SPIR, IPOWER

CONSUMER PREFERENCES FOR TEMPERATURE VARIATIONS

FINAL REPORT
JULY, 2013

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JULY, 2013

PROJECT NO. 27000
DOCUMENT NO. 1
VERSION 1
DATE OF ISSUE 27 July 2013
PREPARED JJD, MHO
CHECKED LIGL
APPROVED JJD

CONTENTS

APPENDICES

1 Summary

In 2025, 50% of Denmark's electricity should be based on wind energy. The iPower platform will help meet this ambition by developing an intelligent and flexible energy system that can handle a fluctuating power generation. Increased flexibility in power consumption enables consumption based on wind power, and reduces the need for investment in electricity distribution networks.

The present study deals with consumers' willingness to accept larger flexibility in power consumption and answers questions like: How large temperature fluctuations are consumers willing to accept? Are there differences in consumer preferences between different segments of respondents?

The study is based on a Stated Preference survey including monthly expenditure for energy, fluctuations in temperature, information on savings and share of green energy in the Stated Preference experiments. 1000 respondents participated in the survey and answered the questionnaire and the Stated Preference experiment.

The study shows that the most important decision parameter for consumers are temperature fluctuations; in second place comes the monthly cost and in third place the environmental awareness in terms of green energy.

Other main conclusions from the study are:

- People would accept 2 degrees of temperature variation without much thought
- There is a substantial willingness to pay for green energy
- People would accept to substitute up to 4 degrees of temperature variation for 50% green energy
- There is a relatively low willingness to pay for an information panel
- Willingness to pay equals approximately 60% of willingness to accept

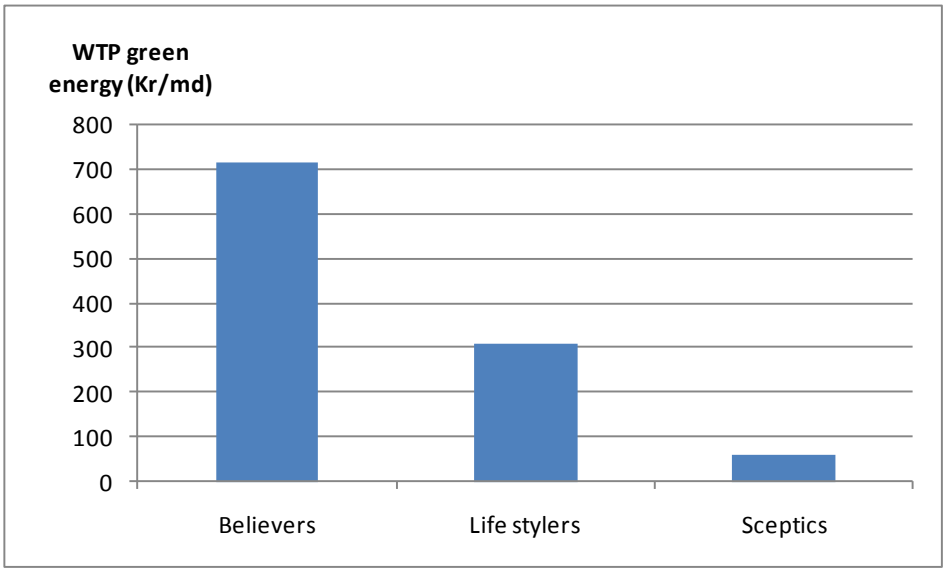
There are only few and scattered correlations between socioeconomics and willingness to pay. One correlation is that women answer more environmentally friendly compared to men.

Besides Stated Preference survey, the study included a Cluster analysis. Based on the cluster analysis the respondents were segmented into three groups:

- Believers: Pro climate but within reason and with an eye to practicality.
- Lifestylers: Pro climate but their lifestyle takes precedence, e.g. cars, food
- Sceptics: Not decidedly negative towards climate, but not pro climate either

Looking at attitudes towards the environment there are some differences between the three groups. Most importantly, the environmentally friendly Believers proved to have a significantly higher willingness to pay for green energy.

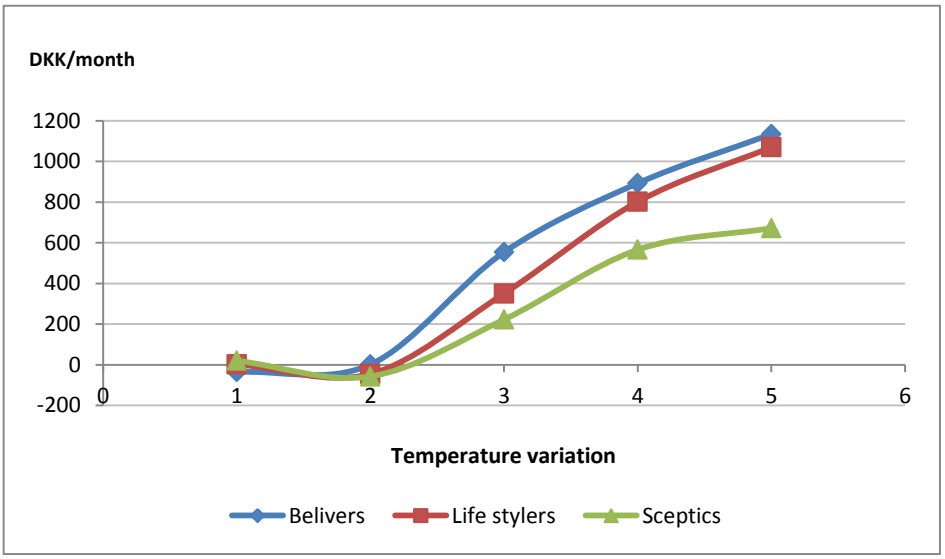
Figure 1-1 Willingness to pay for green energy



On the other hand, it has proven difficult to separate the three segments based on socioeconomics. Therefore, it would be difficult to target campaigns against the individual segments.

As mentioned already, the environmentally friendly Believers proved to have a significantly higher willingness to pay for green energy compared to the other two segments. That does not mean that they will sit at home and freeze to help the environment.

Figure 1-2 Preferences for temperature fluctuations



The Sceptics have very much the same preferences for temperature fluctuations as the other segments. But their willingness to pay is lower, so they are less willing to pay to avoid temperature fluctuations compared to the other segments.

2 Introduction

2.1 Background

One of the major challenges in the Danish energy system in the future is that a large share of the electricity production is planned to come from wind turbines and private small scale solar cells. How do we develop an intelligent and flexible energy system to handle fluctuations in production and consumption of electricity?

From a household perspective the new technological solutions may involve various changes of everyday practices. When different systems and appliances are partly managed from outside, when the home and the car offer energy storage capacity, and when various technical systems in the house produce energy to be integrated in the grid, households may have to change well-known routines and develop new everyday practices.

In order to design technological solutions that work well for consumers, it will be important to include different kinds of users in the innovation processes.

The project focuses mainly on new and changed practices that emerge in relation to demand management and other efforts related to the integration of sustainable energy into the energy system, but the development of the intelligent home may, of course, influence other household practices, as well. The project will investigate the impact of these new and changed practices on the energy consumption patterns of households to rate practices according to their potential for shifting household energy consumption and provide energy savings.

How does the private energy consumer react to being ’forced’ into changes of his/her everyday practices?

What will it take to succeed in getting the private energy consumer to accept and implement changes in his/her everyday practices?

Is it possible to create ideal types or other types of categorizations of the private energy consumers in Denmark?

How do consumers react once the changes of the energy system (due to the innovations in the other work packages) are actually implemented in the household?

This survey is part of the work package 6 in the SPIR project.

This report describes the results of the survey.

2.2 Survey topics

This project is intended to supply information relevant to the other packages in the overall project.

To identify issues relevant to other parts of the iPower project a workshop was arranged with participation of all interested parties of the iPower project. The participants brainstormed on various topics and angles on the questionnaire. The subjects were subsequently discussed and categorized. Finally, the workshop set up a project group to continue the work to identify and delineate topics for the study.

At the end of the workshop it was concluded that the investigation should focus on the following two themes:

• Automation

• Comfort / heat pump comfort

Within these headings the following topics were suggested by the various participants at the workshop. These issues were the basis for the proposals in this work program.

