SHOULD I BUY? WHAT SHOULD I BUY? --THE EFFECT OF NORWEGIAN CONSUMERS' ATTITUDES AND PERCEPTIONS ON HEATING INVESTMENTS WITH BIOMASS ENERGY

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Abstract:

Household consumption of renewable energy is high on the political agenda, and the Norwegian government aims to increase energy efficiency and reduce the dependency on electricity in household heating. To achieve these goals more information about consumers' preferences for heating equipment is needed. We carried out a web survey with 1860 participants to investigate how attitudes, perceptions and socio-economic factors affect households' investment likelihood and choice of new heating equipment in the last 10 years. Estimation results suggested that Norwegians have very different perceptions about different heating equipment. Characteristics of the residence, demographical factors and household's intrinsic factors, such as motivation and environmental attitude, are closely related to their heating investment likelihood and particular choice of heating technology. We find that the motivation of saving costs is significantly associated with the likelihood to invest in heat pumps. We also find that households investing in pellet stoves are more likely to be concerned about the environment than their cohorts.

Keywords: energy; heat choice; home economics; revealed preference

1. Introduction

The uses of renewable energy carriers and increased energy efficiency have been high on the political agenda in many countries, including Norway (EEA, 2002). In particular, the use of biomass has evoked great attention due to its perceived role of reducing CO_2 emissions from fossil fuels and achieving sustainable social development objectives (Rosillo-Calle, 2007) The Norwegian government also wants to reduce the reliance on electricity in residential space heating. Norwegian households have been encouraged to invest in heating equipment

based on other renewable energy sources, such as solid biomass (firewood or pellets)(NorwegianStrategyGroup, 2006). Investment into more energy saving and efficient heating equipment is supported by the government. For example, starting in 2003, Enova (a public enterprise owned by the Ministry of Petroleum and Energy) introduced a program to provide a subsidy of up to 20% of the total investment costs for all types of heat pumps, wood pellet stoves and central control systems (ENERGI-og-MILJØKOMITEEN, 2002-2003 , miljøkomiteen, 2002-2003).

In Norway, household energy consumption accounts for about one third of total final energy consumption, and energy used for heating constitutes approximately half of the energy consumed by households. About 70% of Norwegians rely on electricity to heat their houses, often in combination with other fuels. Energy from biomass (such as firewood, pellets, etc.) is the second largest heat source in Norway (SSB, 2008). Thus, information on the households' choices with respect to heating is of great importance for Norwegian environmental and energy policies. How effective policy measures are in achieving their aim depends greatly on household behaviour. For instance, the installation of heat pumps increased tremendously a few years after their introduction in the market, while investments in pellet stoves still remain week (SSB, 2008).

There could be various influential factors in a household's heating investment decision and choices. Most prior economic studies emphasise the effects of income and prices on household energy consumption decisions (Lewis, 2008, Nesbakken, 1999, Nesbakken, 2001, Vaage, 2000). This is reasonable, since more energy efficient equipment tends to be relatively more expensive and therefore a question arises as to whether consumers are rational in their trade-offs between certain capital costs and uncertain and unexpected operational costs. To study the relationship between the choice of heating equipment and energy consumption

quantity, Dubin and McFadden (1984) developed the basic model to explain durable equipment demand and related electricity usage. Nesbakken (1999, 2001) and Vaage (2000) also addressed Norwegian consumer choice of heating equipment with regard to energy consumption by applying multinomial logit model.

The role of domestic energy consumption on local and global emissions, and their effect on the environment, has gained increased focus in the last decades. As a result, environmental attitudes and intrinsic motivation are likely to play an increasingly larger part of households' decisions concerning energy consumption. This paper aims to provide information on the households' choices and behaviour regarding heating investments and particular choices of heating technology. We report the results from empirical research on the heating investment decision of Norwegian households, based on observation of Norwegian consumers' investments in heating equipment over the last 10 years. The data come from a web-based survey, asking households about their heating investment choices. In the analysis, we focus on two issues: (1) what determines whether the household want to invest in new heating equipment or not, and (2) what are the factors determining the type of equipment to purchase. In the analysis, we pay attention to psychological factors, as well as more traditional economic factors. We focus on socio-economic incentives and the characteristics of buildings and infrastructure, in addition to personal factors such as beliefs, attitudes, motivation, perceptions and personality. This enables us to discuss the of the role of consumers' attitudes and perceptions for the heating investment choice relative to other factors such as income, prices, temperature and other household characteristics.

2. Literature review of motivation for sustainable consumption

Solomn(2010) states that motivation refers to the processes that cause people to behave as they do. From a psychological perspective motivation occurs when a need is aroused that the

consumer wishes to satisfy. This need could be for practical benefit, for example, investing in heating equipment for more heat. Or this need may involve emotional responses or fantasies. In our case, somebody invest in heating equipment for improving the dwelling appearances, or for the sake of protecting the environment. Very few studies have systematically included internal factors like a consumer's motivation, attitude or perception when explaining household investments in new heating equipment.

