bus or bicycling instead of driving the car. However, there is a possibility, according to Ritchie and

McDougall, that habits might interfere with the behaviour that is meant to be reduced. Since curtailment behaviour often involves habituated everyday actions that require little cognitive capacity, it will be harder to make changes. Ritchie and McDougall also point out that curtailment rarely leads to large savings, which might reduce the willingness to adopt these behaviours. There are often policy influences on curtailment behaviour, e.g. campaigns to reduce environmentally harmful behaviour such as car use in densely populated areas (Jansson, 2009).

Maintenance behaviour involves keeping the existing equipment in good working order, extending the durability of the products, e.g. service the car or the existing heating system (Ölander & Thøgersen, 1995). Maintenance behaviour requires some knowledge and information seeking to meet the necessary technical requirements. It often requires some financial investment, however not to the extent as investment behaviour. In the long term smaller investments in maintenance reduce the need for a sooner high investment due to broken technology. Alternatively, maintenance behaviour increases the value of the investment, leading to a long term profit (Ritchie & McDougall, 1985).

Investment behaviour involves a larger change, e.g. insulating the home or changing the type of car to a more energy efficient (Ölander & Thøgersen, 1995). With this type of behaviour a structural change occurs by substituting existing solutions with better ones. In a study by Black, Stern, and Elworth (1985) it was investigated what the most effective influences on household energy adaptations was, and whether there were differences between high and low cost investments. The results showed that there are differences between what predicted high and low cost investment. Predictors of high cost investments were home ownership, belief that personal benefit can be gained from energy efficiency, as well as the number of people in the household.

Low cost investments to improve energy efficiency showed to be directly influenced mainly by the personal norm for energy efficiency, direct payment for home heating and high energy bills. Black, et al. (1985) argued that when the energy bills are unusually high, individuals make low cost improvements on energy efficiency, by e.g. sealing heat leaks around windows or doors, or adding curtains or shades to retain

heat. It does not necessarily lead to long term investments such as insulating floor and ceiling or change of windows. One explanation Black et al. presented to why personal norms played a more important role in low cost investments is that these investments are more determined by factors within the consumer's control. With high cost investments the individual is much more restricted by e.g. financial circumstances, and high cost investments are more time consuming.

Investment behaviour might require investing in an unfamiliar innovation. This can lead to uncertainty and additional need for knowledge (Rogers, 2003). The following section presents *diffusion of innovation theory* and how that can explain features of investment behaviour relatively new or unknown technology.

### **1.4.2 Diffusion of innovation**

Diffusion of innovation theory (Rogers, 2003) can explain why there is a slow progress in the usage of low-energy and sustainable building technologies. Despite the possibility to save large amounts of energy, and thereby save money, sustainable building technologies have not become the dominant choice among people in Norway. Passive house technology is still considered a new technology. It is therefore interesting to see how the diffusion of innovation theory can help explain the decision process of house purchase. This theory might explain the diffusion process both among house project developers as well as among house buyers. In this study the main focus is the house buyers.

Rogers defines diffusion as a process: “*by which an innovation is communicated through certain channels over time among the members of a social system*” (2003, p. 35). The diffusion process varies based on several different factors. Different types of innovations require different means of communication. The communication channels differ depending on who gives and receives information about the innovation. Members of a social system are one or more units engaged in achieving the same goal. It can include individuals, groups, organizations and subsystems all requiring different strategies to accept diffusion (Rogers, 2003).

Individuals typically ask questions such as “What is this innovation, and how does it work?”, “What are the consequences?” and “Will this be a benefit or a disadvantage for me?” Thus, Rogers (2003) argues that the adoption of a new innovation is mainly an information-decision process, where information about the innovation is gathered, and an information-processing activity where the information is evaluated with respect to the potential positive or negative consequences for the individual.

Considering the channels and rates by which an innovation is spread can shed some light on why the diffusion of sustainable building technologies has been slow in Norway. The research on diffusion of innovations shows both why and how an innovation spreads through a community, or why it does not. It involves how the innovation is communicated, through which channels, and how it moves through the social system over time (Rogers, 2003). An innovation might meet resistance among the public. The effectiveness of the diffusion is determined both by the uncertainty around the new and unfamiliar, as well as the way in which the information is channelled. Uncertainty is defined by Rogers as *“the degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives”* (Rogers, 2003, p. 6). The uncertainty indicates a lack of predictability, structure and available information. Through the spread of information regarding an innovation, thereby reducing the uncertainty, it is either adopted or rejected.

Many developers of innovations miscalculate the rate at which the technology is adopted (Rogers, 2003). Usually the developers expect their innovation to be adapted at a far quicker rate than actually occurs. However, there are some that quickly become adopted, e.g. cellular phones and iPods. This shows the importance to understand the complexity of the processes that influence the diffusion of innovations.

In the building industry diffusion of innovations can affect at different levels. On one hand the entrepreneurs, builders and real estate must adopt the innovations to implement or sell them, e.g. building passive houses. On the other hand, the house buyers must adopt the innovations, and be willing to buy the buildings with the new technology. A miscalculation in either of these cases can delay or stop the innovation to become integrated either by preventing the innovation from reaching the market at all (if

diffusion comes to a halt at the builders' side) or by the end users avoiding available solutions.

According to Wejnert (2002) it is important to analyze the characteristics of both the innovation and the adopters. In addition, the environment in which the innovation is introduced must be taken into consideration. In a review of diffusion research Wejnert provided a frame work where three components was presented: *characteristics of innovations*, *characteristics of innovators* and *environmental context*, together with underlying variables, see Table 3.

In the framework of this thesis, the focus is on the characteristics of innovations and innovators. The geographical conditions influence what type of technology is best suited to introduce. Similarly, the societal culture and political conditions affect the diffusion of sustainable building technologies, since they create acceptance and official building policies. However, since this study is investigating factors influencing house purchase decision of a pre-decided house project, the decisions that could be influenced by the environmental context has already been made by the project developer.

**Table 3 Wejnert's framework of diffusion of innovation.**

Component	Variables
Characteristics of innovations	Public versus private consequences Benefits versus costs
Characteristics of innovators	Societal entity of the innovators Familiarity with the innovation Status characteristics Socioeconomic characteristics Position in social network Personal characteristics
Environmental context	Geographical settings Societal culture Political conditions Global uniformity

Source: (Wejnert, 2002)

### **1.4.3 Characteristics of innovations**

An innovation can come in the form of a product, either new or improved, the process by which the product is developed, or as an organizational innovation, e.g. management style (Rennings, 2000). Rennings also points out that the definition of innovations does not specify the impact the innovation has, and that there is a need to specify innovations that contribute towards sustainable development (eco-innovations). Eco-innovations are technological, social or institutional innovations that reduce environmental burdens and contribute to improving sustainable development. Regardless of the type of innovation, Wejnert (2002) identifies two different characteristics that are significant in the diffusion process: consequences and cost/benefit.

An innovation can have consequences on the private or public level, depending on the type of innovation. Innovations aiming at the public level can involve e.g. laws protecting civil rights, and reflect a need on the societal level (Wejnert, 2002). Societal need can be e.g. a need for a political reform. Innovations with private consequences on the other hand, e.g. new medical practices, have an impact on individual needs. Both these types of innovation result in societal changes, if accepted. However, it is important to recognize that the diffusion process and the interaction between adopter and innovation require different strategies depending on the innovation's consequences.

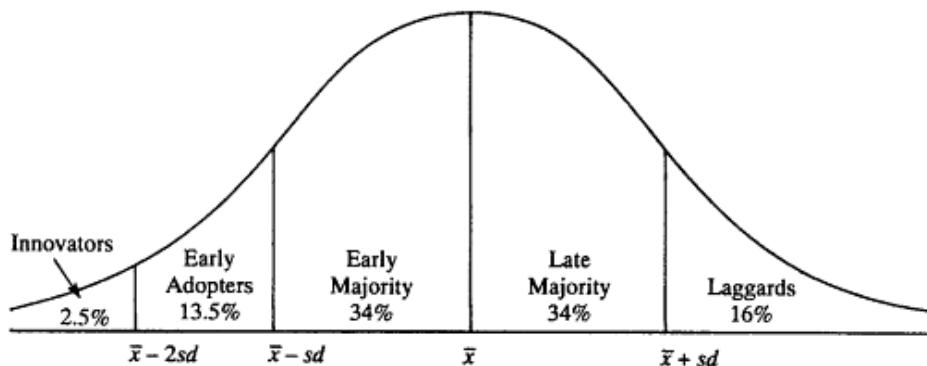
In the perspective of sustainable building technologies, public consequences could involve new building regulations, e.g. low-energy requirements, thus influencing towards a sustainable development on a societal level. This form of development also has private consequences. Changing the building standard, e.g. including new heating system or super insulated windows requires different actions from the residents than traditional building technologies. To succeed with the eco-innovation it is important to consider in what way the buildings are put in a social context, how the users learn to use the buildings and how to embed the technologies into existing traditions (Rohracher & Ornetzeder, 2002).

The cost of an innovation often slows the adoption process, in particular if the cost is not within the same range as the planned resource use of the adopter (Wejnert,

2002). The time perspective to the cost and/or benefit adds to the diffusion process. A study of 400 homeowners in Florida showed that the willingness to invest in an energy saving innovation was higher if the time span of repayment was shorter, i.e. money that was saved as a result of the investment (Grosskopf & Kibert, 2006). From a sustainable building perspective, Hoffman and Henn (2008) presented possible explanations for potential lack of investment willingness, suggesting that if the repayment period does not match the time frame of the home ownership it reduces the willingness to invest.

#### 1.4.4 Characteristics of innovators

The characteristics of the innovator<sup>2</sup> or adopter of an innovation are crucial in determining how the diffusion process unfolds. The characteristics of the adopter influences the perception of the costs and benefits of the innovation, thus being an important part in determining if the innovation is adopted or not (Wejnert, 2002). Rogers (2003) categorizes the adopters into five categories: *innovators*, *early adopters*, *early majority*, *late majority* and *laggards*, see Figure 3.



**Figure 3. Rogers' adoption categorization.**

Source: (Rogers, 2003, p 281)

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<sup>2</sup> In Wejnert's (2002) review of diffusion theories, the term innovator is defined as persons adopting an innovation. Rogers (2003) uses the term innovator to describe the earliest 2.5% of the adopters, see Rogers adoption curve in Figure 3. This thesis uses Rogers' definition.

Rogers presents the typical characteristics and values of the adopter types where the *innovator* has cosmopolite social relationships, communicates with other innovators, has access to the necessary knowledge about the innovation, and financial resources. The *early adopters* are defined as persons whom others look to for information, serving as role models. Usually the early adopters are respected, and have a central position in the social system. They are not very sensitive to uncertainty of an innovation and gain knowledge by adopting. It has been found that early adopters are especially interested in high visibility of the consumption (Fisher & Price, 1992).

A study of adoption of alternative fuel vehicles showed that the early adopters had higher education, more know-how and awareness about the product, higher pro-environmental values, beliefs and personal norms corresponding with alternative fuel use compared to buyers of ordinary cars (Jansson, 2009). This is supported in a study on Norwegians' adoption of sustainable heating systems (Sopha, Klöckner, Skjervak, & Hertwich, 2010). In the study, it was found that younger people and those with typical early adopter characteristics were more willing to adopt new heating systems.

There has been criticism against Rogers' earlier publication regarding the characteristics of the early adopters, especially pointing to the cosmopolite trait, viewed as an extravert characteristic. Saaksjarvi (2003) discusses that several studies of technological innovations show different characteristics of the innovators. The earliest adopters of home computers had more introvert characteristics than would be expected (Dickerson & Gentry, 1983). On the other hand, several other characteristics were consistent with Rogers' definitions, such as information seeking, and higher income level.

The *early* and *late majority* are, as their definition indicates, the majority of the population (Rogers, 2003). The early majority follows the early adopters, but they do not lead, thus reducing uncertainty by waiting for others to adopt first. The late majority is more sceptical and the adoption might be a result of pressure or necessity. Late adopters also include those who would like, but cannot, adopt earlier due to financial reasons. The *laggards* have, according to Rogers, their reference point in the past, e.g. preferring known solutions rather than examining new ones, and are sensitive to uncer-

tainties. Traditions are important to them, and they might experience scepticism and suspicion towards the innovation and the earlier adopters.