Table 1 Participants' suggestion to subjects and themes under "Automation"

Automation versus control
The degree of how much one can control (primarily heating and cooling)
How would you feel about not being able to deliver a consumption flexibility of the electricity system (wind) due to limitations of the grid?
How much economic benefit will it take to accept remote control?
How would you feel about letting your power consumption be controlled automatically by a commercial operator on the basis of an agreement about your comfort requirements and possible gain by participating?
Automation versus user involvement
What will it take for users to accept remote control?
To what extent would you agree that your heat pump takes over your comfort control? 24 hours a day / during night hours / only when you are not in the building
Different consumer segments must have different arguments to accept remote control?
What type of remote control devices do you have? What features do you use? (Technical complexity background for what is daily practice now)

Table 2 Participants' suggestion to subjects and themes under ' Comfort / heat pump comfort'

Comfort / heat pump comfort
How large heat variations are people willing to offer (to avoid everybody having to invest in a new water tank)?
Comfort vs. savings: To what degree is one willing to compromise on comfort to save money/protect the environment?
We need to investigate if consumers see themselves as flexible in terms of temperature in the house or changes in consumption.
How much would the amount of necessary physical changes to the home matter?
Weighing of small cost variations vs. service changes in terms of behaviour.
"Easiness"? How difficult can we allow the use of the technology to be?
Heat pump comfort
How much space can we allow a Smart Grid water tank to take up in our home (m3)?
Prioritization of various characteristics of the heat pump.
Heat pumps without changes of comfort at automatic control. How important are environment and other soft issues when it comes to acceptance of automatic control?

Based on the outcome from the workshop, the work group decided that the survey should focus on user preferences to temperature variations.

How can the right solutions for the Smart Grid become the most attractive choices for the end users?

Which "knobs" can we turn to get involvement from the end users?

- Economic benefit
- Green energy
- Information about own energy consumption
- Social status
- How much should each knob be turned to make it attractive?

3 Design of the survey

Focus of the questionnaire is on user preferences to temperature variations. To achieve that we set up a scenario where the heating system in the private houses automatically adjusts to fluctuations in energy production by increasing the temperature when the cost of energy production is low and decreasing the temperature a little when cost of energy production is high. Furthermore, it may be that some private houses are cut off in situations with overload in the energy system.

In real life the system could be a "soil heating" system powered with electricity from the smart grid.

The system has not been explained in detail to the respondents in order not to confuse this system with their actual heating system or future possibilities for specific heating systems.

A random selection of 1000 respondents from a panel was carried out. Respondents were drawn randomly from a country wide panel (Userneeds) among panelists living in:

- Single-family house / farmhouse
- Terraced house, linked house or two-family house
- Holiday house
- Other – mostly farmhouses

3.1 Overview of the Internet survey

The questionnaire is a stand-alone web-survey developed at COWI and implemented in Accent web survey software. Questions and responses are managed and stored in an online SQL server.

The interview consists of three types of questions:

1 Socioeconomics about respondent and household

2 Attitudes towards energy consumption and the environment

3 Stated preference choices

Each of these three elements is described in more detail in the subsections below.

3.2 Socioeconomics

The first part of the interview collects general socioeconomic data on the household and the individual adults in the household. The purpose of these data is twofold

› Input to data analysis and hypothesis

› Input to analysis of the representativeness of the sample collection.

These questions are designed to match the definitions used by the Statistics Denmark.

Socioeconomic questions are divided into questions on housing and heating system and individual questions. Heating system questions are included because the present heating system may influence respondents' preferences to temperature fluctuations.

Table 3-1 Housing and heating system characteristics

Question	Category
What type of home do you live in?	1. Detached house or terraced house 2. Summer house 3. Apartment 4. Farmhouse 5. Other – Please describe
What size is your home	M²
Do you live in an owner-occupied or rented home?	1. Owner-occupied home 2. Rented home 3. Co-operative home 4. Other – Please describe
Municipality	Name of municipality
How will you describe the area where you live?	1. Rural area 2. Town with between 200 and 1,000 inhabitants 3. Town with between 1,000 and 5,000 inhabitants 4. Town with between 5,000 and 30,000 inhabitants 5. Town with between 30,000 and 100,000 inhabitants 6. City with more than 100,000 inhabitants 7. Other – Please describe
What is the primary form of heating in your home	Local heating with oil burner Local heating with natural gas boiler Local heating with solid fuel District heating Electric heating Heat pump (Gound to water) Heat pump (Air to water) Heat pump (Air to air) Fire place/wood burner Other
Do you have additional heating systems in your home	Yes, electric heating Yes, fire place/wood burner Yes, solar heating Yes, other No
How old is your heating system	Year

What is your average heating consumption per month?	DKK per month

Apart from household information, we also need specific personal information about the respondent.

Table 3-2 Respondent characteristics

Question	Category
Age	Year born
Family relationship	Cohabiting / married Single Other
Sex	Female = 1, Male = 2
Licence holding	Yes No
What is your highest educational level	1. Basic school (primary or lower secondary education) 2. Vocational training (e.g. Administrative assistant, craftsman training) 3. Upper secondary school, Higher Preparatory Examination Course, Higher technical examination or similar 4. Short-term further education (op to 2 years) 5. Higher education (2 to 4½ years) 6. Long-cycle higher education (5 years or more) 7. Other – Please describe
Occupation	01. Employed within the local government 02. Employed within the public sector in general 03. Private employment 04. Self-employed 05. Student, trainee or apprentice 06. Unemployed 07. On job release scheme or retired 08. On disability retirement or on rehabilitation 09. Non-working (self-supporting or on leave of absence) 10. Other – Please describe
How many hours per week do you work on an average?	1. Less than 20 hours 2. 20 - 29 hours 3. 30 - 37 hours 4. Over 37 hours 5. Not relevant
What is the total, annual household income pre-tax	01. Less than 100,000 02. 100,000-199,999 03. 200,000-299,999 04. 300,000-399,999 05. 400,000-499,999 06. 500,000-599,999 07. 600,000-699,999 08. 700,000-799,999 09. 800,000-899,999 10. 900,000-999,999 11. 1,000,000 or more 12. Prefer not to disclose 13. Don't know

3.3 Environmental attitudes and behaviour

Since the major purpose of the survey is to reveal respondents' willingness to pay for a more environmentally friendly heating system it seems straightforward to examine attitudes towards the environment. This is done by the following questions:

- Environmental attitude
- Environmental behaviour.

The environmental attitude questions are meant to support the detailed understanding of the respondent's choices in the stated preference choice sets. In this respect, these questions will be fed into the latent class variable model in the analysis.

Furthermore, these questions will also be used to validate the preferences for temperature and comfort.

The questions in this section are the following, where the respondent is supposed to indicate how much he/she agrees with a number of statements.

Table 3-3 Environmental attitude

Please give your opinion on the next statements. Your opinion is to be given on a scale from 1 to 9 where 1 = Agree completely and 9 = Disagree completely
1. I am not interested in the climate debate
2. Energy savings is not about the climate, but rather about not being dependant on coal, oil or natural gas.
3. I will only conserve energy if it means reduced costs
4. It is important to me that other people (neighbours and colleagues) see me as environmentally conscious
5. I do not believe that there is a connection between my energy consumption and the effect on the climate
6. Even though the Danish energy consumption is small on a global scale, it is important that we are front-runners in the efforts to reduce emission of climate gases.

Table 3-4 Environmental and energy related behaviour

Please give your opinion on the next statements. Your opinion is to be given on a scale from 1 to 9 where 1 = Agree completely and 9 = Disagree completely
1) I regularly check my heating consumption and compare it to that of previous months
3) I leave adjustment of my heating system to someone who knows something about it
4) I am aware of how much electricity, water or heat we use in my household for different things
5) I prefer to pay so that my heating system automatically operates as efficiently as possible
6) I have checked the price of a new heating system

However, one thing is attitudes. Another thing is the actual behaviour. Thus, respondents are also asked concrete questions to reveal their actual environmental behaviour:

Table 3-5 Environmental behaviour

Question	Category
How often do you buy organic food?	Every time . . . . Never
What kind of car do you have?	Petrol Diesel Electric Other
How often do you go to work by car?	Every time . . . . Never

3.4 Energy consumption perceptions

These questions seek to capture the respondent's perception of the different technologies he/she is ranking afterwards.

First, the questionnaires include questions where the respondent is asked to state to which extent he/she agrees with the following statements

Table 3-6 Energy system perceptions

What are the two most important aspects for you if you were to contribute to a more efficient and climate-friendly heating method? (choose two)
1) That other households also contribute to more climate-friendly heating
2) That there is financial gain
3) That other countries also contribute to climate-friendly solutions
4) That it is not too difficult in everyday life
5) That I am kept informed about my climate contribution
6) Other – Please describe

3.5 Stated preference choice sets

The objective of this step is to obtain household preferences to temperature variations.

The choice sets set up hypothetical situations focussing on:

› **Cost of heating your home**. Both increase and decrease in monthly costs compared to the present cost level could be the case.

› **Temperature variation.** Please imagine that heating is controlled by a heating company. For shorter periods of time (one or two hours) a few times a

week the temperature can be a few degrees colder than the temperature you have asked for.

› **Option to avoid lower temperature.** By pressing a button you may avoid the temperature drop that would otherwise have been the case for the following six hours. The button can only be used a limited number of times per month.