2.1. Social responsible consumption

However, there are a series of studies that have looked at motivation for investing in other types of green products like electric cars, energy efficient household equipment, and eco-labelled food products (Davies et al., 2002, Foxall et al., 2006, Lutzenhiser, 1993). Arvola et al (2007) examined the usefulness of integrating measures of affective and moral attitudes into the model in predicting purchase intentions of organic foods. The results partially support the usefulness of incorporating moral measures as well as affective items for attitude into the behavioral research framework Zanoli and Naspetti (2002) presented partial results from an Italian study on consumer perception and knowledge of organic food and related behaviour, in order to provide insights into consumer motivation in purchasing organic products.

2.2. Household heating choice behaviour and factors influencing heating investments

A consumer's decision-making process is complicated and it is impossible to measure everything that influences a consumer's behaviour. In standard economic theory, the main focus is on the effects of income and prices on behaviour. Experiences or perceptions are also important for most people's choice, but have often been neglected in empirical analysis. Furthermore, the consumer may not choose the most preferred alternative because of constraints, either of a physical (e.g. characteristics of the residence such as house age, size

and ownership) or legal nature (legislation, policy regulation, etc.). It is also likely that the heating investment choice depends on the consumer's expectation about the performance of each piece of equipment and the energy sources being used.

Cold and long winters increase the need for efficient heating, and lead Norwegians to value heating performance. Investing in new heating technology is also a good way to improve energy consumption efficiency. By replacing old and low performance heating equipment with improved and energy saving technology, households get better or more heating services per unit of energy. Such investments can also fulfil other needs, such as increasing comfort and/or improving the appearance of the house's decoration, etc. For example, many households enjoy a firewood stove in their living room because they find it cosy and relaxing. It is thus important to include all relevant aspects to the choice in order to explain a consumer's behaviour well, as the economic choice process is shaped by both standard preferences and cognitive and psychometric effects (McFadden, 2001) Especially, attitudes or perceptions of consumers play an important role in this psychological decision making process. According to a theory of planned behaviour (TPB) (Fishbein & Ajzen, 2010), a particular behaviour is chosen under the function of attitudes to this behaviour, such as subjective norms, perceived behavioural control and actual control.. The strength of these three factors comes directly from our belief. In our particular case, we have assumed that heating investment behaviours are shaped by a consumer's attitude to the expected performance of each piece of equipment and the energy sources being used. Thus, this study includes investment motivation, socio-economic factors, attitudes to environments, personality and some measurable variables reflecting constraints, such as dwelling age, size, ownership, etc.

Nyrud et al (2008) documented that heating performance, perceived time and effort to operate the stove, environmental effects and perceived subjective norms, influenced a household's choice on woodstoves. Sopha et al (2010) further identified that communication among households and the perceived importance of heating equipment attributes affected Norwegian households' future choice of particular heating equipment. Mahapatra and Gustavsson (2008) showed that economic aspects, functional reliability and indoor air quality were the important influencing attributes when households were choosing a heating system in Sweden.

In this study, we also have to consider the complexity of Norwegian household heating choice behaviour. Norwegian households usually have the opportunity to use more than one type of heating equipment, applying different energy sources within the same house. The most common combination is electric heaters in combination with firewood, but any combination of electric heater, firewood stove, heat pump, pellet oven or district heating is used. Not only do many households own multiple types of heating equipment, they may also want to invest in more than one type of equipment at the time. This is quite common in our data (see Figure 1). Furthermore, households often cannot define which equipment is the main one in the house. Therefore the multiple cross heating investment create a challenge for our empirical study and choice modelling. We discuss this in detail in 4.3.

3. Data

3.1. Sample and household survey

The data for the estimation were collected from a household web survey conducted in November of 2010. A total of 1860 participants were drawn from both TNS Gallup's web-panel and from those applying for subsidies from Enova, the Norwegian government's agency for handling subsidies for alternative heating systems. Hence forth, we refer to the

former sub sample as the *Gallup sample*, the latter sub sample as the *Enova sample* and the total sample as the *Combined sample*. The Gallup sample is a national random selected sample, which is drawn from Gallup web panel. The Enova sample is a choice based sample, in which observations are drawn from a data base of Enova applicants. The households from this sample mainly applied to Enova for financial support for investing certain type of heating equipment, such as pellet stove. Due to various reasons, not all the households from Enova sample achieved a subsidy payment. Combining the two sources, we get a sample that can both represent the general population and can be used to study subgroups that have invested in heating systems other than electricity.

The same questionnaire was administrated to both Gallup and Enova sample and consisted of 4 sections (Couper &Lamias,2001). In section 1, respondents were asked about their current residence, such as type (apartment or not), age (years), size (6 ranges) and ownership of dwelling (own or not). We asked about the preferred living room temperature (4 ranges). Questions in section 2 were about households' existing heating equipment and investment decisions about new heating equipment during the last 10 years. If households did invest we asked for more details about investment motivations, subsidy status, etc..

Section 3 consisted of questions concerning attitudes to and perceptions of different heating equipment and the environment and about different personality traits. For example, respondents were asked to compare firewood stoves, pellet stoves, electric ovens and air-air heat pumps with respect to equipment attributes (e.g. cost, environmental benignity, air quality, time and effort, etc). They indicated their perceptions on a 7-point Likert type scale (1= highly disagree, 7=highly agree) on each statement. This is the same scale as that used in other attitude or perception questions. Section 4 involved questions about household

demographic factors, such as income (8 levels), education (5 levels), age (year) and family size (5 levels).