The adoption process of an innovation is influenced by what type of societal networks the adopter belongs to as well the position within the networks (Wejnert, 2002). The interaction within the networks strongly influence the adoption process. A study of house purchase behaviour showed that information and recommendation from friends or other house owners with experience from that particular house type was the most important source when gathering information (Koklič & Vida, 2009). This shows that the adopter seeks information within the network of friends and peers, as well as within the network of other house owners, i.e. networks where the adopter has a sense of belonging. Research within public health services has shown that the speed by which an innovation is adopted also depends on the adopter's position in the group network (Becker, 1970).

To make the decision to adopt, the necessary information about the innovation is gathered. Rogers (2003) points out the importance of knowledge with respect to innovations. People need to know about the innovation, how to use it, and why it is useful. If the innovation itself is not familiar, it is possible to reduce uncertainty by making the innovation more familiar through other people's experience with it. Rothwell (1986) suggests that familiarity with new technology can be achieved if the introduction of the technology comes from a trusted person, in a comfortable environment, presented in a natural and informal manner, instead of a sterile high-tech environment.

There are also socioeconomic characteristics of an adopter that influence the adoption process. These characteristics combine both economic and sociodemographic variables, such as education level, urban and rural differences, and technological advancement (Wejnert, 2002). Research shows that socioeconomic characteristics play a minor role in the adoption process. In a study about adoption of alternative fuel vehicles, Jansson (2009) found that sociodemographic variables provided only a weak explanation of purchase behaviour. Other studies, however, found sociodemographic factors to be important, e.g. a study of adoption of solar energy systems, where the adopters were found to be younger, more highly educated, having a higher income

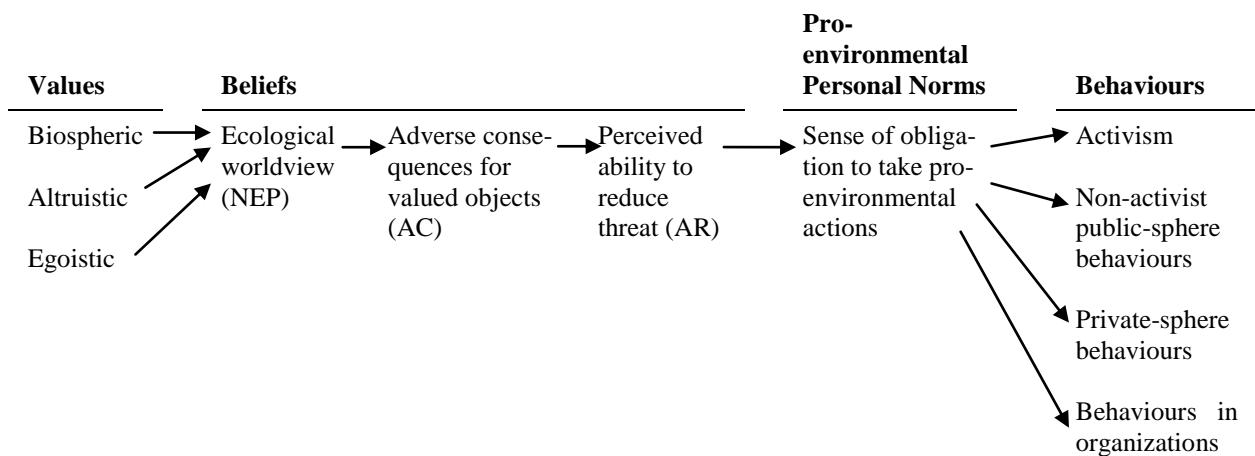
level, being earlier in the family life cycle, and higher in occupational status than the general population (Labay & Kinnear, 1981).

Finally, an individual's personal characteristics influence the willingness to adopt an innovation. Self-efficacy has been shown to correlate strongly with lower perceived uncertainty towards the innovation, thus increasing willingness to adopt (Igbaria & Iivari, 1995). Additionally, it has been shown that self-confidence plays an important role in determining adoption (Klein & Sorra, 1996). Higher self-confidence increased the rate by which the innovation was accepted. If the innovation fits with the adopter's values, it strengthens the confidence and the openness to other innovations. This raises the question of whether a house purchase is influenced by values. In the following section the values, beliefs and norms and their influence on diffusion of sustainable building technology is presented in more detail.

## 1.5 Influence of values, beliefs and norms

How much of the decision to buy a sustainable house is determined by values, beliefs and norms? Much focus has been given to how values, beliefs and norms influence sustainable behaviour in general. Stern et al. (1999) propose the value-belief-norm (VBN) theory of how environmental concern and behaviour are linked to a causal chain of a person's values, beliefs and norms, see Figure 4. This means that each of the variables directly influences the next (Stern, 2000). VBN theory provides a cognitive framework from which to study the adoption process of eco-innovations (Jansson, 2009).

VBN theory separates values into three categories: *biospheric*, *altruistic* and *egoistic* (Stern, 2000). Typical biospheric values are concern for not only humans, but all living creatures as well as the ecosystem itself (Dietz, Fitzgerald, & Shwom, 2005; Schultz, 2003). Examples of biospheric statements are: protecting the environment and preserving nature, unity with nature, fitting into nature and respecting the earth, harmony with other species (Dietz et al., 2005).



**Figure 4. Variables in the VBN theory of environmentalism**

Source: (Stern, 2000, p. 412)

Altruistic values are described as a concern for not only the self but all humans, as well as their needs and having unselfish motives (Piliavin & Charng, 1990). Statements with typical altruistic values are, according to Dietz et al. (2005): a world at peace, free of war and conflict, social justice, correcting injustice, care for the weak or equality, equal justice for all. Typical egoistic values, or self-interest, would put the needs of the self before anyone or anything else (Dietz et al., 2005). The egoistic motives of environmental concern come from caring about the environment because people themselves and those closest are influenced by it. It has been argued that the three directions of values not necessarily occur separately. An individual with high biospheric concerns can also have equally high concerns for the self (egoistic) and others (altruistic). Since humans are a part of the biosphere, the biospheric perspective can involve humans too, including the self (Schultz, 2003).

In VBN theory it is stated that values influence beliefs (Stern et al., 1999). The definition of belief, and its connection to values presented by Stern et al. is: “*...acceptance of particular personal values, beliefs that things important to those values are under threat, and beliefs that actions initiated by the individual can help alleviate the threat and restore the values*” (1999, p. 83). There are three different beliefs that are important determinants of environmentalism, i.e. *new environmental*

*paradigm*<sup>3</sup> (NEP), *adverse consequences for valued objects* (AC) and *perceived ability to reduce threat* (AR).

NEP is described as the concern for the relationship between humans and nature (Dunlap, Liere, Mertig, & Jones, 2000). Human behaviour is seen to influence the balance of nature, and there are limits to how much humanity and society can grow without causing negative impact on nature and that there are negative consequences of environmental changes. AC describes the belief that the environmental conditions might threaten the things we value. AR is the belief that one can act to reduce the threat to the things we value (Stern, 2000). By being aware that action or inaction has environmental consequences, individuals can decide whether to take responsibility for the behaviour (Davies, Foxall, & Pallister, 2002). Biel and Thøgersen (2007) stress the importance of knowing which action is needed, and having the perceived ability to perform it. Awareness of consequences alone without feeling able to do something about them will not help to activate personal norms.

The final causal factor of environmentalism is personal norms, which is a person's "*sense of obligation to take pro-environmental actions*" (Stern, 2000, p. 412). The norm to take pro-environmental action is activated by the beliefs systems NEP, AC and AR. Stern et al. (1999) found support for the proposition that personal norms are the main basis for individuals' pro-environmental behaviour.

VBN theory distinguishes between four different types of behaviour that each has its combination of determining variables (Stern, 2000). The different behaviours are:

- *environmental activism* – involvement in actions with the intent of changing policy
- *non-activist behaviours in the public sphere* – supporting environmental organizations or policy influencers
- *private-sphere environmentalism* – behaviour on individual or household level

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<sup>3</sup> Named *ecological worldview* in the model (Stern, 2000)

- *behaviours in organizations* – influencing towards pro-environmental action in an organization specifically without influencing the individual's private behaviour.

Environmental organizations often base their claims on altruistic values (Stern et al., 1999). Previously, research has mainly focused on how values influence non-consumption, post-purchase and curtailment behaviour (Jansson, 2009). In recent studies Jansson found that high involvement pro-environmental purchase also can be influenced by values, and that there is a correlation between environmental values and purchase of eco-innovations, in this case alternative fuel vehicles.

There is research indicating that norms are not always the main influencing factor of investment choice (Black et al., 1985). In their study, Black et al. found that high cost investment was more influenced by self-interest than personal norms, whereas personal norms was influencing low cost investment. On the other hand, purchase of alternative fuel vehicles, in the study by Jansson (2009), was shown to be influenced by personal norms together with knowledge. This indicates that high and low cost alone is not sufficient to explain whether personal norms have a direct influence or not.

### **1.5.1 VBN influence on early adoption**

According to Rogers (2003) it is the innovators and early adopters that are most likely to be guided by personal VBN factors. The later adopters are more inclined to adopt when the social norm around an innovation has been developed. Studies indicate that an innovation is more willingly adopted if the innovation is in line with the adopter's values (e.g. Klein & Sorra, 1996; Labay & Kinnear, 1981). Does that mean that early adopters of passive houses are environmentalists? Based on the cases of sustainable neighbourhoods, presented in Section 1.3.2, the factors described in VBN theory did have some influence on the house purchase, but were not a determining factor. While the main reasons for all residents were preferred location, size and comfort, in Anneberg it was found that environmentalism did play a role in the decision process for some of the residents. Other early adoption of high cost products, such as the alternative fuel vehicles, were also influenced by VBN (Jansson, 2009).

The passive house market in Norway is still in the developing phase, and is neither available to the majority of the population, nor a part of the social norm. While the passive house projects are increasing, the buyers of passive houses are still within Rogers (2003) category of innovators and early adopters. It is therefore of interest to investigate to what extent the innovators/early adopters are guided by their values, beliefs and norms. With this in mind this study has the purpose of investigating more closely the people who are the innovators/early adopters of passive houses in Norway, as well as what determine their choices. The following section presents the research questions and expectations, thus forming the frame within which this study is conducted.

## **1.6 Research objective**

Buyers of passive houses can be viewed in two different ways. Firstly, they are buyers with the aim of finding a new home in line with other house buyers. Secondly, they are in the front line of adopting an innovation which means they could fit into Rogers' (2003) categories of innovators or early adopters. The first objective of this study is thus to investigate what the sustainable house buyers are looking for in a house, and compare it to other house buyers to see if there are differences in the decision process. Based on that, the following research question was developed:

RQ1. What characteristics of a passive house do (potential) buyers focus on in the decision process?

Both the four cases of sustainable settlement as well as the research on house purchase in general suggest that there are general factors that are prioritized in a house choice. It is expected that the buyers of sustainable houses are interested in the same features as other house buyers, such as location, size and price, based on the cases of passive house settlements presented above.

The first research question addresses the general aspects of a house the buyers were looking for. Additionally it is interesting to find out whether the buyers are more focused on the environmental aspects in particular when they are buying a passive house. This leads to the second research question:

- RQ2. Are house buyers who are interested in a sustainable housing project more focused on environmental aspects around the building than people interested in conventional houses?

The expectation is that some buyers are more interested in the environmental aspects than those buying in other projects, as was found in the four cases above. However, since the housing market in Trondheim is limited, some of the future residents in the sustainable project might have bought their house because there were few other available options. It is expected that the buyers have some more knowledge/concern about environmental issues, and that the environmental aspects reinforce the positive value of the house choice.

Who are the buyers? The third research question involves the people choosing to buy a passive house. Since passive houses are still within the earlier stages of diffusion, the buyers should fall within the categories of innovators and early adopters. If the buyers of passive houses are typical innovators/early adopters, they could have a special interest in the new technology of passive houses. They could also have stronger interest in environmental issues, guided by their values, beliefs and norms as described in VBN theory (Stern, 2000). Based on this, the following research question was developed:

- RQ3. Can different interest categories be identified among the buyers based on the characteristics they focus on?

It is expected that there is some positive interest in the passive house technology, and that the buyers fit into Rogers' (2003) description of innovators or early adopters. Additionally it is expected that there somewhat stronger environmentalist orientation,

as well as the motivation of long term economic benefit as a result of low energy consumption, as was found in e.g. the study by Löfström (2008).

With the three research questions formulated the following methods section presents the procedure of how the study is conducted.

## 2 Method

In this section the procedure of the study and the different aspect of how the data were collected will be described.