› **Information about consumption.** On a small panel or on your computer you will be able to see your heating consumption. E.g. compared to same month previous year or total year-to-date consumption.

› **Green energy for heating.** The share of renewable energy or green energy used for heating of your home.

Figure 3-1 Example of choice set

	Option 1	Option 2	Option 3
Savings, DKK per month	-	-	-
Additional costs, DKK per month	1500	300	-
Temperature variations when you are at home	17-21 degrees	17-21 degrees	16-21 degrees
Avoid lower temperature	No	Yes, six times per month	Yes, six times per month
Info panel about consumption and savings	Yes	No	No
Percentage of green energy for heating	50%	25%	100%

Each respondent was confronted with six choice sets where the information was varied in different ways. For each set, the respondent was asked to select the option that they most preferred compared to the other two options.

In the following section the design of the choice sets is described in more detail.

4 Games design

4.1 Overview

The design is set up in four blocks of choice sets with six choice situations in each block. Each respondent is presented with six choice sets. The choice sets assigned to the respondents were selected randomly.

4.2 Choice design

During each game, the reference technology and the alternative technology are kept constant. Thus, in game 1 each respondent is asked about the conventional vehicle with unchanged characteristics compared to an alternative technology with varying characteristics.

As mentioned above, the design consists of three sets of games with four choices in each game for each respondent.

The general idea is that the left-hand vehicle (the reference vehicle) is a vehicle of the same size and price as the vehicle recently purchased by the respondent. The right-hand vehicle (the alternative) has varying characteristics in each game.

The table below shows how the characteristics for the alternative vehicle are varied during the games.

Table 4-1 Attributes and levels

Item	Alternatives/Levels
Heating cost	50% 25% 10% -10% -25% -50%
Temperature variations	Constant ±1 ±2 ±3
Avoid temperature variations	No Yes, 3 times each month Yes, 6 times each month
Info panel	Yes No
Share of green energy	0% 25% 50% 100%

Follow up-questions to respondents who replied identically in all four games:

When answering the previous questions, you chose the most inexpensive alternatives every time. What is your primary explanation for this?

1 I cannot afford to pay more for heating
2 All payments were higher than what I find the altered service to be worth
3 I cannot imagine paying more
4 Temperature fluctuations and energy consumption are not important to me
5 I didn't know what else to choose
6 Other – Please describe. Please state other explanations, if any.

5 Data collection

The data collection is based on an online questionnaire via the Internet. Respondents are selected from a panel. The data collection included the following steps:

- Focus group interview with two focus groups.
- Pilot survey. Real life data collection from 100 respondents. By the end of the pilot survey some analyses and estimations will be made to check if the questions, price levels etc. provide sufficient variation in the responses.
- Real study. 1000 respondents selected randomly from people living in:

6 Results

This chapter presents the overall data collection results. Results from estimating the stated preference model are reported in the subsequent chapter.

6.1 Socio economics

1,000 respondents responded to the survey. The following tables show central socioeconomic data on the respondents.

When studying the tables, please note that the survey focuses only on respondents living in houses, and that only respondents living in single family houses were invited to participate in the survey.

6.1.1 Data

Family type and sex

More than two thirds of the respondents are men - most respondents lived as a couple with or without children.

Table 6-1 Family type and sex

	Couple	Single	Other
Female	347	109	14
Male	435	91	4

Income distribution

Income is defined as household net income.

Question answered: "What is the household's monthly net income? (amount transferred to bank account each month)"

Respondents have relatively high incomes.

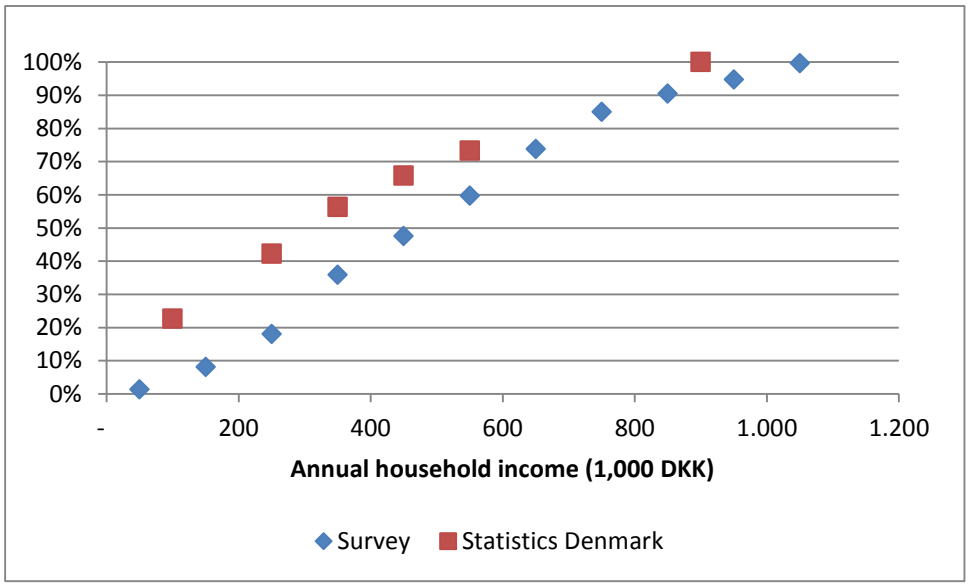
Table 6-2 Income distribution

	Female	Male	All
Less than 100.000	7	5	12
100.000-199.999	27	23	50
200.000-299.999	40	55	95
300.000-399.999	72	73	145
400.000-499.999	47	70	117
500.000-599.999	49	76	125

600.000-699.999	57	43	100
700.000-799.999	45	40	85
800.000-899.999	22	29	51
900.000-999.999	17	24	41
1.000.000 and more	20	39	59
Not willing to tell	61	49	110
Dont know	6	4	10
Average	531,886	550,629	542,045

The annual income for the average single adult household respondent is DKK 542,045. This is well above the average income in general, which is DKK 445,000 annually. The figure below shows the income distribution in the survey sample compared with national statistics.

Figure 6-1 Income distribution compared with national statistics



Age and sex

It is widely accepted that people have different preferences depending on their age and sex.

The following table shows the age and sex distribution in the data set.

Table 6-3 Age and sex distribution

	Female	Male	All
18 - 19	5	1	6
20 - 29	16	7	23
30 - 39	67	35	102

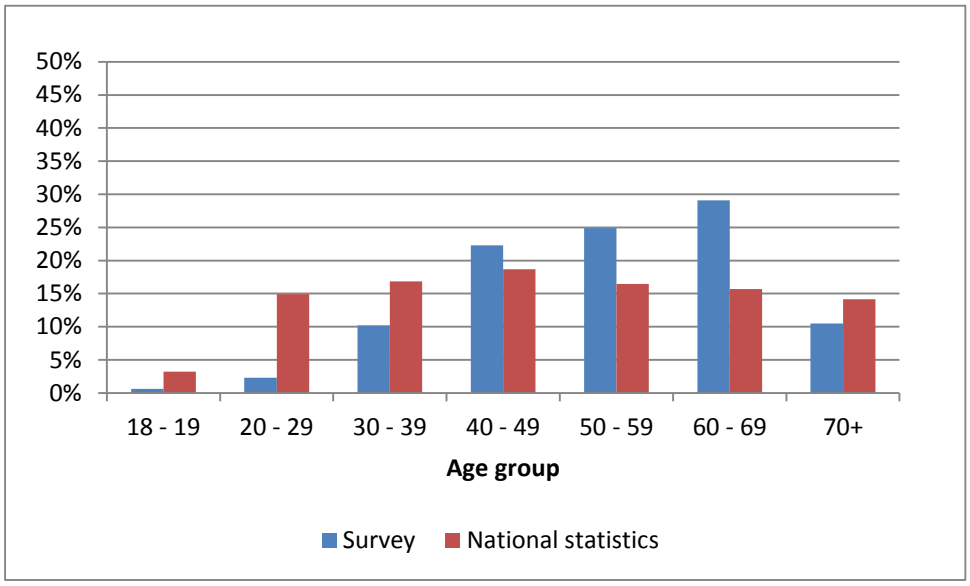
40 - 49	113	110	223
50 - 59	136	113	249
60 - 69	104	187	291
70+	28	77	105
Not stated	1		1
All	470	530	1000

The table and chart below shows the age and sex distribution compared to national statistics.