Insert Table 1 Descriptive Statistics of the Sample

The response rates were 46% for the Gallup sample and 43% for the Enova sample. The average age of respondents in the combined sample is 47 years and the average household yearly income before tax is between 600-800 thousand Norwegian Kroner (ca. 74-100 thousand Euro). More details about the sample are presented in Table 1. Comparing the two sub samples, we can see that the proportion of men was higher than of women, especially in the Enova sub sample. In general, respondents from the Enova sample are younger, more educated, with a higher income and bigger family size, live in a newer house and have moved in more recently than those from the Gallup sample. However, the difference is not significantly big, except for the gender share.

Furthermore, in our study, climate data is second hand data and was collected from the Norwegian Meteorological Institute and are measured in heating degree days, defined as the yearly total temperature sum under the baseline temperature of 17°C. The larger the number, the colder the area is. We rescaled this measure by dividing it by 100.

3.2. Stock of heating equipment

Table 2 illustrates the portfolio of heating equipment in our data. The number represents the percentage of the respondents that own each type of equipment. Results from the random Gallup sample indicate that the electrical heater is the most common piece of heating equipment in the Norwegian home. 78% of the households have electric space heating and 64% have electric floor heating. Firewood stove is the second most common piece of heating

equipment and about 69% of households have it, while 14% of households have an open fireplace. The proportion of households owning air-air heat pump is 26%. Oil/ paraffin stoves still account for about 5% of the heat market share. Since the Enova sample is a choice based sample, the shares of air-water heat pumps and pellet stoves in the Enova sample are much higher than in the Gallup sample.

Insert Table 2 Heating equipment ownership in Norwegian households

3.3. Main heating investment choices in the last ten years

In the Gallup sample, 52% of survey respondents reported that they have invested in at least one piece of heating equipment in the last ten years.

Insert Figure 1 Norwegian multiple heating equipment investment in the last 10 years

Figure 1 shows the complexity of Norwegian heating investments. The names in the boxes are the particular heating equipment. The numbers above the boxes represent the number of sample households that invested in that particular piece of equipment. The numbers along the lines represent the number of those that invested in both types of equipment stated in the end boxes. In the Combined sample, the numbers of households that invested in electrical ovens, electricity cables, heat pumps, firewood stoves and pellet stoves are 349, 256, 336, 376 and 204 respectively. It is quite common that households have invested in more than one piece of heating equipment; some have bought even 3 pieces of equipment. The figure indicates that 149 households invested in both a firewood stove and an electric oven. 110 households have bought both a heat pump and a firewood stove in the last ten years. There are even 40

households that have invested in both firewood stoves and pellets stoves, which are considered highly substitutable for each other. The complexity of these heating investments poses a challenge with respect to the econometric specification in discrete choice analysis, discussed in section 4.

3.4. Motivations of Heating Investment

Table 3 lists the key reasons survey respondents reported regarding their investment decision. Only those households have invested at least one heating equipment have answered this questions. And they are allowed to select more than one motivation.

Insert Table 3 Investment Motivations

The most mentioned reason was to reduce heating costs. In the Gallup sample, 61% of the respondents said this was their purpose of the previous heating investment. 38% of households invest in order to get a better indoor air quality, and 33% said it was to replace worn-down equipment. This might be closely related to the household's decision of renovating the house, which is the reason mentioned by 32% of households. On the contrary, only 12% of households said their investment was motivated by reducing greenhouse gas emissions. And 18% said they did it for improving local environments, while 22% said their heating investment was for the purpose of saving time or effort involved in heating their house.

3.5. Perceptions regarding heating equipment

Perceptions play a very important role in the consumer's choices. They directly influence consumer choice behaviour. Due to the complexity of the decision making process, sometimes, it is the perceived outcome, and not the real outcome, that determines our final choice.

Insert Table 4 Mean scores of perception on attributes from different types of equipment

Table 4 shows detailed information about a household's perception about selected heating equipment with respect to some important attributes. In general, firewood stoves scored high on attributes such as appearance, effectiveness in warming up the house and heating costs. Respondents perceived that it takes time and effort to manage both firewood stoves and pellet stoves. Households particularly think it is much more difficult to arrange or to buy pellets than firewood. Pellet stoves are considered to be environmentally friendly, but not as much as heat pumps. Electrical ovens are perceived as outstanding in terms of investment costs and indoor air quality. Households perceive that a heat pump is better than any other heating system when it comes to costs saving, being environmental friendly and effectively warming up the house. But for heat pumps, the investment cost is perceived to be very high and with only an 'ok' appearance, as well as behaving badly in indoor air quality.

There is no heating equipment that can perfectly meet all needs of the household and each kind of heating equipment has its own advantages or disadvantages. Households will choose one type of equipment over others according to how they value and perceive the different attributes and their unique needs.