### 2.1 Research design

The purpose of this study is to get a deeper understanding of to what extent people are attracted to sustainable house projects because of the sustainable feature. To investigate this it was decided to contact individuals/families that recently have, or are planning to purchase a sustainable house in the near future. The ambition was to conduct interviews with the purchasers, followed by a questionnaire to gather additional information on the opinions about house characteristics, and general information about environmental attitudes and behaviour. More details about the structure of the interviews and questionnaire are presented below.

### 2.2 Population

In order to find a suitable population, an ongoing passive house building project was selected, Miljøbyen Granåsen, and approached through its real estate agency Heimdal Eiendomsmegling. Miljøbyen Granåsen is a new building project in Trondheim, which includes detached and terraced houses, as well as apartment buildings. There will be a total of approximately 300 units, see Figure 5 ([www.miljobyen.com](http://www.miljobyen.com)).

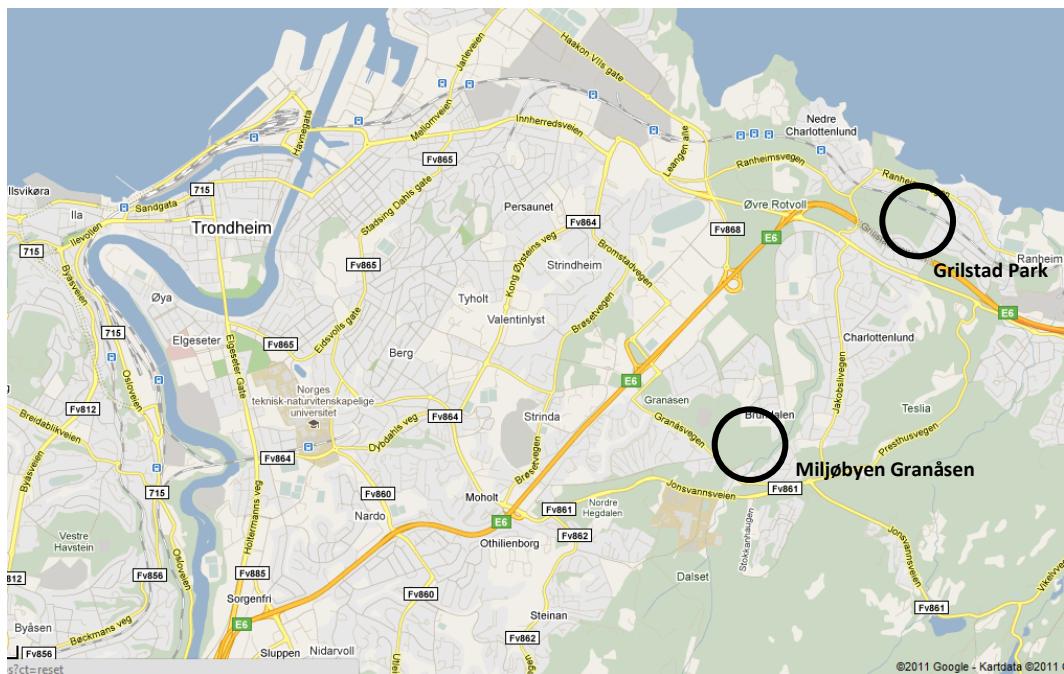


**Figure 5. Illustrations of detached houses, terraced houses and apartments at Miljøbyen Granåsen, Trondheim.**

Source: ([www.miljobyen.com](http://www.miljobyen.com))

The detached and terraced houses are already on sale and the building process started in 2011. The Granåsen area is a quiet area with mainly detached houses, located close to the university campus Dragvoll, and is not far from the hiking/recreation area Estenstadmarka. The distance to the city centre of Trondheim is approximately seven kilometres, for a map see Figure 6. There are several schools and kindergartens in the surrounding area, making it attractive to young families.

The new neighbourhood has a pronounced environmental profile, where the buildings are of passive house standard and will be heated by district heating, to meet the Norwegian climate conditions. In addition, the area will have an advanced underground waste separation system, limiting the need for transporting away waste close to the houses. There will be specified parking areas to reduce traffic within the neighbourhood. There will also be parks and playground areas for outdoor activities close to home to reduce the need to use transportation to find outdoor activities.



**Figure 6. Map of Trondheim showing Miljøbyen Granåsen and Grilstad Park**

Source: <http://maps.google.no/>

When contacted for the first time in October 2010, Heimdal Eiendomsmegling was in the process of selling the first group of houses, in total 17 units. In November 2010 the sale of the next group of units, 28 terraced houses, was initiated, making this area suitable for recruiting a sample.

Originally the study aimed at comparing two neighbourhoods, Miljøbyen Granåsen and Grilstad Park, see Figure 6. Grilstad Park is in the design of the houses very similar to Miljøbyen Granåsen, but does not have passive house standard. It is located much closer to the sea, rather than close to a hiking area. Unfortunately, it was not possible to get a big enough sample from Grilstad Park. However, one interview was conducted there and it is included in this study since it can illustrate some important points.

## 2.3 Sampling procedure

To get in contact with the house buyers the real estate agency agreed to forward a request for interview participants from the author. Preferably both buyers and potential buyers would be contacted, but the real estate agency did not agree to this, due to market sensitivity. The real estate agency was not willing to put any stress on the potential buyers out of fear it would influence their purchase decision. Out of respect for their otherwise willingness to help, the condition was accepted.

After the necessary approval from NSD<sup>4</sup> was in order, a request was sent by email to those who had already signed the purchase contract. The request described the main purpose of the study without specifically stressing the environmental focus, to limit influencing the participants' response as much as possible. Since only the people who had already made the purchase decision were contacted, 9 detached houses and 7 terraced houses that were available for the request. Out of the 16 requests, three families responded positively. At a later stage one more interview could be conducted, giving a sample of 25 % of the population, which on a response rate level is within the normal range.

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<sup>4</sup> Norwegian Social Science Data Services assists researchers with data gathering and analysis, as well as issues of privacy and research ethics ([www.nsd.uib.no](http://www.nsd.uib.no)).

## 2.4 The sample

The four families volunteering for interviews at Miljøbyen Granåsen were of similar socio-demographic background. The real estate agency mentioned when questioned that the campaign targeted all ages and life stages, from families with small children to seniors. However, the sample were all between 30 and 45 years of age, either planning or having children. One interviewee had been told that most house buyers in this neighbourhood were families with children. This shows that even if the agency is targeting a broad variety of people in the advertising campaign, a specific socio-demographic group is more attracted to the area. Additionally, the smaller units had not, at the time of the request for this study, been put out for sale. The price range for the houses targeted for this study varies from NOK 3.4 to 5.7 million. The interviewee from Grilstad Park was in a different age category, with adult children. The sociodemographic background was not specifically investigated, but became clear from the interviews. All participants are already living in Trondheim.

The interviewees all belong to households with at least two persons. For the interviews either both of the adults in the household, or just one of them participated. The households were given letters A, B, C and D, to distinguish them from each other, and the Grilstad Park interview, the letter E, see Table 4.

To ensure anonymity of the participants, they are given fictive names, based on the household letter as follows:

**Table 4. Participants being interviewed**

Household	Interviewees
A	Andreas
B	Bodil
C	Carl and Cecilie
D	Dennis
<b>Grilstad interview</b>	
E	Elizabeth

This makes a total sample of five households and six people. In the results of the interview they are categorized by household, since the couple have discussed and answered the questions together. In the questionnaire, all responses are treated individually.

## 2.5 Interviews

The interviews were scheduled and performed during late January and early February 2011. The locations for the interview varied according to the participants' wishes. Thus, the interviews were conducted at the home or at the office of the interviewees as well as in a study room at the university. Three were done during daytime and one in the evening. Written informed consent was gained before beginning each interview.

Qualitative research literature points to the importance of creating a relaxed environment when conducting interviews (Johnson, 2001; Silvermann, 2005). Whether tape recording is causing relaxation or disturbing is discussed in the literature (Warren, 2001). On the one hand, tape recording gives a smoother feeling of conversation when the interviewer does not have to stop and take notes. It might influence the responses when the participants have to wait, or it might be distracting that the interviewer has to pay attention to the notes while listening. On the other hand, recording the interview might cause some unease, since many people are not accustomed to an interview situation. In this study it was decided that the interviews was to be recorded to ensure that no data would be lost. The recorder used was an ordinary mp3 player. The choice of technology is that it is small and does not attract attention, thus adding to a more relaxed environment.

In order to help the interviewees get into the flow of the interview as easy as possible, it is important to both record the interviews and to start in an open fashion (Silvermann, 2005). This gives the interviewee time to structure the topic that is being discussed to be able to remember more details. The interview questions in this study were semi-structured, starting with open questions about what potential house purchases had been considered, and the reasons behind the decision. The interviewees were also asked about the house characteristics that were prioritized. If environmental

aspect was not presented, they were asked about it at the end of the interview. The interviews lasted from 10 to 35 minutes. The interview guide can be found in Appendix A.

While the thesis is written in English because of the international profile of the master program, the interviews were conducted in Norwegian. This was done to eliminate losing possible interviewees due to language barriers. The responses relevant to this study have been translated by the author.

## 2.6 Questionnaire

To add more information about environmental questions in general, a questionnaire was developed and given to the participants after the interview. The purpose of the questionnaire was to gather more information and, where it is possible, compare the participants of this study with other studies (Barlindhaug & Ruud, 2008; Special Eurobarometer 295, 2008; Stølsbotn, 2000). This gives an indication to how typical this sample is for the general public. Since the sample of this study is very small, it is not possible to apply inference statistics, but the comparisons are merely treated as indications to support the interviews. The items in the questionnaire concerned participants' views on environmental issues, and what aspect of the house they considered to be important.

The questionnaire contains items from several different surveys, specifically aiming at buyers of sustainable houses, see Appendix B for the entire questionnaire. The first four items in question 1 were constructed for this study, and include the importance of size, location and price of the house. The remaining items in question 1 and the items in question 2 were gathered from a Norwegian report on resident satisfaction with newly built houses (Barlindhaug & Ruud, 2008). The two sets of questions from Barlindhaug and Ruud's study include statements about what aspects the new houses have, e.g. it including a balcony, garage or the distance to main roads. Additionally it was asked whether there was a willingness to pay additional costs for environmental or energy efficient solutions. In the present study, the participants are asked to rate how important these aspects were for determining house choice.

The third question in the questionnaire was gathered from the Eurobarometer. This is a European survey measuring different topics each year. In 2008 a survey measuring European citizens' attitudes towards the environment was conducted (Special Eurobarometer 295, 2008). The aim was to measure public opinion, attitudes and behaviour towards the environment. From the Eurobarometer survey, one item was chosen, asking how important it is to the individual personally to protect the environment.

Question 4-7 are items from the *values, nature and environment study* (Stølsbotn, 2000) The Stølsbotn study investigated how people report e.g. their attitudes towards science and nature, knowledge of science and nature, trust in environmental information, and questions regarding private pro-environmental behaviour. The questions used in the present study cover areas regarding willingness to pay increased taxes, or reduce comfort level to protect the environment.

The New Environmental Paradigm scale was originally developed by Dunlap and Van Liere in 1978, and has been widely used since. This scale aimed at measure the public's environmental concern in areas such as air and water pollution, energy conservation and negative aesthetic value (Dunlap et al., 2000). However, as societal as well as environmental changes have occurred, a need for a revised version has become prominent. A new revised version was presented by Dunlap et al. (2000) called the New Ecological Paradigm (NEP) scale. The revised NEP contains 15 items with a framing of both pro- and anti-NEP items, including a wider range of ecological views, and an updated terminology. All the 15 items of the NEP scale are included in the questionnaire used in this study, as question no. 8 with a request to give an *agree – not agree* rate.

As with the interviews, the questionnaire was conducted in Norwegian and translated to English by the author.

## **2.7 Interpreting the data**

The interviews were transcribed fully, and the analysis was made by extracting the key statements that give answers to the research questions. Interpreting the results and developing the concepts directly from the data gives a solid foundation from where to draw conclusions (Charmaz, 2003). Krippendorff (2004) argues that content analysis of interviews where the answers are open-ended is a suitable analysis form. By analyzing the content of the transcripts, one identifies the statements that involve the research questions, and extracts the key statements to make the material comparable. Based on these theoretical guidelines the important concepts found in the transcripts were highlighted and categorized into key characteristics. To gain as wide understanding as possible, statements that both confirm and disconfirm the research expectations were collected.

## 3 Result

The interviews and the questionnaire give both an individual perspective of house purchase determinants, as well as an idea of the general environmental concern. In this chapter the results from the study will be presented. The results are categorized according to the research questions.