Table 6-4 Age and sex distribution compared to national statistics, %

	Survey	**DST**
18 - 19	1%	3%
20 - 29	2%	15%
30 - 39	10%	17%
40 - 49	22%	19%
50 - 59	25%	16%
60 - 69	29%	16%
70+	11%	14%
Not stated	0%	0%
All	100%	100%

Figure 6-2 Age and sex distribution compared to national statistics, %

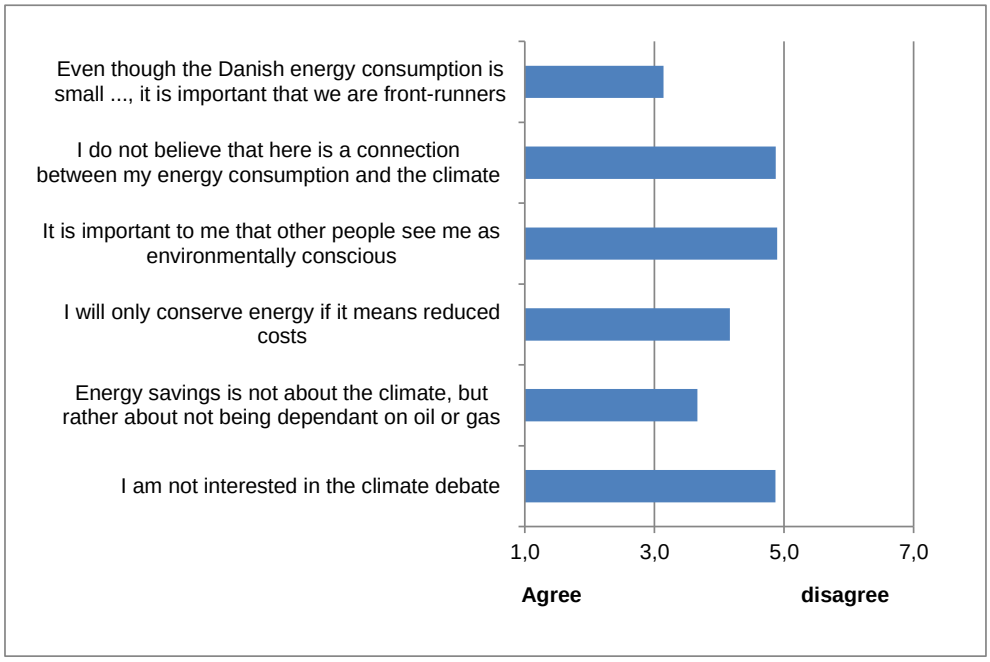


The younger age groups have a significantly lower representation in the survey compared to the national statistics. On the other hand, the higher age groups are overrepresented in the survey. The major reason for this systematic skewness is most likely due to the sampling procedure focussing on people living in single family houses, since young people more often than older people live in flats.

6.1.2 Environmental attitude

The respondents' attitude shows that they say they do care for the environment. They are aware that their own impact on the environment is important although it is small. And they say they are interested in the climate debate.

Figure 6-3 Environmental attitude



6.1.3 Environmental behaviour

However, one thing is what they say they care about. Another is what they actually do. There is a clear tendency that respondents are interested in automatic systems that can save energy for them so they won't need to think about it every day.

Thus they may care for the environment, but the majority would prefer not having to put much effort into energy savings every day. They would rather pay to make sure the heating system can do it for them.

Figure 6-4 Environmental behaviour

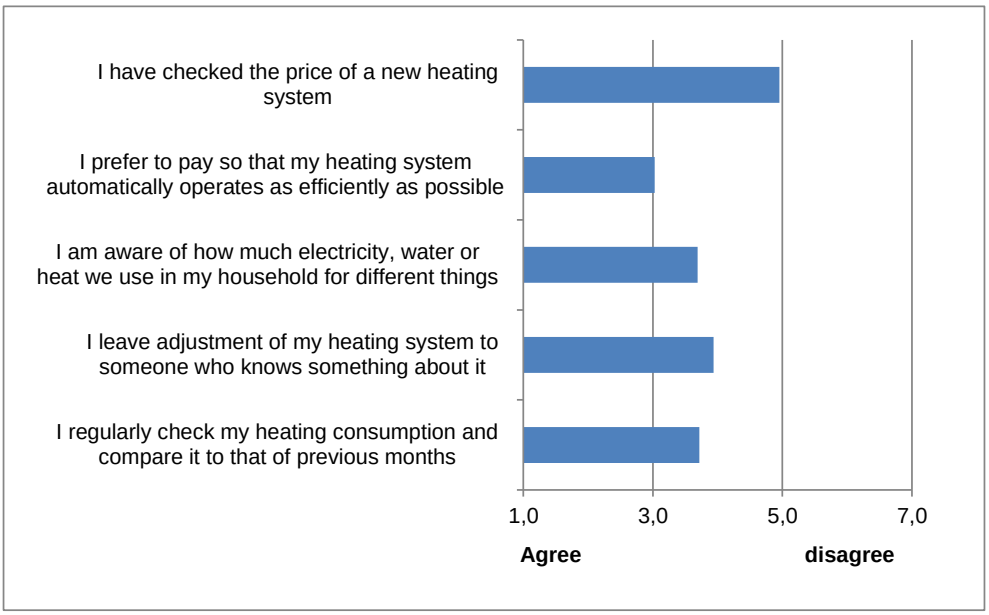


Table 6-5 How often do you buy organic foods?

	Frequency	%
1 Alwavs	39	3.9
2	149	14.9
3	192	19.2
4	215	21.5
5	150	15
6	149	14.9
7 Never	106	10.6
Total	1000	100

The environmental attitude and behaviour is analysed in more detail in the cluster analysis in section 7.

6.2 Data cleaning

This section presents the main results from the stated preference part of the survey.

Before estimating the model, responses were evaluated to identify and eliminate protest bids and other responses where there were indications that replies may not have been well considered. In total, 65 responses were left out of the analysis due to various reasons.

Table 6-6 Responses left out of the analysis

	Count
Protest bid	25
Extreme answer	15
Extremely low energy consumption (< 10 DKK/month)	21
Extremely high energy consumption (>5000 DKK/month)	10
Total	71

As there is some overlap between these responses, the total number of respondents left out of the analysis is 65 and not 71 as stated in the table above.

6.2.1 Protest bids

To identify potential protest bids, respondents who always selected the most inexpensive alternative were given a follow-up question.

Table 6-7 When answering the previous questions, you chose the most inexpensive alternatives every time. What are your primary explanations for this?

	Frequency	**Share**
1. I cannot afford to pay more for heating	108	29%
2.All payments were higher than what I find the altered service to be worth	79	21%
3. I cannot imagine paying more	90	24%
4. Temperature fluctuations and energy consumption are not important to me	25	7%
5. I didn't know what to choose	25	7%
6. Other – Please describe	51	13%
Total	378	100%

There may be valid reasons why respondents chose the most inexpensive alternative throughout the questionnaire. It would be OK if respondents always selected the leftmost alternative if this alternative was always seen as the most beneficial alternative. On the other hand, we want to be sure that respondents have considered the alternatives carefully before choosing the preferred answer.

Thus, protest bids were defined as follows: respondents who always chose the most inexpensive alternative, and who answered:

- I did not know what to choose

Respondents who selected the "Other" option where asked to describe why they selected the most inexpensive option. Examining these comments it appeared that most of these were selected because it was the most suitable choice. None of these were considered protest bids.

6.2.2 Conflicting answers

Conflicting answers cover respondents who gave answers representing conflicting attitudes in different questions. Conflicting answers were identified as extreme observations in the cluster analysis. The conflicting answers that led to extreme values in the cluster analysis are respondents who agree that they are not interested in the climate debate at all. However, at the same time they stated that they would like to save energy even if they would not save any money. Although there may be subtle explanations why these two statements may not be conflicting, we suspect the answers are the result of respondents who did not give their answers sufficient thought. Therefore we decided to leave these 15 respondents out of the analysis.

6.2.3 Extremely high or low heating cost

Respondents with extremely high or low energy consumption are left out of the analysis because the energy consumption enters into the calculation of the cost of the alternatives.

There may be specific reasons why the cost of heating may be very high or very low in some cases. We cannot be sure how respondents would interpret the alternatives in these special cases. Therefore it was chosen to leave these 31 respondents out of the analysis.

7 Clustering of the respondents

Apart from the obvious clustering of respondents by age, gender, education and income, the study has made an attempt at clustering by attitude toward the environment and climate change. The clustering is based on a set of statements in the questionnaire which the respondents were asked to indicate their agreement (or non-agreement) with.

The statements are:

- I regularly check my heating consumption and compare it to that of previous months
- I leave adjustment of my heating system to someone who knows something about it
- I am aware of how much electricity, water or heat we use in my household for different things
- I prefer to pay so that my heating system automatically operates as efficiently as possible
- I have checked the price of a new heating system
- I am not interested in the climate debate
- Energy savings is not about the climate, but rather about not being dependant on coal, oil or natural gas
- I will only conserve energy if it means reduced costs
- It is important to me that other people (neighbours and colleagues) see me as environmentally conscious
- I do not believe that there is a connection between my energy consumption and the effect on the climate
- Even though the Danish energy consumption is small on a global scale, it is important that we are front-runners in the efforts to reduce emission of climate gases
- How often do you buy organic foods?
- How often do you take your car to work?