4. Empirical approach

We assume the household first makes the decision of whether to invest in a new heating system or not. If the household decides to invest, it subsequently needs to choose the type of heating equipment. The first choice is estimated by a binominal logit model (Train, 2003). Ideally, we would have liked to estimate the second choice as a multinomial model, but due to the complexity of the investment decision mentioned above, it is not possible to define mutual exclusive alternatives in the choice set. Thus, we need to apply binary choice analysis of the investments for each of the particular heating equipment separately.

Model specifications

In the first estimation, the decision whether to invest or not is represented by a dummy variable, indicating whether the household has invested in heating equipment during the last 10 years. This decision is assumed to be influenced by a number of factors, including characteristics of the household and residence (income, education, age of household members, dwelling type, ownership, size and age of the residence), the need of heating equipment, attitude to environmental factors, personality traits (e.g. degree of procrastinating, willingness to throw away old stuff, preferred room temperature, etc.) and policy measures faced by the respondent (investment subsidies). The indirect utility of the investment decision is approximated by:

$$y_{1i} = \beta_0 + \beta_1 Apartm_i + \beta_2 Houseage_i + \beta_3 HouOwn_i + \beta_4 Housesize_i + \beta_5 Income_i + \beta_6 Educ_i + \beta_7 Age_i + \beta\ Familysize_i + \beta_9 AttEnvir_i + \beta_{10} Greenbuyer_i + \beta_{11} attProc_i + \beta_{12} AttOld_i + \beta_{13} Temp\_liv_i + \beta_{14} EnovaApp_i + \beta_{15} Subsidystat_i + \varepsilon_i \quad (1)$$

Where y_{1i} is the ith household investment decision, taking the value of 1 if they did invest in the last 10 years, otherwise 0. ε_i is the disturbance term, which is assumed to fulfil standard assumptions.

In the second set of estimations, we estimate the probability of choosing a particular type of equipment given that the household has chosen to invest. We assume that the decisions depend on both external factors, such as residential characteristics, climate, government policy etc., and internal factors, such as owner's socio-economic factors, attitudes and perceptions to equipment and environment. The indirect utility of the choice of heating equipment is approximated by:

$$y_{2i}^{j} = \beta_0 + \sum_{k=1}^{8} MotivReason_{ik} + \beta_9 Apartm_i + \beta_{10} Houseage_i + \beta_{11} HouseSize_i + \beta_{12} Climate_i + \beta_{13} Income_i + \beta_{14} Familysize_i + \beta_{15} Age_i + \beta_{16} Education_i + + \beta_{17} MembEnv_i + \beta_{18} MILORG_i + \beta_{19} AttEnvir_i + \beta_{20} Greenbuyer_i + \mu_i \quad (2)$$

where y_{2i}^{j} is the *i*th household investment choice for heating equipment *j*, *j*=(firewood stove, pellet stove, air-air heat pump (hereafter referred to as heat pump), electric heater) and *k*=(investment motivations). y_{2i}^{j} takes the value of 1 if they did invest in the *j*th equipment, otherwise 0. μ_i is the disturbance term, assumed to have the normal properties.

The probability of a household choosing a particular equipment over the alternatives is assumed to be influenced by the respondent's socio-economic situation, such as income, education, age, family size; environmental attitude; residential type, size and age; and attitude measures on investment motivations.

5. Results and discussion

5.1. Estimated results for the household's decision to invest or not

Below we present the logit estimated results of model (1), based on Stata data analysis software (StataCorp., 2009). In this model the dependent variable is whether households have invested in new heating investment during the last ten years or not.

Insert Table 5 Estimated likelihood coefficients of a household's heating investment

Table 5 reports the detailed estimated coefficients from binary choice modelling on the likelihood of heating investment. The names of the explanatory variables and their descriptions are listed on the left side of the table. Column 1 results are based on a combined sample; Column 2 and Column 3 are based on the Gallup sample and the Enova sample respectively. Overall, the results from combined sample and Gallup sample is pretty close. The sign of the coefficients and the significance level are similar. Only for Enova sample, results looks very different. As we mentioned, Enova sample is a choice based sample, the observations from the sample are supposed to be the group have considered this heating investment decision much more than the ones from Gallup sample.

In general, residential characteristics, income, education, environmental attitudes, time preference and unwillingness to throw away old stuff significantly influenced households acting on heating investment.

First of all, *dwelling characteristics* seem to be the most significant factor associated with their investment likelihood. All three sample results imply that households living in an older house are more likely to invest. To live in an apartment very significantly reduces the probability of investment, possibly because of the availability of common heating systems. The Combined sample and the Gallup sample results provide further evidence that the size of

the house and owning the house have significant positive effects on the investment likelihood. Bigger houses need more heating and ownership of the house might increase the incentives to invest.

Secondly, *demographic factors* play an important role in the investment likelihood. In the Combined and Gallup samples, we find that households with higher income are associated with an increased likelihood of investment, while higher education level is associated with a lower investment probability. There is no significant relationship between respondent's age and investment likelihood. This is somehow as expectated Family size is only significant in the combined sample and it implies that bigger households are more likely to invest.