### 3.1 Important house characteristics

The first research question was: *What characteristics of a passive house do (potential) buyers focus on in the decision process?* To answer this question the research participants were asked to describe what they were focusing on when they were examining potential houses/projects. The purpose was to hear what the interviewees themselves would state first, without being led to focus on specific aspects. However, during the entire interview more desired features were discussed. An overview of all features mentioned will be presented after the quotes in a table.

In the beginning of the interview the respondents were asked to describe what they were focusing on when they were looking for a house to buy. The quotes are translated, but otherwise presented in the same wording as they were stated by the interviewees. The quotes answer the question: *“What were the most important aspects you were focusing on when looking at houses?”*

**Andreas:**

*Yes, that would be the location, that it is child-friendly. That would be a notion that says quite a lot. That it is not close to a busy road, these kinds of things, noise, dust. Still biking distance to the centre and our jobs. [...] That it is space around. Not so dense. For example, these detached houses at Granåsen, where we bought, there are several rows of detached houses, and the ones in the middle. We bought one at the end, and in the middle would not have been an option for us.*

**Bodil:**

*Well actually we have been looking for some time in this area. And we have looked at different options here, both things that are sort of already built, and also projects, so, we have pretty much been looking for something in this area. ... Well, it is sort of Dragvoll [University Campus, author's note] and also the hiking area [Estenstadmarka] that made us end up with this.*

**Carl and Cecilie:**

*Carl: We did that [look at other houses first, author's note]. We didn't participate in any bidding rounds, but we were looking at several. But we... we mostly consider cost/benefit, right? For after a while we realised, houses within a reasonable distance to the city, and with a reasonable size, and that were sensibly planned, that is well used space. Then they were sold at prices that paralleled that we just as well could buy new.*

*Cecilie: A lot of those houses [the old ones, author's note], in my opinion, there was something with the foundation or the bathroom, and you never know how much it will be in addition. Plus, with old houses you know a bit about insulation and these things. Then it is kind of as you say, cost/benefit with relation to expensive to buy but cheap to live in. We hope!*

**Dennis:**

*We were prepared to buy an old house, just to be able to get a house at all. So the most important criterion is just finding a house. With the size of a terraced house. It was the most important criterion really, and it is not very many of them in Trondheim now.*

**Elisabeth:**

*We had actually decided on a small terraced house with three bedrooms. ...we wanted to live closer to the sea, and we wanted to have earlier spring and later winter. That was one thing, and the other is that we have lived in this area before [close to Grilstad Park<sup>5</sup>, author's note], when we were young. And we liked it very much. So we wanted to move back there when we were selling our detached house.*

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<sup>5</sup> For map see Figure 6 page 30

The quotes show that the interviewees are mostly concerned with finding a house within the desired location; both regarding distance to jobs and city centre, and that it is safe for children. Either space around the house or being close to leisure areas is also important. All aspects that were mentioned as important during the interview are listed in Table 5 and are sorted by interviewee, and categorized into main topics, and a more detailed sub-topic.

**Table 5: House characteristics and important criteria for choosing to buy.**

Interviewee	Category	Details
Andreas	Location	Child-friendly Short distance to jobs and centre Walking distance to hiking area Not close to busy road, avoiding noise and dust Easy access to the highway (E6)
	Financial benefits	Possibility to rent out room/apartment in the basement Saving electricity
	House characteristics	Space around the houses/garden
Bodil	Location	Wanted to live in this particular area Walking distance to hiking area
Carl & Cecilie	Location	Short distance to jobs and centre Access to outdoor playing areas and nature
	Financial benefits	Most value for the money
	House characteristics	Hobby room
Dennis	Location	Short distance to jobs and centre Good public transport connection
	House characteristics	Good floor plan Size of the house
	Location	Lived in the area before Close to the sea and nature Earlier spring/later winter <sup>6</sup>

The quotes and statements in Table 5 show that the prioritized features determining the house choice concerns location, financial benefits and house characteristics. There are some differences between the participants on what is most important within

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<sup>6</sup> Compared to the where she lives now, which is higher above sea level than Grilstad Park.

these criteria. Elizabeth, for example, has prioritized living close to the sea, while the buyers of Granåsen prefer the closeness to forest and hiking areas.

The characteristics presented in Table 5 show what aspects that the interviewees themselves discussed during the interview. The questionnaire listed different aspects and the participants were asked to consider how important they were when the purchase decision was made. This was done to get information on aspects that the interviewees had not mentioned themselves. The aspects could be rated as: *not important at all, not important, neither important nor unimportant, rather important* and *very important*. Table 6 shows the number of people that have rated an aspect as very or rather important, as well as how many in each category. In this table, the interview from Grilstad Park is included as well, and the response is indicated by the asterisk. For a table of all the responses, see Appendix C.

Table 6 shows how the respondents from Miljøbyen Granåsen and the one from Grilstad Park together. With all responses together it shows that the features rated as most important are concern for indoor environment, garden, price of the house, long term savings and car parking close the house. This is consistent with the interviews in the way that price, long term savings, and garden are considered important. In the interviews the aspects of car parking was not mentioned. Only one interview discussed the indoor environment and its environmental impact. This will be presented in more detail in Section 3.2.

The feature that was considered least important was having a sauna. Other features that were not considered important were closeness to water/sea, restaurant, cultural activities, and shopping centre. Indoor features that were not important were having a waste separation system in the house, refrigerating room, and a central vacuum cleaner.

The interviews show that the desired features were adjusted over time. When a house with all the desired features could not be found, it was necessary to decide what features that had to be disregarded. The following section presents what the buyers were not able to include when buying the house, even if that was originally the plan.

**Table 6. Results from the questionnaire. Number of interviewees rating statement as important.**

Statement	Total no. rated as important	Very important	Rather important
Consider indoor environment in the home	6	6*	0
Home has private outdoor area on ground floor	6	4*	2
Price of the housing	6	3	3*
Reducing operational costs over time	6	3	3*
There is car parking at the house	6	3*	3
Home is within walking distance to hiking area	6	2*	4
Size of the housing	6	1*	5
Home has alarm against water leakage	5	1*	4
Home is within walking distance to a school	5	0	5
Home has a balcony/porch	4	4*	0
Home has a view	4	1	3*
Home is less than 500 m. from bus stop	4	1*	3
Home has a private (undisturbed) garden	4	1*	3
Home has an indoor fire place	4	0	4*
Home has an open kitchen/living room	3	0	3
Home is within walking distance to grocery store	2	1	1*
Home has a garage	2	1*	1
Save the environment as much as possible	2	0	2*
Home has a separate laundry room	2	0	2
Home has access to common outdoor area	2	0	2
Home has a waste separation system	1	1*	0
Home is within walking distance to lake/sea	1	0	1
Home is within walking distance to restaurant or other cultural entertainment	1	0	1
Home is within walking distance to shopping centre with multiple stores	1	0	1
Home has a refrigerating room	1	0	1
Home has a central vacuum cleaner	1	0	1*
Home has a sauna	0	0	0

Note: The statement “*Housing is located close to trafficked road*” was removed. It became clear that the respondents interpreted it in different ways, which make it not comparable.

\* = rating from Grilstad Park.

The house buyers in this study spent a long time looking and planning for what type of house to buy. Then, when an opportunity arose, the decision to buy was for some of them rather quick. Andreas explains:

*What happened then was a bit lucky, because we were... we did not realize that there had been sale start at Granåsen. But we still decided, or I did, to go there and look, at their sales office. Then it turned out that there was someone who had not gotten the financing approved. And that [the house they bought, author's note] was at the end of the street. And luckily we were first in the queue, now that it was put up for sale again. Therefore we just went for it. So it was a kind of spontaneous, in that sense.*

Dennis has a similar experience. He explains that the decision to extend their search beyond the original location was made within just a few days, after planning and looking at houses for longer period of time. For Carl and Cecilie the decision to buy a house at Miljøbyen Granåsen was influenced by time pressure. They had to plan for a change in their need of space. Since Miljøbyen Granåsen is a new project it will not be finished before 2012. That was something they had to consider when deciding to buy a new house. Cecilie discusses the time limit:

*Well, we were... if we were getting a new house, we had to start deciding within a certain time, we found out. Because it takes a year before it is finished. So, if we were getting something new, we had to make the decision within a certain amount of time. If not we sort of had to find a used then. With respect to space.*

### **3.1.1 Desired features that were not realized**

In the planning process before buying a house there were aspects that were desired and that originally were included in the criteria for which house to choose, but were not realized. The reasons were either due to limitations in the housing market or because other criteria were realized and the buyers settled for those. The quotes below show examples of what the interviewees wanted to be included in the house, but that was not possible to achieve. Additionally, a list of all the aspects that could not be realized is presented after the quotes.

Bodil discusses how features of the house were down prioritized to be able to find a house within the desired area:

*[...] it is a little like (laughter), it is relatively boring houses actually, small terraced houses with a tiny garden, based on sort of the layout with the room planning and all that, you'll find there are 13 of the dozen really. Not that exciting to be honest, so that wasn't exactly what was decisive here.*

Carl also discusses how all the houses look the same, and how they wanted a bigger garden. When that was not possible if they were to buy this house, they found a different solution:

*What I find a bit negative is that there is a lot of similar houses, without much outdoor space. There is almost no garden. And I expect that when you think about children it could have been nice, when they are older, to have a garden to play in. But we'll just have to go do that at the cabin.*

Andreas had very specific wishes in the beginning of the purchase process. They had made a plan of how the dream home would be, and started with that in mind. He talks about how the desired features are adjusted over time away from the dream home:

*Yes, to put it a bit extreme, a small farm... a central small farm, within biking distance to work, right. And that's not possible, right! But that's what we wanted really, basically. So we have spent some time viewing houses, and sort of made some reflections in the process, and lowered our demands along the way on some things. And we had very specific desires about what the house would look like inside for example. Large separated kitchen and such things. And those things are like, we won't get that now. We'll just have a living room and open kitchen integrated, right? So we sort of had to make adjustments, or, what to call it, lower the demands.*

Dennis was very focused on a specific area when looking for a house. Since there are few terraced houses in the market, they decided to go beyond the desired location. He explains<sup>7</sup>:

*We were rather specific about wanting a house in the area where we live now [...] We were looking at a lot of houses, loosing several bidding rounds [...]. And then extended the area eventually.*

These examples show the process where some criteria are adjusted over time, to increase the chance of finding a house. If there are no houses of the desired type and within the area that was preferred, other areas had to be included as well. Similarly, when it was not possible to find the desired indoor plan, there were adjustments in demand. Table 7 shows all aspects that were discussed during the interviews.

**Table 7. Aspects that was desired, but could not be realized**

Interviewee	Category	Details
Andreas	House characteristics	Wanted a large separate kitchen Position of rooms, e.g. kitchen in third floor Large garden
Bodil	House characteristics	The style of the house was considered boring
Carl & Cecilie	House characteristics	Large garden
Carl		View from the house
Dennis	Location	Not the prioritized location

The aspects presented in Table 7 show that with the exception of Dennis, it is house characteristics that are negotiable when adjusting the determinants.

### 3.1.2 Aspects considered positive but not determinant

There are also aspects that were not determining the house choice, but after the purchase were considered very positive. The environmental aspect of passive houses is mentioned as positive. Since the second research question asks specifically about the environmental aspects the results regarding that will be presented in detail in Section

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<sup>7</sup> Name of the area has been removed to maintain anonymity

3.2. In addition to the environmental aspect, there were other aspects that were considered positive. All interviewees felt it was positive that the house was new and have some thoughts about that. Carl is reflecting on the dangers of buying an old house:

*Yes, the worst is leca stones of course, because the old foundations of leca stones crumble away. That's a classic. And foundations that people made themselves, really, especially in the old days, it was common that people bought a house, and then it was [...] possible to do things yourself, and the things you did yourself were often for example the foundation. And if you are one of those, you want to save money, and make the foundation yourself, and you might not be particularly handy. And then it is... then you actually have the foundation of the house, on which you place something worth two millions. It is then badly built. And we don't know that when we take over the house, right? Unless you buy a new one, of course.*

Andreas is also discussing how they started looking at older houses, but for financial reasons decided it was beneficial to buy a new house.