The respondents were asked to rate their agreement to these statements on a scale from 1-7.

Not all of these statements were used in the final clustering. The ones that were used are highlighted in the list above.

7.1 What is a cluster?

In this context a cluster is a group of respondents that share similar - but not identical - attitudes towards the selected statements. Clustering is a statistical method to measure the "distance"[1] between each respondent and by way of statistical tests to determine which respondents are most alike and how many distinct subgroups (clusters) there are.

Applying a statistical method to real data will always pose challenges. Any result must be interpreted in light of the choice of method as well as the method of data collection. In this case, the wording of the statements and the subsequent interpretation of the statements by the respondents play a vital role. This is the reason why the final results of the cluster analysis are only based on a subset of the statements. Some of the statements were simply too close in meaning, while other statements resulted in a very low variation in responses (nearly all respondents answered in the same way).

7.2 Results

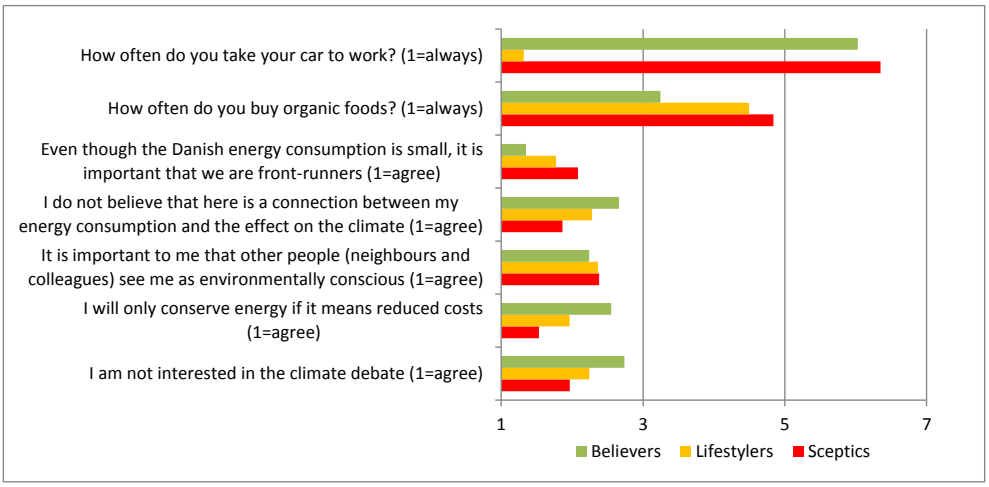
The analysis identified three distinct clusters with varying attitudes towards the climate. Out of the total set of respondents, 15 fell outside these clusters due to their very extreme answers to the statements. These 15 fall into two additional, although not statistically significant, clusters. In total, five clusters, of which only three are statistically significant and suitable for meaningful descriptive statistics:

- Activists: Pro climate to the point of being irrational
- **Believers:** Pro climate but within reason and with an eye to practicality.
- **Lifestylers:** Pro climate but their lifestyle takes precedence, e.g. cars, food
- **Sceptics:** Not decidedly negative towards the climate, but not pro climate either
- Angry old men: The climate debate is a hoax

The statistically significant clusters are the three "middle" clusters Believers, Lifestylers and Sceptics. In the following, these three clusters will be described in terms of age, gender, geography, education and income. First is presented the average score given by each cluster to the selected statements in the analysis.

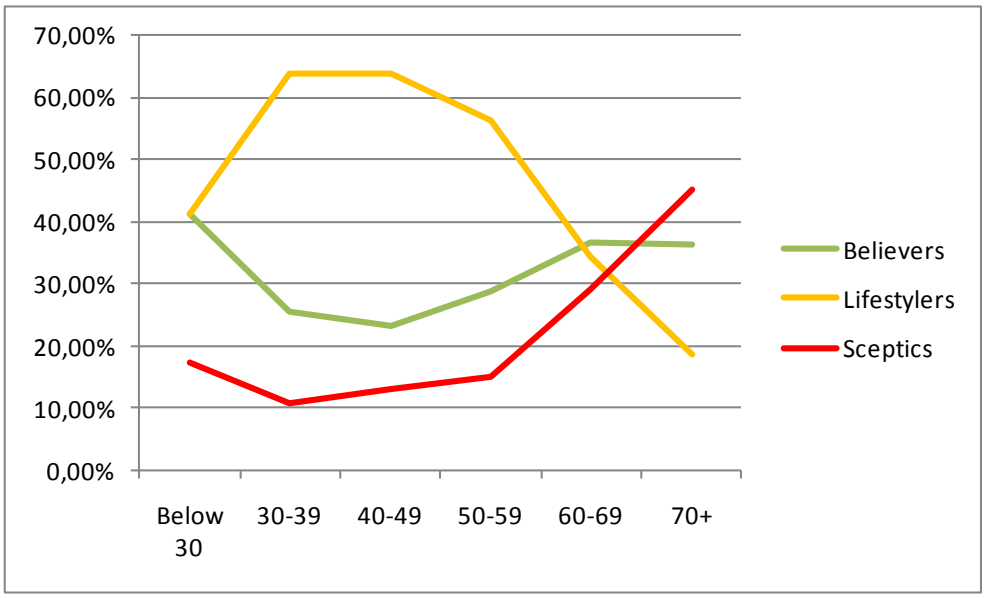
Figure 7-1 Clusters by average response to the selected statements

[1] Distance can be measured in many ways, but the basic principle is the same as measuring the distance between two points on a map. In this case, however, the map is not 2-dimensional but n-dimensional.



It is obvious, that two of the main factors that differentiate the clusters are their use of cars (Lifestylers use cars very often, Believers and Sceptics only rarely) and their use of organic food products. There is still significant variation between the clusters in their responses to the rest of the statements, but on a much lower level.

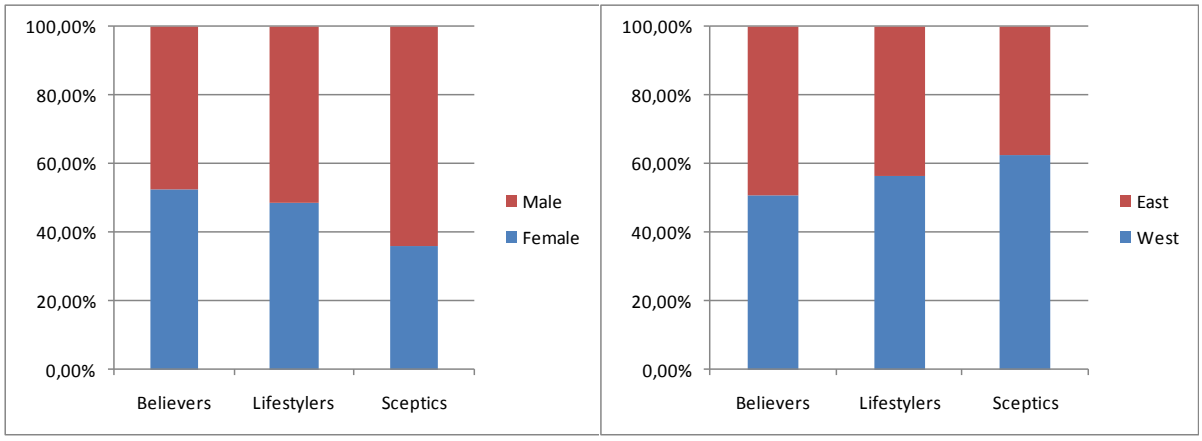
Figure 7-2 Clusters by age



The age distribution in the clusters varies greatly. Many Lifestylers are in the workforce. Lifestylers and Believers seem to net out in the sense that age groups with relatively many Lifestylers have relatively fewer Believers and vice versa. This could indicate that the demands of a working and family life push believers into the Lifestylers cluster. At a later stage, when work and family life become less demanding, many Lifestylers revert to Believers. As the survey presents a cross section of the population, this remains purely speculation.