A*ttitudes and perceptions* provide a mixed picture. More environmentally concerned people are less likely to invest, but it is opposite for those who used to buy green products. We suspect that, people who claimed to be environmentally responsible are not necessary the same as those who buy environmentally friendly products. The two variables concerned with personality traits are statistically significant. For time preference, if one is a more procrastinating type, he or she might have a reduced likelihood of investment. It is easy to understand that, since investing in new heating equipment is not a simple task for most Norwegian households. For the ones not willing to throw away old objects, there is a smaller likelihood of investment. Furthermore, households that prefer higher room temperatures are much more likely to invest in new heating equipment.

The households that *applied for subsidies* from the government have a much higher investment probability than those which did not. This may be due to the Enova respondents having thought through their investment plans before applying for subsidies to a much higher degree than their counterparts.

As we understand, investing in new heating equipment is not an easy decision for most Norwegian households due to the large cost, time and input of effort. In some cases, one even needs to renovate part of the house in order to replace or install particular heating equipment. Even though households value the heating performance, the required capital, time or effort might be the potential barriers for house owner's investment decision. Therefore, the above identified influenced factors will help us better understand the heating investing decision process.

5.2. Estimated results on heating investment choice

Model (2) focuses on the different drivers of heating investment given particular choices. The dependent variables are likelihoods of investing in an electrical oven, heat pump, a firewood stove or a pellet stove respectively. The logit estimations results are calculated based on combined sample, because by that we can have sufficient observations for modelling the investment likelihood for pellet stove. The share of pellet stove for Norwegian households is quite small in the national random sample.

Insert Table 6 Estimated coefficients for heating investment choice

Table 6 reports the detailed estimated results from modelling the households heating investment choices. The name of the explanatory variables and their descriptions are listed on the left hand side of the table.. Results columns 1-4 show the four groups of independently estimated coefficients for modelling whether households invested in an electric oven, a heat pump, a firewood stove or a pellet stove.

First of all, obviously the chosen heating equipment is affected by dwelling characteristics and households' income, family size, environmental attitudes and investment motivations, etc. As we suspected, investment choices are influenced by different factors and in different direction. The common factor with positive influences is the age of the dwelling. An older house is positively associated with investment in all kinds of different heating equipments. The investment can be explained by the need to replace old, not well-functioning equipment. But we should also note there are large investing needs if one has a newly build house.

5.2.1. Effects of the investment motivations on heating choice

The investment likelihoods of different equipment are significantly affected by the real motivations of the households. From the results we see that households, who purposely wanted to reduce their heating costs, have been much more likely to invest in heat pumps, than electric ovens, firewood stoves or pellet stoves. It could be due to the perception that heat pumps are more energy efficient and cost saving, which is consistent with the previous results on households' perceptions on various equipments in table 4.

If households were not satisfied with the appearance of their previous equipment, they would have a higher probability of investing in traditional firewood stoves or electric heating, with a much lower probability in investing in heat pumps and pellet stoves.

Similar arguments hold when a household's investment behaviour is motivated by the renovation of a house. Also in this case there is a positive impact on the choice of an electric oven and firewood stove, and negative impact on the choice of a pellet stove. The reasons could be that households simply wanted to replace the previous old style equipment (electric oven and firewood stove) by new ones. They might be quite satisfied with previous types of

equipment and not willing to adopt different and not so familiar types of equipment, such as a heat pump or a pellet stove.

The households who wanted to save time or effort in heating were less likely to invest in firewood stoves or electric ovens and more likely to invest in a pellet stove or heat pump. This group of pellet stove buyers may be fond of biomass heating, but do not like the much workload needed for managing a firewood stove.

We note that compared with equipment based on electricity, the firewood stove and pellet stove buyer are more likely to live in colder areas. Households living in places needing longer heating times are more likely to invest in biomass energy heating equipment. This could be explained by a household's risk aversion. It is quite risky to be only dependent on electric heating in very cold climates.

5.2.2. Household demographic factors and heating choices

Households' income level is positively associated with the investment in electricity based equipment; no matter whether it is electric oven or heat pump. Bigger households are more likely to choose pellets and less likely to buy a heat pump and a firewood stove. Age of respondent showed significant negative relationship with investing in electrical ovens. We did not find any significant relationship between households' education level and their heating choices.

5.2.3. Characteristics of residence and heating choices

As we mentioned earlier, the age of the house is the most significant factor in this choice analysis. Increasing investment in all kinds of heating equipment is associated with an older

residence. One explanation of biomass investment in older houses could be that people living in older houses might also use more biomass energy, due to the large demand of heating . Another reason could these old and large houses could be the farm house, in which using firewood for heating is conventional and economic. Different types of houses also may well explain their choice. People living in apartments are more likely to invest in an electrical oven and much less likely to invest in a firewood stove. House size is a significant factor negatively associated with the likelihood of choosing electric heating. This finding is hard to explain, as we would assume that bigger houses need more heating and that we should therefore find positive correlations with investment likelihood in all kinds of equipments.