*When we have been looking for houses, we have been to house demonstrations, mostly older... older houses, because they often have larger gardens, in Trondheim anyway. But then you begin at four, four and a half, five millions, if you want a nice location, or what we consider a nice location. And then you have to start to renovate. Since these houses often are from the 60's, 70's, 80's and that can get quite costly. Often two kitchens, several bathrooms if there is an apartment for letting, and the roof needs fixing, drainage and a lot of windows. That is sort of the things that only cost money. And then at Granåsen, there it's just new. It cost a bit more, but you don't have to pay maintenance at the same level the first years.*

Similar to Carl and Andreas, Bodil also reflects on that it is a relief to know that the house is new, and that there are no hidden problems:

*It is so nice to think about it being completely new. Then it is sort of like, you don't have to think about something being rundown and needs to be exchanged immediately. But at the end of the day, I think that location is the most determining single factor.*

Dennis explains how the fact that the house was new added a positive experience after the decision was made:

*Then there was the location that we had to extend the area. And we argued among ourselves that there would be this area, sort of, from the city centre and up to Granåsen that would be a nice future sector. But that it is new, that was something we... When we first had made the decision to move to that side of the highway, then it was... Ah yes! New! Then we started to really like the idea.*

The financial benefit of saving energy is also considered positive. Andreas discusses how this has changed his view of the debated in media on electricity prices.

*I enjoy every time I read in the newspapers or watch media that the electricity prices is going up. Personally I think they are going up to European level. And that means perhaps twice the price in Norway today. And if you think about it... you know... if you have the choice, as an electricity supplier to sell to Norway, or abroad where they pay twice the money. What do you do? You sell to the ones who pay the most, and then the prices will even out at one point or another. That is why I think the prices will increase. In that way I am very pleased that it is a passive house.*

Most interviewees discuss the financial benefit and environmental aspect together. Thus more results on the financial benefits are presented in the next section. To summarize the aspect that was considered positive, but did not determine the purchase, was that the houses are new, that they are passive houses and that there will be significantly lower electricity bills in the future.

### **3.2 The environmental aspects of the passive house**

The second research question was: *Are house buyers who are interested in a sustainable housing project more focused on environmental aspects around the building than people interested in conventional houses?* The interviewees were asked about how important the environmental and energy saving aspects were. The responses evolved mostly around the energy (and money) saving possibility of buying a passive house. The interviewees experience the environmental aspect as positive, both with respect to

environmental values and economic benefit. However, most participants pointed out that this was not the main reason for choosing that particular house to purchase.

**Andreas:**

*Whether it is because of energy or because you know that the electricity prices goes up, and what this costs... It is sort of divided in two, isn't it? Yes, I think it might be... Yes... I'm not necessarily thinking about saving because electricity is in environment... environmentally friendly, because in Norway electricity is the most environmentally friendly energy you can use, in that sense [...] If we would have built a house, we would definitely have looked at other alternatives than electric heating. In Norway – my opinion is that electricity is the most environmentally friendly way of heating there is, really. Yes, because it is, there are no emissions. There is a turbine and then you put something electric on a wire and then you get heat, because of... from water, right. But everyone cannot use it. As it is now, with the electricity prices going up and down, it is fine to have an option to change with. Wood pellets or... well Heimdal [the project developer, author's note] uses district heating. These houses have district heating and I think that is a good thing to be able to switch between.*

**Bodil:**

*I would absolutely say that it [the environmental aspect, author's note] adds to the positive. That is a kind of... it was a good thing in every way. And saving electricity is a good thing for both us and the environment, so that is definitely a positive addition, but it was not any essential factor. Because the first project we were interested in was not this type of environmental project, so you do not have to pretend we are more environmentally concerned than what we are. But it was an element of this project that we liked really well.*

Elizabeth, who has not bought a passive house was the only one reflecting on other environmental impact of the houses, especially the indoor climate and possible chemical evaporation.

*We cannot do anything with the painting, if we are going deeply into the climate topic, thinking about evaporation and these things. That is something that those who work there are exposed to. During the process there will be, in every new*

*house there will be evaporation the first year you live there. So I do not really think we can influence anything there.*

Elizabeth also mentions the importance of environmental influence. However, in line with the results from Miljøbyen Granåsen it does not influence the choice of location.

*If we had the opportunity to choose between two houses with close connection to the sea, both of them. Because that is what attracts us about Grilstad, we would certainly have thought it was better with a passive house. It is very important to consider the environment. But it is simply the connection to the sea, and the earlier spring that has been the main focus.*

It was clear in the interviews that the environmental aspect was not determining the house choice. While it is perceived as very positive once the decision is made, even the interviewees that express environmental concern chose the house based on other aspects. Results concerning environmental values will be presented further in the following section, together with other characteristics of the buyers themselves.

### **3.3 Characteristics of the buyers**

Finally, the third research question was investigated: *Can different interest categories be identified among the buyers based on the characteristics they focus on?* The purpose of the research question was to find if it is possible to identify similar characteristics of the buyers as was found in Löfström's (2008) study, i.e. economical motivation, environmental interest and technological innovators/early adopters. If the interviewees did not mentioned it themselves they were asked about different aspects and whether they were considered. The results show that the interviewees have different motivation behind their choices, and the results will be presented in detail categorized in the three different motivation factors. However, it is important to remember these motivation factors influenced, but were not single determinants of the house choice.

#### **3.3.1 Economic motivation**

All interviewees are positive about the saving possibilities of the passive houses. Andreas, Carl and Cecilie are more guided by economical motivation than the others for

the house choice and discuss in detail the financial benefits, as has already been presented in sections 3.1 and 3.2. Carl describes the economical motivation as he sees it:

*It basically comes down to it being cheap to live in. So, an investment of buying a house will eventually, if you just wait long enough, most likely be paid back. While the money that was spent on electricity, those are gone. In a way.*

Opposite from the other interviewees Dennis was more critical towards the money saving potential. The payback time of the additional investment cost is too long for it to be of significance according to him:

*Mostly environment, actually, the economic issue is... Of course, you save some electricity every year, but I estimate that to repay the additional investment by reducing the electricity bill alone... The real estate agency mentioned that there is a couple of hundred thousand of additional investment on the houses, the terraced houses. So with a couple of hundred thousand, to save maybe 15000 a year ... it is quite long repayment time on that investment. So, purely financial, it is a bit of bonus. Both the environmental benefit and financial benefit is a bonus, but it was not crucial. We could have decided to buy a poorly insulated terraced house and then planned to insulate it later or something like that.*

The results show that there is an economic motivation amongst the interviewees, and that it is strongest with Andreas, Carl and Cecilie. The other interviewees find it a positive addition but do not seem to be guided by it in the same way.

### **3.3.2 Environmental interest**

As has been shown with the two first research questions the environmental aspect had minor influence on the house choice compared to other aspects. There were however, items in the questionnaire as well as topics in the interviews discussing the environmental interest of the participants, e.g. based on the factors in VBN<sup>8</sup> theory (Stern, 2000). Most of the interviewees did not present themselves as especially environmentally concerned. They pointed out that it was positive that passive houses are better for

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<sup>8</sup> Value-belief-norm theory (Stern, 2000)

the environment than traditional houses. At the same time they did not want to appear more environmentally concerned than they actually were. Carl and Cecilie discuss the topic of environmentalism and buying a passive house:

**Carl:**

*No, neither of us has a membership in “Natur og Undom” [environmental organization, author’s note], in that sense. But it is a bonus on top of things so that is good. But what we primarily thought of was the question of cost. Using little money on electricity, while still being warm and comfortable.*

**Cecilie:**

*And that it is new, and within the limit [30 minutes to city centre, author’s note].*

Bodil also expresses that she does not want to appear more environmentally friendly than she actually is, as was quoted in section 3.2:

*[...] so you do not have to pretend we are more environmentally concerned than what we are.*

Dennis stated that he has environmental interest. However, it is not prioritized when a house is being bought. He described his reaction when he realized Granåsen was a passive house project:

*Then it became a bit more positive [...]. I am a bit interested in these things. But, then that came as an extra bonus.*

In the questionnaire the participants were asked: “*How important is it to protect the environment for you personally?*” The response was 1 person (16,7%) stating very important, and 5 persons (83,3%) stating rather important. None answered that they believed it was not important to save the environment. In the EU-based study from where the item was collected 96% rated the question as either very important or rather (fairly) important (Special Eurobarometer 295, 2008). 64% rated the question as very important, while 32% stated fairly important. This indicates that it is not considered as important to protect the environment in the current sample as in the Eurobarometer.

There is no Norwegian data for comparison since the Eurobarometer survey shows result from EU-member states.

In the questionnaire it was asked if the participants were *willing to pay more for a house with sustainable features, given that all other aspects were identical*. All respondents stated that they were willing. Table 8 shows a comparison with the study from where the item was collected (Barlindhaug & Ruud, 2008). Barlindhaug and Ruud's study show that a majority are willing to pay more for sustainable features (86%).

**Table 8. Willingness to pay more for a sustainable house. Comparing with the original study.**

If two otherwise similar housings were for sale, and one had energy saving or pro-environmental features, would you be willing to pay more for that housing?	Current study %	Barlindhaug & Ruud's study %
Yes	50	21
Yes, if the difference in price correspond to what I in the future will save of energy cost	50	65
No	0	14

Additionally, the questionnaire contained questions about willingness to pay *much higher prices, much higher taxes or reduce living standards* to protect the environment. The responses are consistent with the original survey (Stølsbotn, 2000), where most were either willing or unwilling, or rather unwilling.

**Table 9. Responses to willingness to pay higher prices, higher taxes and reducing living standards to protect the environment. Comparing with the original study.**

Items	Current study %	Stølsbotn's study %
How willing would you be to pay much higher prices to protect the environment?		
Very willing	0	7,0
Rather willing	16,7	32,2
Neither willing nor unwilling	67,0	29,3
Rather unwilling	16,7	17,4
Very unwilling	0	10,6
Don't know	0	0,1
How willing would you be to pay much higher taxes to protect the environment?		
Very willing	0	3,7
Rather willing	16,7	18,6
Neither willing nor unwilling	33,4	23,4
Rather unwilling	50,0	27,5
Very unwilling	0	24,4
Don't know	0	2,4
How willing would you be to accept a reduction in your living standards to protect the environment?		
Very willing	16,7	5,4
Rather willing	33,4	31,0
Neither willing nor unwilling	16,7	27,5
Rather unwilling	33,4	21,4
Very unwilling	0	12,1
Don't know	0	2,5

The questionnaire included the question: *How often do you take the time to separate glass, metal, plastic, paper etc. considering recycling?* The responses show two (33%) stated that they always separate waste, and four (67%) that they do it often. In the original survey (Stølsbotn, 2000) the responses were that 34,4% always separate and 39,9% separate often.

Finally, the questionnaire also included the NEP scale, a five point scale ranging from strongly agree – strongly disagree. The results are compared with another sample (Vikan, Camino, Biaggio, & Nordvik, 2007), see Table 10. The comparing sample consists of students in Trondheim. The students show relatively higher ecological concern in general, except for statements 2, 7 and 11. The statements with a difference of more than 0,5 are 4, 5, 9, 10 and 15, showing that there appear to be differences between the samples.

**Table 10. Mean score and item for NEP scale comparing the current study to a study by Vikan et al. (2007)**

New Ecological Paradigm items	Current study	Vikan et al. study
1. We are approaching the limit of the number of people the earth can support	3,17	3,19
2. Humans have the right to modify the natural environment to suit their needs	3,67	3,50
3. When humans interfere with nature, it often produces disastrous consequences	3,67	3,81
4. Human ingenuity will insure that we do not make the earth unliveable	3,00	3,53
5. Humans are severely abusing the environment	3,00	4,13
6. The earth has plenty of natural resources if we just learn how to develop them	2,33	2,43
7. Plants and animals have as much rights as humans to exist	3,67	3,58
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations	3,67	4,00
9. Despite our special abilities, humans are still subject to the laws of nature	3,50	4,28
10. The so-called “ecological crisis” facing humankind has been greatly exaggerated	3,17	3,67
11. The earth is like a spaceship with very limited room and resources	3,50	3,20
12. Humans were meant to rule over the rest of nature	3,50	3,68
13. The balance of nature is very delicate and easily upset	3,83	3,95
14. Humans will eventually learn enough about how nature works to be able to control it	2,83	3,30
15. If things continue on their present course, we will soon experience a major ecological catastrophe	3,33	3,77

From the interviews it was shown that the participants did not consider themselves environmentalists. They are pleased about moving to a sustainable house, but the sustainability aspect did not have high priority. The NEP scale additionally showed a slightly lower environmental concern compared with the student sample. However, the participants answered that they are willing to choose a sustainable house over a traditional, given that the other features are similar. They also reported that they separate waste, either always or often. Compared to Stølsbotn's (2000) study, the participants of the current study report being more willing to reduce living standards. Dennis was the only one of the four interviews at Granåsen who stated being interested in environmental issues. However, he specified that it would not have been prioritized over location, or type of house.