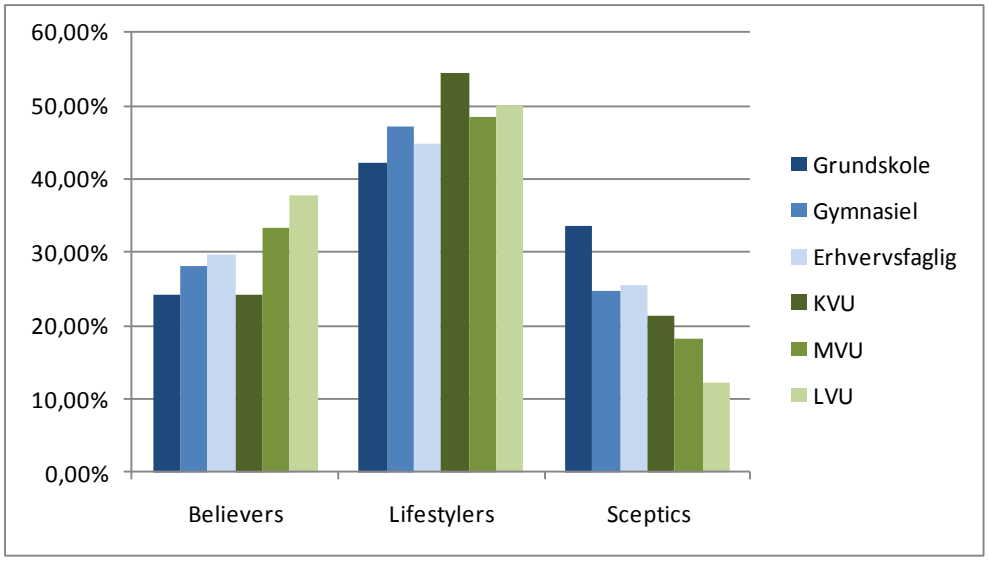
Sceptics are on average much older than both Believers and Lifestylers.

Figure 7-3 Clusters by gender and geography



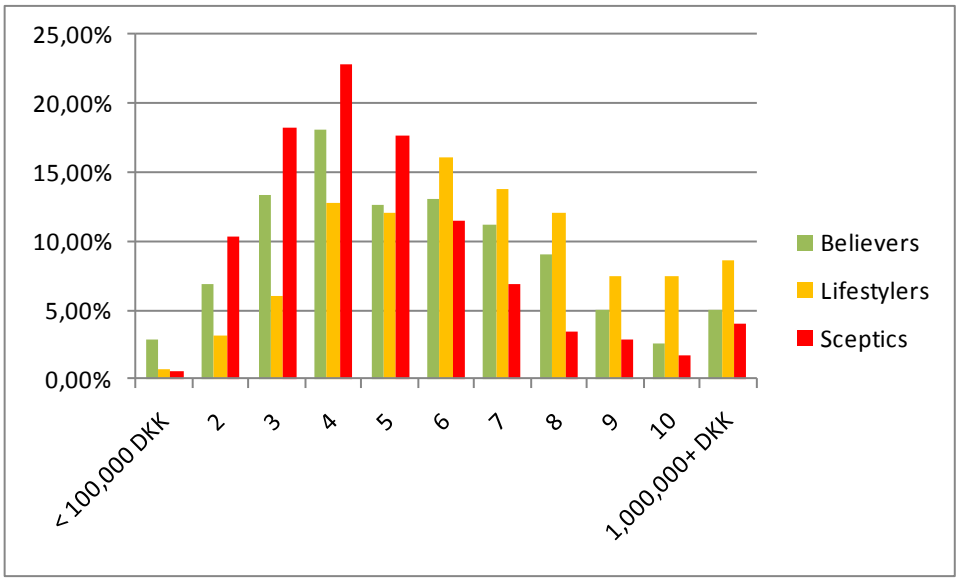
The figures above show the distribution of the clusters by gender and geography. On these two parameters, the distribution of Believers and Lifestylers is sufficiently close to the overall distribution of the survey sample to be statistically indistinguishable. Sceptics on the other hand have a significantly different distribution. Men from western Denmark are much more likely to be sceptics.

Figure 7-4 Clusters by education



The frequency of Believers is higher among respondents with higher educational levels and vice versa for sceptics.

Figure 7-5 Clusters by income



Lifestylers and Believers tend to have higher incomes on average.

7.3 Conclusion

Clustering the survey sample by their attitude towards the environment and climate was possible and has provided some interesting results. The process of clustering the respondents also revealed how important the wording of questionnaires can be and how difficult it is to anticipate the respondents' interpretation of the questions. Likewise the process has shown how difficult it can be to categorize and label a population that by nature has a continuum of different attitudes, preferences and backgrounds.

We found three statistically significant clusters:

- **Believers:** Pro climate but within reason and with an eye to practicality.
- **Lifestylers:** Pro climate but their lifestyle takes precedence, e.g. cars, food
- **Sceptics:** Not decidedly negative towards the climate, but not pro climate either

In general, better educated young women with higher incomes from eastern Denmark are most likely to be Believers. This merely confirms what other studies have found and the general consensus, but the results have been found using statistical methods and are statistically significant.

These clusters will be tested for their ability to explain willingness to pay in the Stated Preferences section in later sections.

8 Stated preference results

This section presents the main results from the stated preference part of the survey.

8.1 Parameter estimates

This subsection shows the main results of the estimation of the simple model estimated as a conditional logit model.

Table 8-1 Parameter estimates from main model, conditional logit.

	Parameter estimate	t-Value
Parameter values		
Savings (%)	0.8223	6.1
Cost (%)	-1.7673	-9.7
Savings, dummy	0.2991	4.3
Option to avoid lower temperature	0.2763	6.8
Info panel	0.1070	3.1
Green energy	0.3167	18.4
Temperature variation 1 degree	0.0645	1.0
Temperature variation 2 degree	0.0589	0.9
Temperature variation 3 degree	-0.3760	-5.2
Temperature variation 4 degree	-0.7114	-10.2
Temperature variation 5 degree	-0.8385	-12.3

Conditional (fixed-effects) logistic regression model fit

- Number of obs = 16830
- LR chi2(13) = 2092
- Prob > chi2 = 0.0000
- Log likelihood = -5116
- Pseudo R2 = 0.17

The following table gives the results from the more advanced mixed logit model with panel specification. As can be seen, parameter estimates are estimated at a high level of significance. This is mainly due to a very large number of respondents in the survey. Furthermore, respondents seem able to reply meaningfully to questions.

Table 8-2 Parameter estimates from main model, mixed logit.

	Parameter estimate	t-Value
Parameter values		
Savings (%)	1.0048	6.5
Cost (%)	-1.6854	-8.4
Savings, dummy	0.4134	5.2
Option to avoid lower temperature	0.3177	7.1

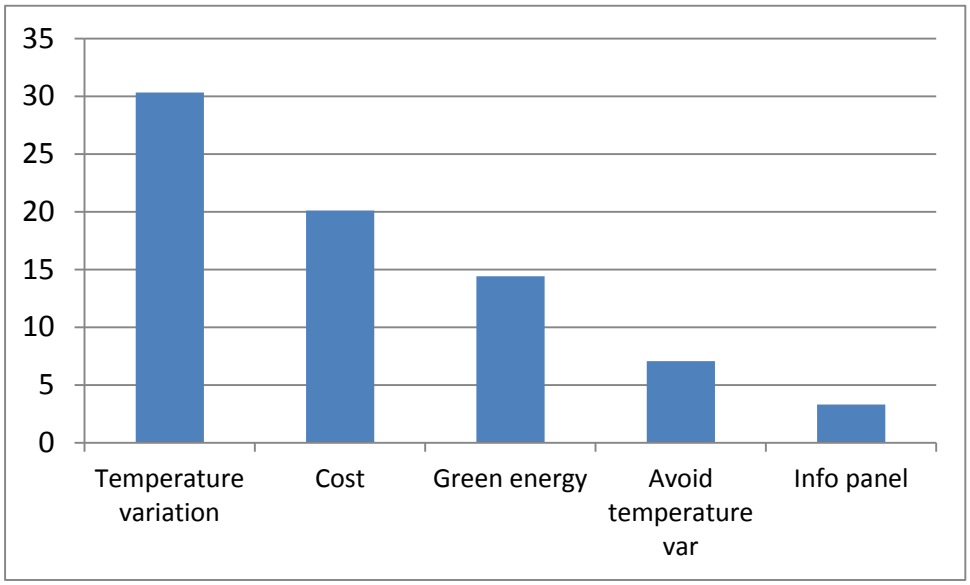
Info panel	0.1355	3.3
Green energy	0.4071	14.4
Temperature variation 1 degree	-0.0148	-0.2
Temperature variation 2 degree	0.0494	0.7
Temperature variation 3 degree	-0.4277	-5.4
Temperature variation 4 degree	-0.8940	-11.0
Temperature variation 5 degree	-1.1654	-13.1
Standard errors		
Green energy	0.5611	17.0
Temperature variation 1 degree	-0.7343	-6.3
Temperature variation 2 degree	-0.0565	-0.3
Temperature variation 3 degree	0.0453	0.3
Temperature variation 4 degree	-0.1216	-0.3
Temperature variation 5 degree	0.9762	10.1

Mixed logit model fit

- Number of obs = 16830
- LR chi2(6) = 271.86
- Log likelihood = -4981
- Prob > chi2 = 0.0000

There are large variations in the size of the t-values. The t-values give a measure of how much the respondents have taken this issue into consideration when choosing between different alternatives. If the respondent did not care about green energy, the t-value for this attribute would have been zero. The chart below summarises the t-values and this way gives some indication as to how important the different attributes are to the respondent when choosing between alternatives.