5.2.4. Environmental attitude and investing in pellet stoves

The results show that environmental attitudes matter significantly when relating with the investment choice on pellet stoves. People's attitudes to the responsibility of environment issue is significantly associated with the buying likelihood of a pellet stove. This result is consistent with households perception of pellet stove in Table 4. People score high for pellet stove in terms of its environmental performance. But note that heat pump has been scored even higher on this attribute. It implies that the potential pellet stove investor (for the sake of saving environment) might move to invest in heat pump. This result reveals one of the reason for low share of pellet stove, comparing with heat pump. Although the government subsidies is still available for pellet stove, it lost the game for heat pump, which had the financial support but not any more.

6. Conclusion

In this paper, we have investigated factors influencing household heating investment decisions and choices. The goal was to provide more knowledge on household energy investment behaviour, namely energy efficiency behaviour. Based on a national web survey of revealed preference data household respondents, we have found evidence that a consumer's attitude and perception affect a household's energy heating investment decision and choice significantly. The investment *decision* is not only affected by income factors, but also by dwelling characteristics, demographical factors and other individual attitudes and perception factors, such as environmental attitudes, time preferences and attitudes to throwing away old stuff.

On the other hand, the household choice of equipment is highly influenced by investment motivations or the practical need for heating attributes, environment attitudes, residential characteristics, climate and some demographic factors. Estimation results suggested that Norwegians perceived different heating equipments very differently in terms of various attributes, although all serve the same function: heating up the house. And the characteristics of the residence, demographic factors and household's intrinsic factors, such as motivations and environmental attitudes, are closely related to their heating investment decision and choices. We find that cost saving motivation is significantly associated with investment likelihood in heat pumps. A firewood stove is a popular traditional heating choice and also meets the need of decorating the house. Pellet stove buyers are more environmentally concerned and their investment may be influenced by environmental perceptions of pellet oven. We expect that this knowledge will be useful in relation to marketing strategies and policy making. For example, by knowing that being procrastinated could significantly preventing households investing in a more energy efficient solution, we can purposely design some mechanics to help to overcome or reduce the negative effect of that. Also, by knowing

being environmental concern is a potential driver for one choose to invest pellet stove, we can emphasis on environmental gain for information campaign for promoting pellet stove adopting.

Acknowledgements

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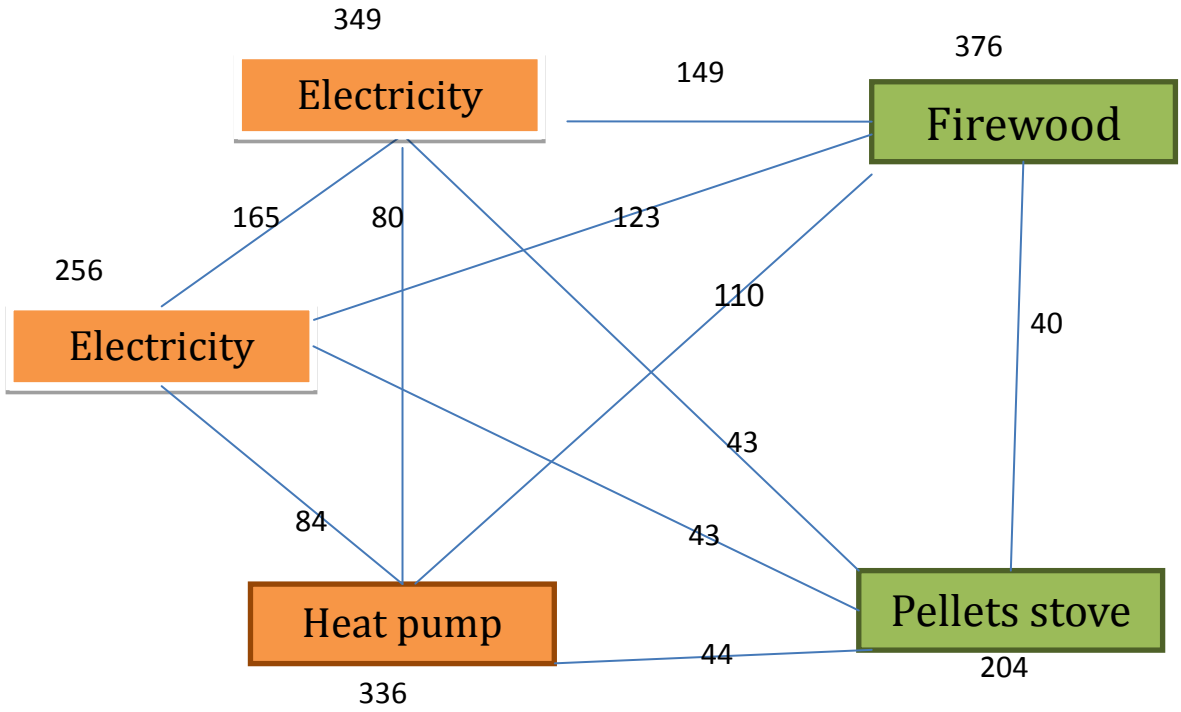
Figures and tables:

Figure 1 Norwegian multiple heating equipment investment in the last 10 years



Sources: own 2010 heating survey, combined sample, N=1860

The numbers above the box represent the number of households that invested in particular equipment. The numbers along the lines represent the number of those that invested in both types of equipment stated in the end boxes.