As presented in VBN theory (Stern et al. 1999) three different types of values were found, i.e. *biospheric*, *altruistic* and *egocentric*. The results of this study show that concerning house purchase, the egocentric values has the strongest influence, in the sense that e.g. the preferred location, type of house or closeness to recreational areas has the highest priority. There are strong values related to nature, several interviewees discuss Granåsen's closeness to nature as a positive aspect of the choice and how it will become easier to be able to get to hiking/skiing areas without using transportation.

**Andreas:**

*And then I think it is positive that it is not so far to Estenstadmarka [hiking/skiing area, author's note]. We are very interested in outdoor activities both of us. And just the fact that you have the opportunity to just go hiking straight from the house, without having to drive.*

Similarly, Elisabeth talks about the value of being closer to the sea, and how that influences the seasons with earlier spring and later winter. However, the strong value towards nature and natural environment involves recreational and leisure activities, rather than preserving nature. This shows that participants are more guided by egocentric values than biospheric.

*We thought it was a great benefit that there is such a short distance to the recreation area Ladestien [a track following the shoreline of the sea, author's note] without you having to drive to a parking lot first. So that we can go for walks. That was important.*

The results show other aspects that are highly valuable to the participants. One reason for the high priority of location for Dennis and Elisabeth is the fact that they wanted to continue living in a familiar area. For Dennis, that was not possible, due to limitations in the housing market, but the new location they finally decided on located approximately three kilometres from the desired area, and the areas are similar with mostly detached houses.

### **3.3.3 Early adoption of the technology**

In diffusion of innovation theory, Rogers (2003) identified the early adopters as persons typically taking the lead in development, not being very sensitive to uncertainty of the innovation, being younger and having an above average income level. The income level and age was not specifically investigated in this study, thus it is not possible to compare this with other studies. However, it was clear that the interviewees at Granåsen were all between 30 and 45, having a focus on the child friendliness of the area.

Other typical characteristics of innovators/early adopters are the interest in and knowledge of the technology being adopted, i.e. passive house technology. There was some indication of technological interest among the participants. Dennis had knowledge about passive house technology previous of the purchase, and was questioning the reasoning behind the choice of heating system:

*The only thing I find a bit negative is that they chose to include district heating, that I do not understand. [...] The energy need is so low that they just could have used for example solar panels combined with electricity, or just a heat pump.*

Andreas showed both interest in the technology and how the planning of the houses had been done. He was concerned with the practical use and comfort of the different rooms:

*Yes, if I was to describe some negative sides then it would be that ... well it is supposed to be really closed, airtight, right, and then, that is fine. But that puts high demand on your ventilation system too. And then you have to change, change the air. And that is a great thought, because then you can bring all the heat, and run it through a heat exchanger and then change it. But, what does not work in a practical sense is that you do not want the same temperature in the living room, as in the bathroom, as in the kitchen, or as in your bedroom. You want different temperatures. Warmest in the bathroom, preferably, and cold in the bedroom and somewhere between perhaps in the living room. But the ventilation system that is integrated here then, or specified, then it is the same temperature all over. And that's, that is a bit strange. There theory and practice does not add up. But, I guess there are possibilities to control it, I don't know.*

Andreas also expressed some disappointment that the basic features included in the purchase did not involve more technical gadgets:

*What I find a bit disappointing is that the basic “package” that Heimdal [real estate agency, author’s note] sells does not include more technological gadgets to control light, electricity, and sun shading and that sort of thing. That I would have expected by a house in 2011, that is being built in 2011 that it is included, when it has passive houses, or environmental neighbourhood. You know, insulation is one thing, but, well I guess it is a sales promotion from their part. I don’t know, they are quite expensive in the first place.*

Except for Dennis, the interviewees do not fit into Rogers’ (2003) innovator/early adopter categories of not being sensitive to uncertainty around new technology. They discussed the uncertainty and expressed some concern of possible problems with the passive house. They also discussed different means of reducing the level of uncertainty. Dennis had previous knowledge about passive house technology, and was not very concerned about the uncertainty of adopting new technology.

*It is relatively new in Norway, but in for example Germany there are some more passive houses. So there is a certain risk that there will be problems in the beginning. But then again, we are buying a new house, and there are a lot of guarantees and such things. When we saw that Sintef Byggforsk [research unit in Trondheim focusing on building and infrastructure, author's note] was involved and that it was well monitored. Then we can trust more that it will be properly done than if there was someone doing it on their own, an entrepreneur that suddenly want to build passive houses and then using us as test dummies without academic support available.*

He was aware of potential problems, but since he had investigated the resources that had been used during the project development, the uncertainty was reduced due to trust and that the academic foundation was sound.

Cecilie has concern for the functionality of the technology after reading local newspaper articles about passive houses:

*Most of it will probably be good, but I have heard a comment in the newspaper, with an expert warning against passive houses. That it will be too closed, and if there is moisture coming in, it will be hard to get it out again. So that the house was too airtight and that someone in Oslo had to move out in the summertime because it got too hot. So I guess that is the criticism.*

By comparing the technology to something familiar, she reduces the uncertainty around the technology:

*But it might be a bit like passive house standard here [current apartment, author's note] I would say, with respect to district heating and considering it is well insulated, and these things. Then we know much more what... I feel that we know a bit more about what we get. Because it is very similar.*

Bodil also has some concern for how well the technology will function based on hearing about problems with other passive house projects.

*I have heard that, I know it can work poorly if it is not a well balanced ventilation. I have heard the people have had problems to make it work in practice. Maybe bad indoor environment... But then it said in the project that there might be frost on the outside of the windows, since they are so hermetically sealed. So I see myself standing outside the windows scraping the ice! So, no we see it as primarily positive. We save electricity and... Of course with this winter where the electricity prices have been extreme you think that it is nice to have a passive house.*

When asked about their opinion about the new technology, i.e. passive house technology, it showed that some of the respondents were not early adopters by their own choice. Bodil is reflecting on taking the risk of using unfamiliar innovations:

*I think the attitude is that it has to be regulations that come from the outside. It should not be up to each person to have to take... it feels kind of unfair. [...] People are not willing to take that personal risk. Since there is so much uncertainty, it must be the public that takes... that take direction there.*

Carl and Cecilie are expecting some problems by being the first to use the technology, and this dialogue show the unease of being early adopters:

*Carl: It is just something about starting with new technology, where we in a way were the first ones to use it. Then it can give you some surprises. My experience is that the newest of the new, whether you buy a cell phone or a house, or cars, they do not always work that well in the beginning. You can have some production errors, you can have some.... So, yes, if it works as it should work then it will be great. I am actually prepared for some surprises.*

*Author: So you would actually have preferred that it had been tried out some more before...*

*Carl: For my part. Yes*

*Cecilie: Yes*

*Author: Because some people like that it is the newest, and want to be first, while others like that it is...*

*Cecilie: ...yes, and then we can be number two! But that is how it is. It was all the other aspects that, well, the ones we mentioned before. That was more determining,*

*and then it just became a bonus that it is a passive house. We will just have to see what it will be like.*

While several of the interviewees were not comfortable with being the early adopters of the passive houses, there were expectations that their future neighbours will have typical innovator characteristics as described by Rogers (2003). As Carl states:

*I imagine that many... about our future neighbours, that it is an almost extreme need for electronics, that they are concerned with new things and have solid jobs with a good income. But that is most likely my prejudices.*

The results show an indication of the same three interest categories as in the Anneberg settlement, i.e. *economical*, *ecological* and *technological* interest. There was a clear economic and technological interest, and some ecological interest. However, it was only the economic interest that had any influence on the house choice. Thus, ecological and technological interests cannot be included as determinants for the passive house purchase.

These results have given interesting indications of determinants of passive house purchase, and the implications of the findings will be elaborated in the discussion section.



## 4 Discussion

After a brief summary of the most important results the remaining discussion chapter will be structured according to the research questions and implications and conclusions for each question will be presented. Limitations and weaknesses of the study will be discussed in the final part of the discussion chapter as well as an overall conclusion and suggestions for continuing research.

The findings of this study shows that the most important characteristics of what determines which house to buy is its location, type of house including size, price and number of rooms, as well as closeness to nature. Characteristics such as garden size, view and control over the floor plan were initially desired but were disregarded while compromising to find an available house. The financial benefit of the low energy consumption, as well as the reduced environmental impact was a positive addition to the house choice, but was not influencing the house choice.

While the influence of environmental values on the purchase decision was described to be weak, it was possible to identify one aspect where nature related values had some influence. The choice of prioritizing to move close to hiking and recreation areas is strongly influenced by the value of being close to nature, and the possibility to enjoy the peacefulness that nature offers. This is however not based on biospheric values, but the egocentric values of using nature for relaxing and recreation purpose (Stern, 2000; Stern et al., 1999).

In the study in Anneberg, Sweden, three types of interest were found among the participants, *economical*, *ecological* and *technological* interests (Löfström, 2008). In the present study the participants indicated clear economic and technological interest, and to some extend also ecological interest. However, it was only the economic interest that determined the house purchase decision.

## 4.1 House characteristics influencing purchase decision

The first research question involved the house characteristics:

- RQ1. What characteristics of a passive house do (potential) buyers focus on in the decision process?

The study showed that the aspects that were most important were related to the location, e.g. distance to work and city centre, distance to nature, and that it is a child friendly neighbourhood with kindergarten and school nearby. Other important aspects were possible financial benefits from the energy saving potential and indoor characteristics, e.g. number of rooms or possibility to rent out an apartment.

The findings are consistent with the studies by Löfström (2008) and Ornetzeder et al. (2008), where location, size and closeness to recreation areas are the most important features. In the Vienna and the Lindås settlement the residents reported closeness to recreation areas and nature as one of the most important determinants of why they bought at that location (Isaksson & Karlsson, 2006; Ornetzeder et al., 2008). Additionally, the distance to the city centre and work determined the choice of location, and this was also found in the Lindås and Anneberg settlement (Isaksson & Karlsson, 2006; Löfström, 2008).

The eight variables that were found important for choosing which house to buy in Saaty's study (1990) were: *size of house, location to bus lines, neighbourhood, age of house, yard space, modern facilities, general condition and financing available*. These variables were discussed during the interviews and it was found that all except *modern facilities* were important. Modern facilities include e.g. integrated waste separation system or that the house is adapted for new appliances. This feature was not discussed by the participants during the interviews, and the questionnaire showed that waste separation system was not considered important to the house buyers. A probable explanation for this could be that there is no tradition for an integrated waste separation system inside the houses and therefore not expected that such a system should be built into detached and terraced houses. The other variables presented by Saaty were mentioned during the interviews and were considered important for determining the house

choice. However, there were some differences between which variables were considered most important.

Saaty's study did not include location as a variable, other than distance to bus stop, since it was a hypothetical house choice. The results in this study as well as previous research on place identity (e.g. Proshansky et al., 1983) indicate that it is necessary to include location to be able to understand what determines the house choice. The participants of this study are all moving within Trondheim, and know the area they are moving to well. In fact, several of the interviewees expressed an attachment to the chosen areas<sup>9</sup>.

The features that were least important were having a sauna, closeness to water/sea, restaurant, cultural activities, and shopping centre. The findings show that when leisure activities are concerned, closeness to nature is preferred over closeness to cultural activities. This might be explained by the Norwegian tradition of spending time in nature, and how nature is being used by Norwegians for leisure purposes. It has been shown that spending time in nature correlates with environmentalist orientation and sustainable consumption (Nisbet, Zelenski, & Murphy, 2009). This correlation could not be found in the Trondheim sample, but that could either stem from the small sample size or the fact that there are cultural or sociodemographic differences and traditions. Nisbeth et al.'s study included undergraduate students as well as executives living in Canada. The Trondheim sample consists mainly of people within the earlier family stage, i.e. having or planning to have children.

Indoor features that were not important were having a waste separation system in the house, a refrigerating room, and a central vacuum cleaner. This indicates that when choosing which house to buy, technological installations of the house did not influence the house choice in this sample. A possible explanation might be that this is features that can be installed at later stages, if desired.