Figure 8-1 T-values summary



The most important attribute in the survey is clearly the temperature variations. Most important to the respondents is high temperature variation of 3 degrees or more. Second most important is the cost of the heating system.

At the other end we see that the information panel has only limited importance to the respondents.

8.2 Willingness to pay

In principle, all parameter estimates are calculated in terms of how much the single component, "i", contributes with compared to one unit of each attribute

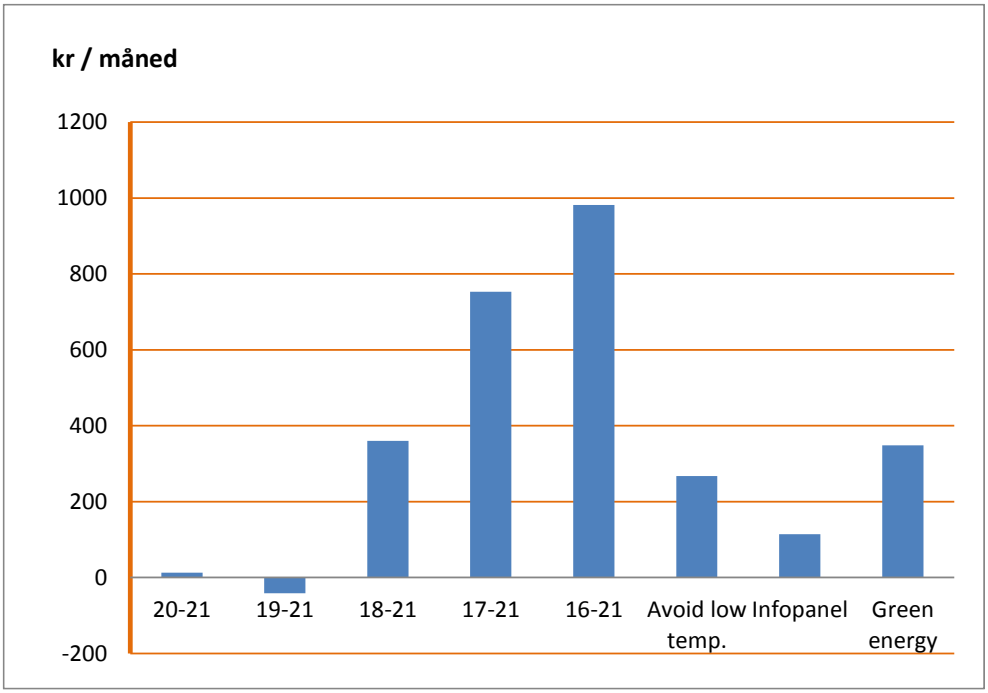
$$\delta U / \delta \beta_i$$

When dividing two parameter estimates Utility disappears, and what is left is a measure of how the respondents weigh one attribute against the other. When dividing by price estimate, the result is willingness to pay measured as DKK per one unit of the attribute.

$$Betalingsvilje(\beta_1) = \frac{\frac{\delta U}{\delta \beta_1}}{\frac{\delta U}{\delta P}} = \frac{\delta P}{\delta \beta_1}$$

The figure below shows the model results calculated as willingness to pay.

Figure 8-2 Willingness to pay, DKK per month



There is a very high willingness to pay to avoid large temperature variations. This seems reasonable, since such high temperature variations would almost be the same at not having a heating system at all.

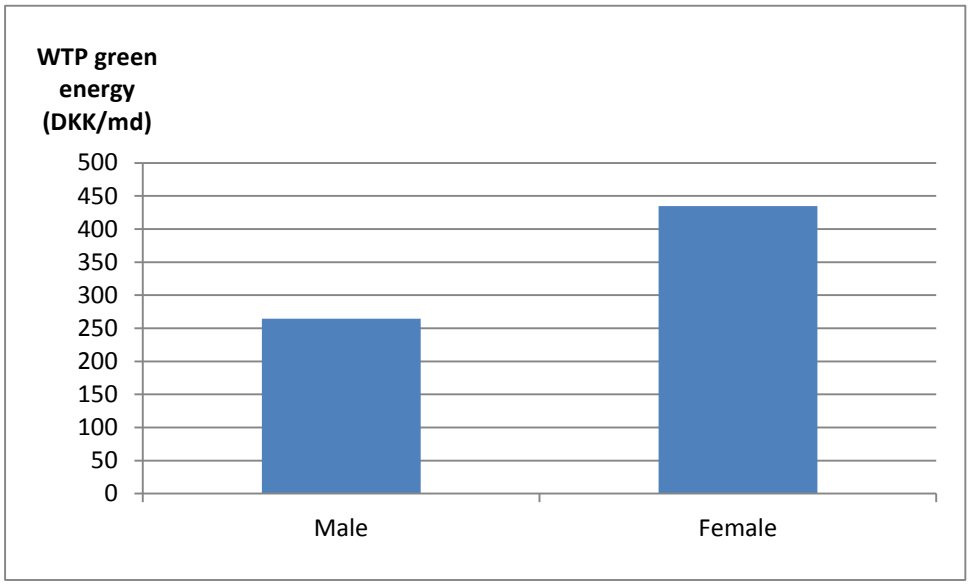
On the other hand there is no willingness to pay to avoid small temperature variations. Thus according to respondents' answers they would accept a variation with temperature drops of up to 2 degrees without compensation.

8.3 Differences by socioeconomics

8.3.1 Sex

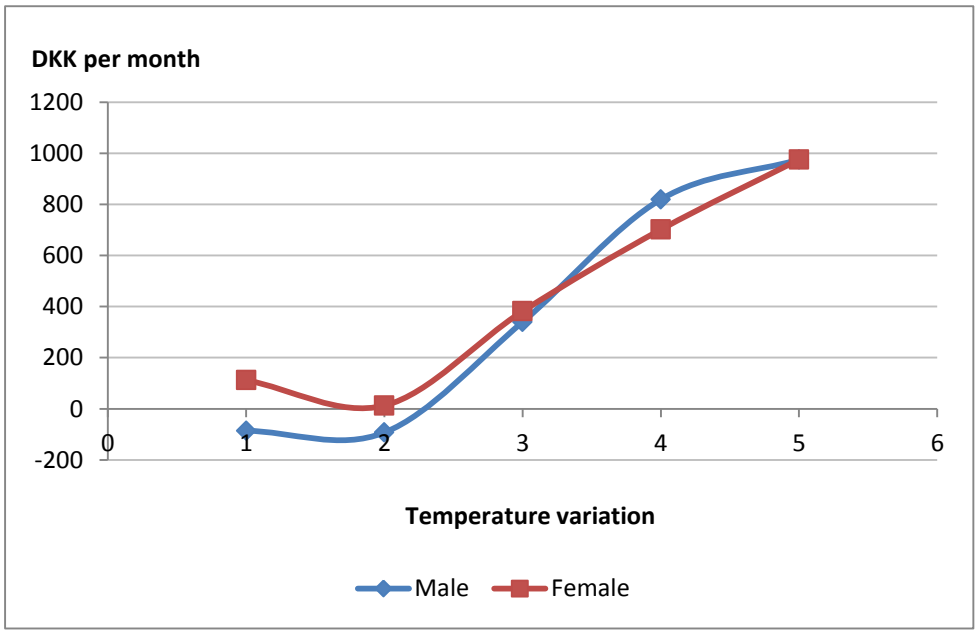
As can be seen from the parameter estimates and willingness to pay below, female respondents seem to have more preferences for green energy compared to men.

Figure 8-3 Willingness to pay for green energy



However, this difference is not reflected in the willingness to pay for temperature variations. In this respect there is no significant difference.