Table 1 Description of survey sample

	Mean and standard deviation					
	Combined sample		***Gallup sample***		***Enova sample***	
Family income (1-8 scale)	4.23	(1.58)	3.93	(1.56)	4.57	(1.54)
Family members (1-5 scale)	2.73	(1.22)	2.32	(1.07)	3.21	(1.21)
Education (1-5 scale)	3.44	(1.15)	3.37	(1.16)	3.52	(1.13)
Age (years)	47.87	(12.53)	48.96	(12.99)	46.59	(11.83)
Gender (Female=1, male=0)	0.33	(0.47)	0.46	(0.50)	0.17	(0.38)
Size of house (1-6 scale)	3.56	(1.14)	3.24	(1.13)	3.95	(1.02)
Age of house (years)	38.99	(23.71)	40.51	(22.61)	37.21	(24.83)
Time_live_house (years)	14.18	(12.74)	15.61	(13.33)	12.49	(11.79)
Sample size, N	1860		1004		856	
Responds rate			0.46		0.43	

Table 2 Household ownerships of heating equipments, percentage

Equipment	*Combined sample*	*Gallup sample*	*Enova sample*
Electrical oven	70.11%	78.09%	60.75%
Firewood stove	69.09%	68.92%	69.28%
Electrical cable	62.10%	63.94%	59.93%
Air_air heat pump	25.11%	25.60%	24.53%
Open fireplace	14.09%	13.55%	14.72%
Oil/paraffin/gas stove	4.68%	5.08%	4.21%
Air_water heat pump	11.13%	1.49%	22.43%
Pellet stove	14.46%	0.60%	30.72%
Ground source heat pump	0.97%	0.60%	1.40%

Table 3 Heating investment motivations

Heating Investment Reasons	*Combined sample*	*Gallup sample*	*Enova sample*
To reduce heating cost	72.54%	61.10%	80.45%
To get better indoor air quality	41.58%	38.14%	43.96%
Previous one broke down	30.02%	32.64%	28.22%
Updating equipment due to refurbishing	33.05%	32.45%	33.46%
To save time and effort in heating	29.17%	22.20%	33.99%
To improve local air quality	22.96%	17.65%	26.64%
To reduce climate change gas emission	22.11%	12.14%	29.00%
Previous one does not look good	7.76%	9.49%	6.56%
To increase house sale value	7.60%	3.98%	10.10%
To get more comfort	2.95%	3.23%	2.76%
N	1289	527	762

Table 4 Mean scores of perception on attributes of different types of equipment

Attitudes to equipments attributes	***Electricity oven***	***Firewood stove***	***Pellets stove***	***Heat pump***
Investments cost is low	5.67 (1.63)	3.75 (1.65)	2.59 (1.49)	3.08 (1.70)
Yearly heating cost is low	2.79 (1.58)	5.09 (1.67)	4.03(1.68)	5.22 (1.55)
Effectively warm up house	4.32 (1.75)	5.39 (1.49)	5.17 (1.48)	5.85 (1.27)
Difficult to get heating stock		1.83 (1.40)	3.67 (1.95)	
It is environmental friendly heating equipment	4.23 (1.98)	4.29 (1.71)	5.12 (1.47)	6.09 (1.13)
It takes much time and effort	1.31 (0.84)	4.17 (1.74)	3.82 (1.53)	1.62 (1.16)
It gives bad air quality	4.32 (1.84)	3.55 (1.71)	3.33 (1.48)	2.65 (1.69)
Its appearance fits the house	4.81 (1.87)	5.48 (1.69)	4.35 (1.94)	3.85 (2.01)

NOTE: All items are measured in scale, 1 is highly disagree and 7 is highly agree, Gallup sample, N=1004.

Table 5 Logit estimated coefficients of heating investment likelihood

Explanatory variables	*Description*	*Combined sample*	*Gallup sample*	*Enova sample*
Dwelling factors:				
Apartm	Living in apartment, 1= Yes, 0= No	-1.470***	-1.413***	-1.521**
		(-0.217)	(-0.246)	(-0.495)
Houseage	Age of dwelling, divided by 10	0.177***	0.149***	0.238***
		(-0.029)	(-0.035)	(-0.055)
HouseOwn	House ownership, 1=Own, 0=Rent	1.222***	1.261***	1.054
		(-0.241)	(-0.262)	(-0.857)
Housesize	Size of house, 1-6 scale	0.230***	0.281***	0.178
		(-0.069)	(-0.082)	(-0.137)
Demographic factors:				
Income	Household yearly income before tax,	0.087**	0.117**	-0.041
	1-8	(-0.036)	(-0.041)	(-0.079)
Education	Education level, 1-5 scale	-0.098*	-0.123*	-0.017
		(-0.058)	(-0.068)	(-0.116)
Age	Age of household respondent,	0.054	0.0397	0.045
	divided by 10	(-0.057)	(-0.068)	(-0.115)
Familysize	Household size, 1-5 scale	0.112*	0.134	0.063
		(-0.067)	(-0.084)	(-0.116)
Attitudes and perceptions				
Temp_liv	Preferred living room temperatures,	0.283**	0.438***	-0.068
	1-4 scale	(-0.107)	(-0.128)	(-0.208)
AttEnvir	Attitude to Environment,	-0.109**	-0.132**	-0.080
	1-7 scale	(-0.053)	(-0.064)	(-0.097)
Greenbuyer	Buyer of environmental product,	0.142**	0.129**	0.189**
	1-7 scale	(-0.046)	(-0.056)	(-0.083)
PROCR	Procrastination,	-0.083**	-0.087**	-0.091
	1-7 scale	(-0.037)	(-0.044)	(-0.074)
ATTOLD	Unwilling to throw old stuffs,	-0.067*	-0.079*	-0.031
	1-7 scale	(-0.037)	(-0.044)	(-0.069)
Subsidized factors				
Subsample	Subsample indicator,	-0.922***		
	1=Gallup, 0=Enova	-0.175		
Substatus	Enova subsidy,1=with, 0=without	1.344***		1.391***