Other indoor features were presented as desired, but had to be disregarded when the purchase was made. This involves room planning, location of different rooms in

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<sup>9</sup> Also including the participant from Grilstad

the house, as well as how the rooms are integrated with each other, e.g. an open kitchen. Since the buyers were not able to find these features among the houses in the desired location, and within an affordable price range the features was not prioritized. This might suggest that there is a desire to control the outcome of the design, and to take part in the planning of where the different rooms are placed. However, when the decision on which house to buy is made, the buyers settle for the pre-designed solutions if they have to. There will most likely be financial limitations connected to the possibility to control the design and to make changes in the design of the houses.

As Sirgy et al. (2005) stated it is more likely that a house is bought if both the functional needs are met and symbolic aspects can be included. It was clear that some of the interviewees did not feel that the symbolic aspects were being met, which includes identifying oneself with the type of house. The interviews showed that the style of the houses was considered boring and far from the desired house type with e.g. a large garden and separate kitchen/living room.

Buying a house requires high cognitive involvement. There is a need for information search, gaining knowledge, financial settlement, and preferably at the same time find a house with the desired features (Laurent & Kapferer, 1985; Ölander & Thøgersen, 1995). The current results show that a high investment decision that requires cognitive involvement can be changed rather quickly, if the opportunity to achieve a desired goal arises. A possible explanation for quick high investment behaviour is that the house market in Trondheim is so limited that the choice of house is not considered as a decision. When the options are very limited it is not possible to prioritize houses with the features that is desired. The available options within the financial frame will be considered and the best option is chosen. If there is a high demand for houses it might be necessary to decide rapidly not to miss the opportunity. However, there is a possibility that in the decision making process, after searching for information, and gaining knowledge, there comes a point where people go forward with the decision despite of uncertain elements. When the decision has been planned for a certain amount of time, and it has not had a successful outcome, some of the criteria are changed and people go for the best available option regardless of previous plan. This

change in the decision making process is very interesting, and should be explored further.

When the interviewees were reflecting on the differences between new and old houses it was evident that they were not specifically focusing on buying a new house. Most of them had started the search by looking at older houses. A few had also been involved in bidding rounds. The interviewees discuss the problems with buying old houses with potential hidden problems and that it would not be more beneficial than buying a new house. This is consistent with the findings in Barlindhaug and Ruud's (2008) study which showed that people preferred new houses because it required less maintenance compared to older houses. Additionally, the quality of the old houses was not sufficient, or they did not find an old house that fit their needs.

The interview with Dennis revealed that it is possible to change one's opinion about the benefits of whether to buy a new or old house *after* it was decided to start looking for new houses as well. Dennis found justification for choosing to buy outside the originally desired area by arguing that Granåsen is still within what he believes a future attractive part of Trondheim. He also started to add positive value and benefits to the choice of buying a new house.

Another important factor that might limit the options is the time perspective. The current household might not be functioning optimal anymore, due to changes in e.g. need for space. This adds pressure to the decision process, and it might not be possible to include all desired features if such options are not available at the time the purchase needs to be done. It is clear from the interviews that the decision process of buying the house has been planned for some time. Some of the interviewees have been looking for between 1-2 years before making the choice. However, this contemplation stage in most cases suddenly came to an end when the opportunity to buy a house at Granåsen arose.

The conclusion of the first research question is that the overall most important determinant of house choice was the location. What determined the right location differed somewhat according to needs and interests. While the participants of this study had specific features they were looking for in a house, they were willing to negotiate

and to disregard some of them. The decision to buy was for some of the participants a rather quick decision, where a change in focus opened for new opportunities. To some of the participants the final purchase decision was perceived as rather spontaneous.

## **4.2 Focus on the environmental aspects**

The second research question addressed the environmental aspects of the house:

- RQ2. Are house buyers who are interested in a sustainable housing project more focused on environmental aspects around the building than people interested in conventional houses?

It was unfortunately not possible to investigate this question as detailed as originally planned. The objective was to compare two neighbourhoods, Miljøbyen Granåsen and Grilstad Park, where the house style is similar but only Granåsen has passive house standard. The purpose was to see if it was possible to distinguish a stronger environmental focus with the buyers at Miljøbyen Granåsen than could be found at Grilstad Park. This could not be confirmed since there was not enough data to compare to. There is nonetheless valuable information to discuss related to this research question. The one interviewee at Grilstad Park proved to be the person with the most environmental concern. However, it had not influenced her choice of house. Similarly, the interviews at Granåsen showed that the environmental aspect around passive houses was not determining the choice of house. It was added as a positive effect after the purchase was made.

The positive view of the environmental aspects in the aftermath of the purchase can possibly be explained as a way to confirm the purchase. By adding more positive aspects that will be gained with the new purchase, people confirm that they made the right decision. If they experience cognitive dissonance towards buying a more expensive house than originally planned, or towards buying a new house instead of a more affordable older one the positive aspects will serve as justification.

When discussing the environmental aspects around the passive houses, the interviewees combined the financial benefit of lower energy consumption together with the lowered environmental impact. It was found that when the interviewees considered the

energy saving potential of a passive house, it was mainly thought of as a financial benefit. Only one participant expressed doubts about how beneficial the long term saving would be compared to the higher price when buying the house. Interestingly he was also the one showing most environmental interest of the interviewees at Granåsen, and did not consider the financial benefit as positively as the others. He also expressed more positive interest in the saved environmental impact than the others. However, the passive house technology did not determine the choice. Elizabeth, at Grilstad, did express that if there had been a passive house in the Grilstad area she would have preferred to buy that. This adds to the finding that the environmental impact of the house is not prioritized.

Comparing these findings with Isaksson and Karlsson (2006), Löfström (2008) and Ornetzeder et al. (2008) shows some differences. In Anneberg, Lindås and Vienna it was shown that the environmental aspect had some influence on the decision process. In this study it added positive value to the choice after the decision was made. This study shows more similarities with the Kassel settlement where it was found that the environmental aspect did little to attract tenants. The study of the Kassel settlement did not find that the environmental aspect of the houses attracted any residents. When the campaign focused on features such as balcony and that it was a new building the interest increased (Schnieders & Hermelink, 2006). This shows that in the Kassel settlement it is the conventional characteristics that are most important, which was also found in the Trondheim sample. It was not asked about how the buyers perceived the environmental focus of the marketing of the project in this study (example can be found on [www.miljobyen.com](http://www.miljobyen.com)). However, it was clear from the interviews that the environmental focus in the Granåsen project was not what attracted the attention of the buyers.

## **4.3 Characteristics of the buyers**

The third research question involved the people buying a passive house:

RQ3. Can different interest categories be identified among the buyers based on the characteristics they focus on?

It was expected to find a positive interest in the passive house technology as a new technology, and that the buyers would fit into Rogers' (2003) description of innovators or early adopters. Additionally, it was expected an environmentalist orientation, as well as the motivation of long term economic benefit as a result of low energy use. The three interest categories will be discussed in more detail separately in the following sections.

### **4.3.1 Economic interest**

The interviewees were well aware of the energy saving potential of passive house technology. The financial benefit was perceived as positive by all interviewees but one and had some influence on the purchase choice of two participants. The buyers were willing to pay more for the house if that led to a lower operational cost in the long term. This is consistent with the interest category defined by Löfström (2008) as well as with the settlement in Lindås, where the economic benefit was perceived as positive but not determinant for the buyers. One participant however, was more critical to how beneficial the long term savings would be, and did not consider the financial benefit as important, since the increased price of the house counterbalanced the long term savings.

Hoffman and Henn (2008) argued that the willingness to invest in an innovation with long term financial benefit increases if the pay-back period fits the time frame of the residents. This could explain why the buyers at Miljøbyen Granåsen are willing to invest in a more expensive house and in the long term save energy consumption costs. It is likely that the buyers are planning to live in these houses for a long period of time, since they were particularly looking for a house in a child friendly area.

### **4.3.2 Environmentalism**

The study also aimed at exploring whether environmental values, beliefs and norms influenced the house choice, as described in the VBN<sup>10</sup> theory (Stern, 2000). If people base their house choice on VBN variables this would be shown in the interviews and questionnaire. However, there was no indication that the interviewees in this sample were guided specifically by environmentalism. The environmental aspect was perceived as positive, as described in section 4.2, but at the same time the interviewees explicitly specified not being environmentalists.

The findings suggest that there might be a need for an even more distinguished separation of pro-environmental investment behaviour than just high and low cost. While both house purchase and car purchase are considered high cost investments, the determinants are somewhat different. In the study by Jansson (2009), the results showed that the adopters had higher level of environmentalism, and that it did influence the adoption decision. This was not found in the current study of passive houses. In fact, it was the interviewee from Grilstad Park, the non-passive house resident, who expressed most concern about environmental issues.

These findings could be explained by the pressure in the housing market in Trondheim. The limitations of available houses can reduce the possibility to choose *between* options. The house buyers are forced to choose one option or not, and if not, wait for the next opportunity. The possibility to travel to work, as well as the financial frame creates boundaries that the buyers must consider. These boundaries limit the actual possibility to make a choice. This is confirmed in the interviews where the participants explain how they had to disregard some of the desired features. This is different than with a car purchase, where the buyers have all the options available at the same time and are free to choose the one that best fit their needs and desires.

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<sup>10</sup> Value-belief-norm theory (Stern, 2000)

### **4.3.3 Unintended innovators/early adopters**

Labay and Kinnear (1981) found the early adopters to be younger, more highly educated, having a higher income level, being earlier in the family life cycle, and higher in occupational status than the general population. Based on the interviews, similar characteristics were found in the current study. However, it was not found that the desire to be an early adopter was the determinant of choosing a passive house. This supports the findings in a study by Rohracher and Ornetzeder (2002) showing that while the buyers of sustainable houses had typical early adopter characteristics, it was not the desire to be an early adopter that led them to buy the house. The most important factors were the more traditional, such as need for more space and the location.

One participant expressed interest in the energy saving potential of the technology, and discussed that he would have used energy saving technology if he would have built a new house instead of buying. However, it did not determine the choice, since other features e.g. space around the house were more important. This shows that being an early adopter of sustainable technology is not intentional among the participants of this study.

In fact, other interviewees expressed concern about being early adopters of passive houses. They discussed possible uncertainties about the technology, e.g. being too hot in the summer, or complications with adjusting the indoor temperature in different rooms. There is an expectation by the participants that it might be necessary to accept some reduction in comfort as well as reduction in control of the indoor climate. However, the uncertainty was reduced by e.g. investigating that the project had academic foundation, and that the developers were cooperating with trusted institutions. Other means for reducing uncertainty were discussing the guarantees that follow new buildings or familiarizing the passive house by comparing it with their current resident. In general, it seems that the participants of the study have trust in the developers, which is consistent with the settlement in Lindås. However, whether the trust is higher or lower than with conventional projects was not investigated in this study.

Interestingly the results show that the interviewees expect innovator and early adopter characteristics of the neighbours, even though they are not themselves in this category by choice. The findings from this study show that none of the interviewees chose this location due to the innovation. Thus, being an innovator or early adopter had less significance with respect to sustainable house purchase than it did with e.g. alternative fuel vehicles (Jansson, 2009), both being high-cost investments.

Finally it is important to recognize, as Rennings (2000) point out, that high investment innovations are often slow in diffusion rate. As it is seen within the building sector, passive houses were introduced in the late 1980's (Passive House Institute, n.d.). Despite its significant energy saving potential, passive houses are still not a part of the majority's choice of building and buying, at least not in Norway. A realistic time-scale according to Rennings would be as much as 50 years or more for larger social or economic innovations, such as a new building technology.

The results indicate that it might give additional information about the diffusion of passive houses if the willingness of adoption among the developers and real estate agencies was studied. The adoption possibility among the house buyers is limited if the developers resist adoption. As it was stated by the interviewees, there is an expectation that the adoption of new sustainable building technology is too much responsibility for individuals, and that the guidelines should come from official regulations rather than pro-environmental values among the buyers.

#### **4.4 Limitations and weaknesses of the study**

There are some limitations to choosing a population of this type, i.e. buyers of sustainable housing projects. The population is small, thus making it very vulnerable with respect to willingness to participate. However, it is important to investigate and discuss current topics regardless of convenience of the sampling process. This study could only gain access to 16 housings from the detached and terraced houses, and the final sample size was smaller than what was desired. The sample is homogenous, and strong indications can be found in the results. In a few years time it will be possible to do a similar study and include the apartments as well. This would give a population of ap-

proximately 300 housings and probably a larger sociodemographic variety. To get access to a larger population to sample from, one could have extended the population to include other ongoing building projects from other cities. However, this had to be weighed against the time and resource limitations of the thesis.

By interviewing people after the purchase has been made, give a retrospect description of the decision process. This can have given a slightly different result than it would if the interviews had been made while the participants were in the decision stage. Hindsight bias could influence the buyers to present the decision stage more in line with the result than what was actually the case, leading the buyers to present more aspect that confirms that the choice was a good one.

The author's inexperience of interviewing can of course influence the content of the interviews. Despite some practice before hand to increase interviewing skills, one often needs several interviews to get the experience and skill that a more senior researcher has achieved. The inexperience of interviewing has, in this study, led to shorter interviews than desired which in turn might have lead to a smaller data material than an experienced interviewer would have achieved. However, since the interview guide contained questions that are directly related to the research questions, the data collected are relevant for the study. If the interviewer had had more experience, the data would probably have been more detailed and created a broader picture of the interests and opinions of the interviewees. A possible solution to weigh up for the inexperience could have been to extend the interview guide with more back up questions in case there would be a need to extract more information from the participants.

In retrospect there are some questions that could have been included in the interviews. For instance, asking if the interviewees had considered the time perspective of living in the new house would have given an interesting indication to how the increased short term investment would be paid back in the long term saving of reduced energy consumption. This could then have been compared to Hoffman and Henn's (2008) findings.

An innovation such as a sustainable house has several adoption stages before being implemented into society. This study focused on the end user in the private sphere. Due to the limitations in the housing market it might have been more relevant to focus on other stages in the diffusion process e.g. how the developers adopt passive house technology.

## **4.5 Final conclusion and suggestions for future research**

The overall conclusion from this study is that the sustainable building projects of the type that is used in Miljøbyen Granåsen is perceived more as a housing project in line with conventional projects than it is perceived as a technological innovation. The buyers did reflect on the new technology and expressed some uncertainty, but there were other aspects that were more important than the building technology. From the results it is not possible to conclude that the buyers would have preferred a conventional house if it was located in the same area. However, the concern that was expressed show that the level of uncertainty towards what to expect by living in a passive house would be much reduced. The location of the houses as well as the limitation of the housing market is the strongest determinant factors. The low-energy feature of the passive house was not a determining factor of the house choice, but was considered a positive addition to the choice. Additionally, the low-energy feature is more considered from the economic perspective than from the positive environmental effect.

Passive house technology is still in the early stages of adoption, hence the house buyers fall into the categories of innovators or early adopters, according to Rogers' (2003) definition. However, the study shows that the buyers are not innovators/early adopters by their own choice. This again shows willingness to take the risk of an unfamiliar innovation if it fits the most important criteria of the house. There were participants that could be categorized as economically motivated, since the cost/benefit perspective was considered important when the purchase decision was made. Several of the participants specifically stated not wanting to appear more environmentally interested by choosing a passive house. This shows that they are not guided by pro-environmental values, beliefs and norms as described in VBN theory (Stern, 2000).

Instead, the buyer highly valued living close to nature and using the nearby hiking area in their leisure time.

For future research it would be very interesting to investigate possible behaviour change by the residents in Miljøbyen Granåsen. Will living in a sustainable house have a spillover effect on other pro-environmental behaviour, and will it change the residents' environmental attitudes positively? Research has found a spillover effect from one pro-environmental behaviour to another, i.e. one behaviour increases the motivation to adopt other related behaviours (Thøgersen & Crompton, 2009). In a Norwegian study on low-energy houses it was found that 12% of the participants reported a high degree of increased pro-environmental behaviour, and 77% report some increase after moving into the low-energy houses (Kleiven, 2007).

There is of course the possibility that living in a sustainable house gives the residents a feeling of already being pro-environmental and that justifies less pro-environmental behaviour in other areas. This *rebound effect* occurs when people increase their environmental impact in one area as a result of a decrease in another (Hertwich, 2005). One example is that a household saves energy and thereby money by installing a heat pump, and then uses the money to travel more by e.g. airplane. If one measures the total emission level of the household this secondary effect might cause the total environmental impact of the house to be less effective as was intentionally planned. It might even backfire, and cause a higher environmental impact than before. The investment of a passive house is higher than with a conventional house and this means that the saved money from the lowered energy consumption is a "pay-back". There might still be a rebound effect from lowering pro-environmental behaviour in other areas, since living in a sustainable house is a large pro-environmental investment. This is a research field that will have to be investigated in detail, as the low-energy housings become more common.

Finally, the findings in this study suggest that the adoption of sustainable technology is a decision on the developer level rather than for the individual purchaser. The limitations in the housing market in Trondheim, as well as the strong focus on location causes people to buy what is within an acceptable price range, sustainable or

not. This focus can of course change as the passive house technology becomes more familiar, and the benefits for both personal economy and environmental impact become more known. Exploring the developers' and real estate agencies' willingness to adopt innovations could give important knowledge of how sustainable building technologies should be introduced into the housing market.

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## **Appendix A: Interview Guide**

Hvilke type boliger har dere sett på før dere bestemte dere for å kjøpe huset?

Hva var det dere fokuserte på når dere så på boliger?

Hvorfor var du interessert i å kjøpe hus på Granåsen eller Grilstad? Er det forskjell fra andre områder?

Hvor viktig var ... (nedenforstående aspekter) når du skulle velge hvor du vil bo?

- Miljøaspektet
- Den nye teknologien som brukes (å være tidlig ute med den nye teknologien som brukes i området)
- Energibruk
- Innemiljøet og den eventuelle helsemessige påvirkningen

Hva anser du at fordelene med å bo i passivhus, eller bolig med miljøvennlig profil er?

Hva anser du at ulempene med å bo i passivhus, eller bolig med miljøvennlig profil er?

# Appendix B: Questionnaire

## Spørreskjema om boligvalg

**De første to spørsmålene handler om hva du mente var viktig når du vurderte å kjøpe bolig.  
Kun et kryss pr alternativ.**

**1. Hvor viktig var følgende aspekter når du tok beslutningen om valg av bolig (uavhengig av om ditt nye hus oppfyller disse aspekter eller ikke)?**

	Ikke viktig	Lite viktig	Ikke viktig	Ganske viktig	Svært viktig
Priset på boligen.....	<input type="checkbox"/>				
Størrelsen på boligen.....	<input type="checkbox"/>				
Redusere driftskostnader på lang sikt.....	<input type="checkbox"/>				
Ta hensyn til innemiljøet i boligen.....	<input type="checkbox"/>				
Spare miljøet så mye som mulig.....	<input type="checkbox"/>				
Boligen ligger i gangavstand fra skog og mark.....	<input type="checkbox"/>				
Boligen ligger i gangavstand fra sjø og vann.....	<input type="checkbox"/>				
Boligen har utsikt.....	<input type="checkbox"/>				
Boligen ligger mindre enn 500 m fra stoppested for kollektivtrafikk.....	<input type="checkbox"/>				
Boligen ligger i gangavstand fra skole.....	<input type="checkbox"/>				
Boligen ligger i gangavstand fra restaurant og kulturtildel.....	<input type="checkbox"/>				
Boligen ligger i gangavstand fra dagligvarebutikk.....	<input type="checkbox"/>				
Boligen ligger i gangavstand fra et senter med flere butikker....	<input type="checkbox"/>				
Boligen ligger ved trafikkert vei.....	<input type="checkbox"/>				
Boligen har balkong/veranda.....	<input type="checkbox"/>				
Boligen har kjølerom.....	<input type="checkbox"/>				
Boligen har eget vaskerom.....	<input type="checkbox"/>				
Boligen har badstue.....	<input type="checkbox"/>				

	Ikke viktig	Lite viktig	Verken viktig eller ikke viktig	Ganske viktig	Svært viktig
Boligen har sentralstøvsuger.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen har åpen kjøkkenløsning (mot stue).....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen har tilrettelagt system for kildesortering av avfall.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen er ekstra sikret mot vannlekkasjer med alarm (sensorer).....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Det hører biloppstillingsplass med til boligen.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Det hører garasje med til boligen.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen har private utearealer på bakkenivå.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen har tilgang til felles uteområde.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen har privat hage (uforstyrret).....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Boligen har peis/kan installere peis.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**2. Dersom to ellers like boliger skulle selges, og den ene hadde energisparende eller miljøvennlige innretninger, ville du akseptere å betale mer for denne boligen?**

- Ja
- Ja, hvis prisforskjellen tilsvarer det en i framtiden ville spare på energiutgiftene
- Nei

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**De resterende spørsmålene handler om dine holdninger til miljøvern generelt, ikke bare i sammenheng med hus og huskjøp.**

**Kun et kryss pr spørsmål.**

	Veldig viktig	Nok så viktig	Ikke så viktig	Ikke viktig i hele tatt	Vet ikke
<b>3. Hvor viktig er det for deg personlig å beskytte miljøet?.....</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Svært villig	Nokså villig	Verken villig eller uvillig	Nokså uvillig	Svært uvillig	Vet ikke
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**4. Hvor villig ville du være til å betale mye høyere priser for å beskytte miljøet?.....**

**5. Hvor villig ville du være til å betale mye høyere skatter for å beskytte miljøet?.....**

**6. Hvor villig ville du være til å godta en reduksjon i din levestandard for å beskytte miljøet?.....**

	Alltid	Ofte	Av og til	Aldri	Resirkuler- ing fines ikke der jeg bor
<b>7. Hvor ofte tar du deg tid til å sortere glass, metaller, plast, papir o.l. med tanke på resirkulering?.....</b>	<input type="checkbox"/>				

**8. Ta stilling til følgende utsagn og markér i hvilken grad du er enig eller uenig:**

	Helt uenig	Uenig	Verken enig eller uenig	Enig	Helt enig
Vi nærmer oss grensen for det antall mennesker som jorda kan brødfø.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Menneskene har rett til å forandre naturmiljøet for å imøtekommne deres behov.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Når mennesker griper inn i naturen får det ofte katastrofale følger.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Menneskenes dyktighet og klokskap vil sikre at det IKKE blir ulevelig på jorda.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Menneskene misbruker miljøet i alvorlig grad.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Jorda har overflod av naturressurser, bare vi lærer å gjøre oss nytte av dem.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Planter og dyr har like stor rett som oss mennesker til å eksistere.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Naturens balanse er stabil nok til å motstå påvirkningene fra moderne industriland.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Til tross for våre spesielle evner er vi mennesker fremdeles underlagt naturens lover.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Helt uenig	Uenig	Verken enig eller uenig	Enig	Helt enig
Den såkalte "økologiske krisen" som menneskeheten står overfor har blitt sterkt overdrevet.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Jorda er som et romskip som har meget begrenset plass og ressurser.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Det er meningen at menneskeheten skal herske over resten av naturen.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Naturens balanse er ømfintlig og svært lett å forstyrre.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Menneskene vil til slutt finne ut nok om naturen slik at de vil være i stand til å kontrollere den.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hvis ting fortsetter på sin nåværende kurs, vil vi snart få oppleve en større økologisk katastrofe.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Appendix C:

# Result on importance level of house features

**Numbers show how many that responded on each level of importance.**

	Not important at all	Not very important	Either important or unimportant	Rather important	Very important
Price of the housing				3	3
Size of the housing				5	1
Reducing operational costs over time				3	3
Consider indoor environment in the home				6	
Save the environment as much as possible	1	3		2	
Home is within walking distance to hiking area				4	2
Home is within walking distance to lake/sea	2	3		1	
Home has a view	1	1		3	1
Home is less than 500 m. from bus stop	2			3	1
Home is within walking distance to a school			1	5	
Home is within walking distance to restaurant or other cultural entertainment	3	1	1	1	
Home is within walking distance to grocery store		2	2	1	1
Home is within walking distance to shopping centre with multiple stores	4		1	1	
Home has a balcony/porch			2		4
Home has a refrigerating room	3	1	1	1	
Home has a separate laundry room		1	3	2	
Home has a sauna	5		1		
Home has a central vacuum cleaner	2	2	1	1	
Home has an open kitchen/living room		1	2	3	
Home has a waste separation system		4	1		1
Home has alarm against water leakage			1	4	1
There is car parking at the house				3	3
Home has a garage		1	3	1	1
Home has private outdoor area on ground floor				2	4
Home has access to common outdoor area			4	2	
Home has a private (undisturbed) garden	1	1		3	1
Home has an indoor fire place	1	1		4	

Note: The statement "*Housing is located close to trafficked road*" had to be removed. It was phrased in a way that could be interpreted in different ways. It was thus not possible to ensure that the responses are comparable.