	(-0.253)		(-0.26)
Constant	-2.023**	-3.211***	-0.975
	(-0.643)	(-0.731)	(-1.51)
N	1742	943	799
log likelihood	-787.099	-534.848	-243.753

NOTE: Dependent variable equals 1 if household has installed new heating equipment costing more than NOK 3000 in the last 10 years, zero otherwise. Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.

Table 6 Logit estimated coefficients for heating investment in different equipments

Explanatory variable	*Descriptions*	*Firewood stove*	*Pellet stove*	*Electricity oven*	*Heat pump*
Dwelling factors:					
Apartm	Living in apartment,	-0.988**	-0.600	0.750**	-1.018
	1= Yes, 0= No	(-0.425)	(-0.648)	(-0.377)	(-0.635)
Houseage	Age of dwelling,	0.0995**	0.137***	0.0813**	0.119***
	divided by 10	(-0.032)	(-0.041)	(-0.034)	(-0.035)
Housesize	Size of house, 1-6	-0.094	-0.044	-0.232**	0.103
		(-0.079)	(-0.103)	(-0.086)	(-0.088)
Climate	mean heating degree days,	0.0289**	0.0613***	0.007	0.013
	divided by 100	(-0.012)	(-0.015)	(-0.013)	(-0.014)
Investment motivations:					
M_cost	To reduce heating cost	-0.204	-0.112	-0.144	1.022***
		(-0.164)	(-0.220)	(-0.176)	(-0.219)
M_look	Previous one looks not good	1.020***	-0.823**	0.789**	-0.713*
		(-0.249)	(-0.407)	(-0.260)	(-0.372)
M_brokedown	Previous one broke down	0.123	-0.006	0.869***	-0.548**
		(-0.156)	(-0.211)	(-0.163)	(-0.194)
M_TandEf	To save time and effort	-0.581***	1.221***	-0.572**	0.316*
	in heating	(-0.170)	(-0.192)	(-0.187)	(-0.171)
M_IndoAi	To get better indoor	-0.036	-0.258	0.228	0.667***
	air quality	(-0.149)	(-0.192)	(-0.162)	(-0.160)
M_CO2Emi	To reduce climate change	0.046	0.742***	-0.349*	-0.385*
	gas emission	(-0.179)	(-0.210)	(-0.202)	(-0.199)
M_Ronava	updating equipment due	0.412**	-0.379*	0.701***	-0.227
	to refurbishing	(-0.154)	(-0.212)	(-0.162)	(-0.183)
M_HouValue	To increase house sale value	0.119	-1.002**	-0.017	-0.930**
		(-0.261)	(-0.472)	(-0.277)	(-0.376)
Demographic factors:					
Income	Household yearly income	0.071	0.002	0.195***	0.131**
	before tax, 1-8 scale	(-0.054)	(-0.072)	(-0.058)	(-0.060)
Familysize	Household size,1-5 scale	-0.120*	0.205**	-0.060	-0.311***
		(-0.071)	(-0.089)	(-0.076)	(-0.081)
Age	Age of household	-0.015	-0.088	-0.208**	0.043
	respondent, divided by 10	(-0.068)	(-0.092)	(-0.073)	(-0.075)
Education	Education level, 1-5 scale	0.053	0.023	0.107	0.034
		(-0.068)	(-0.087)	(-0.075)	(-0.076)
Attitudes to environment:					
MILORGn	Envir_org member,	-0.021	0.660*	0.500	0.282
	1=Yes, 0=No	(-0.323)	(-0.344)	(-0.337)	(-0.343)
AttEnvir	Attitude to Environment,	0.062	0.029	0.056	0.050

	1-7 scale	(-0.059)	(-0.081)	(-0.064)	(-0.065)
Greenbuyer	Buyer on environmental	-0.011	0.107	0.023	-0.053
	product	(-0.053)	(-0.073)	(-0.057)	(-0.059)
Constant		-2.431**	-5.893***	-1.788**	-3.478***
		(-0.790)	(-1.083)	(-0.857)	(-0.891)
N		1079	1079	1079	1079
log likelihood		-611.057	-404.273	-538.022	-513.665

NOTE: Dependent variables: Household has invested in firewood stove/pellet stove/ electricity oven/ heat pump respectively. Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.001

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