Figure 8-4 Willingness to pay to avoid temperature variations



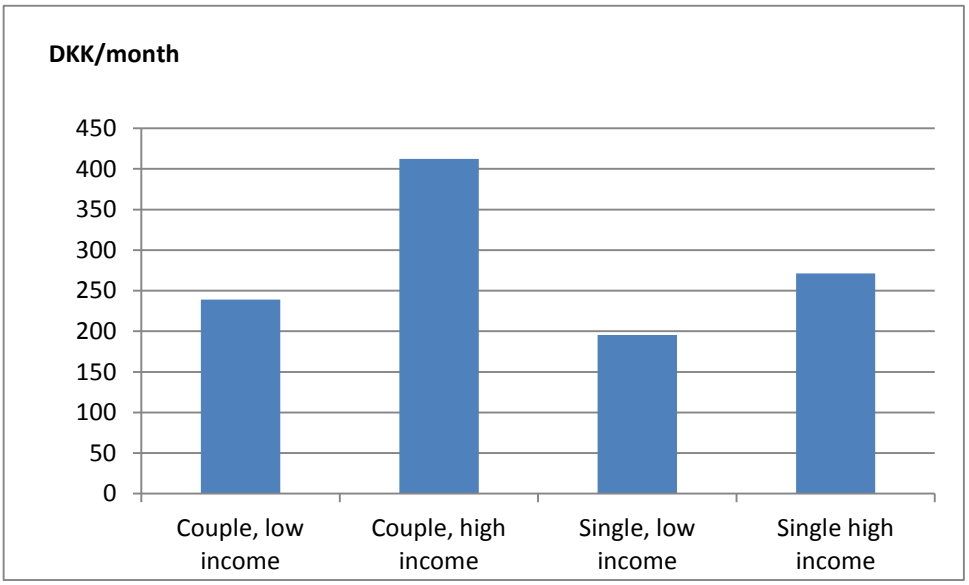
Thus, although female respondents do care more for the environment compared to male respondents, they are not willing to freeze to help the environment.

8.3.2 Income

The willingness to pay for green energy increases with income. The chart below shows the willingness to pay for green energy grouped according to income.

As can be seen, there is a tendency that high-income groups have a higher willingness to pay for green energy.

Figure 8-5 Willingness to pay for green energy



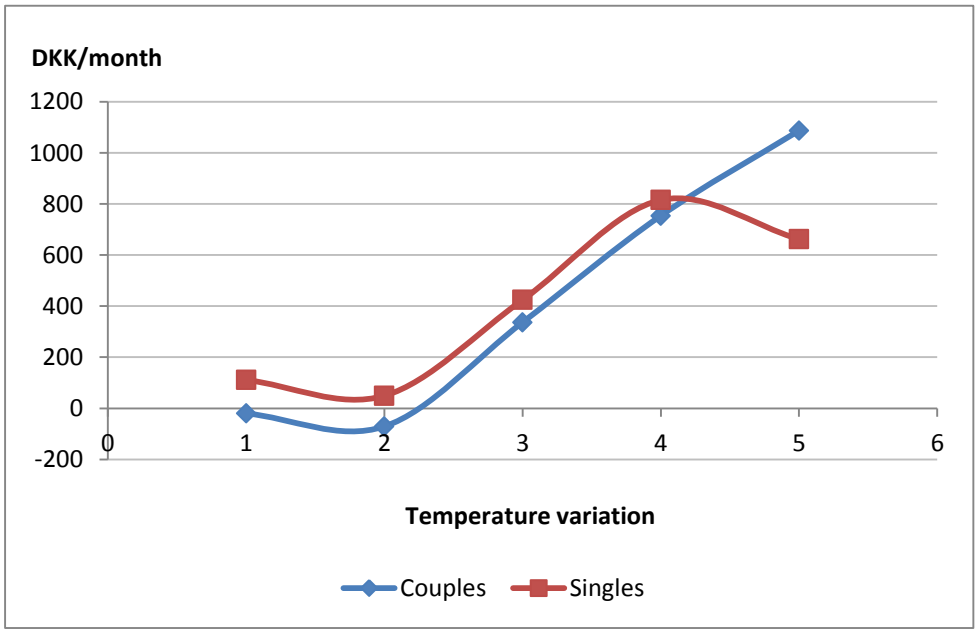
Willingness to pay is a product of price elasticity and the preferences. It is a general finding also in other studies that high-income groups have lower price elasticity. This is also the case in this study. This fact would lead to higher willingness to pay in general.

However, on top of that, model estimations also reveal that higher income groups have higher preferences for green energy.

8.3.3 Family type

Preferences for temperature variation differ between family types. Single type families do have significant lower willingness to pay for large temperature variations compared to couples.

Figure 8-6 Willingness to pay to avoid temperature variations

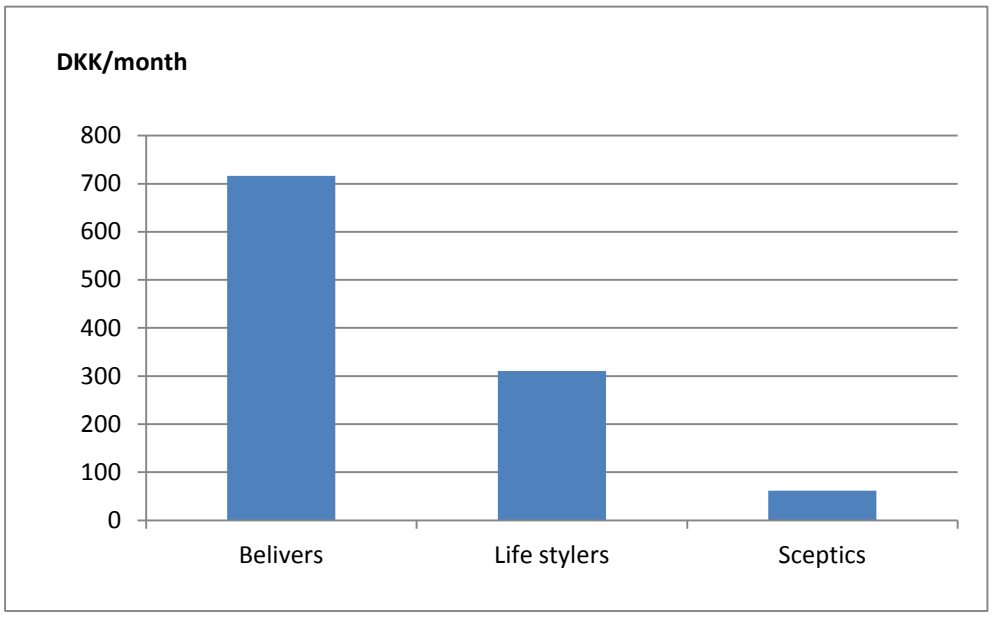


The reason is unclear, but it is possible that large temperature reductions are perceived as more bothersome when more people in the household are affected. It may also be that the respondent takes his or her partner's preferences into account when answering the questionnaire. When two people are affected there is a higher probability that one of them dislike cold temperatures.

8.3.4 Environmental attitude

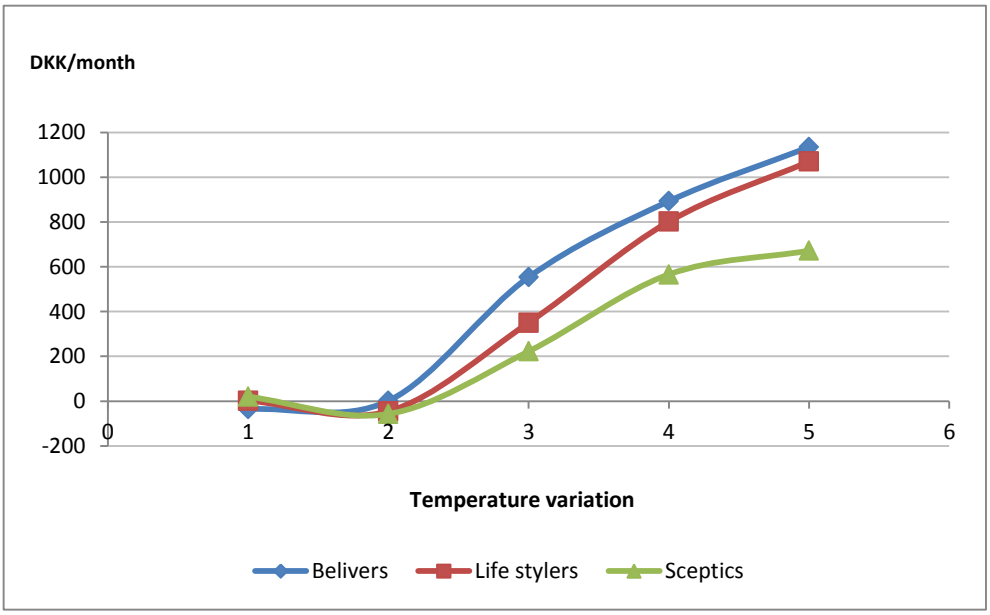
Looking at attitudes towards the environment there are some differences between the three groups. Most importantly, the environmentally friendly Believers have proved to have a significantly higher willingness to pay for green energy.

Figure 8-7 Willingness to pay for green energy



On the other hand, it has proven difficult to separate the three segments based on socioeconomics. Therefore, it would be difficult to target campaigns against the individual segments.

Figure 8-8 Willingness to pay to avoid temperature variations



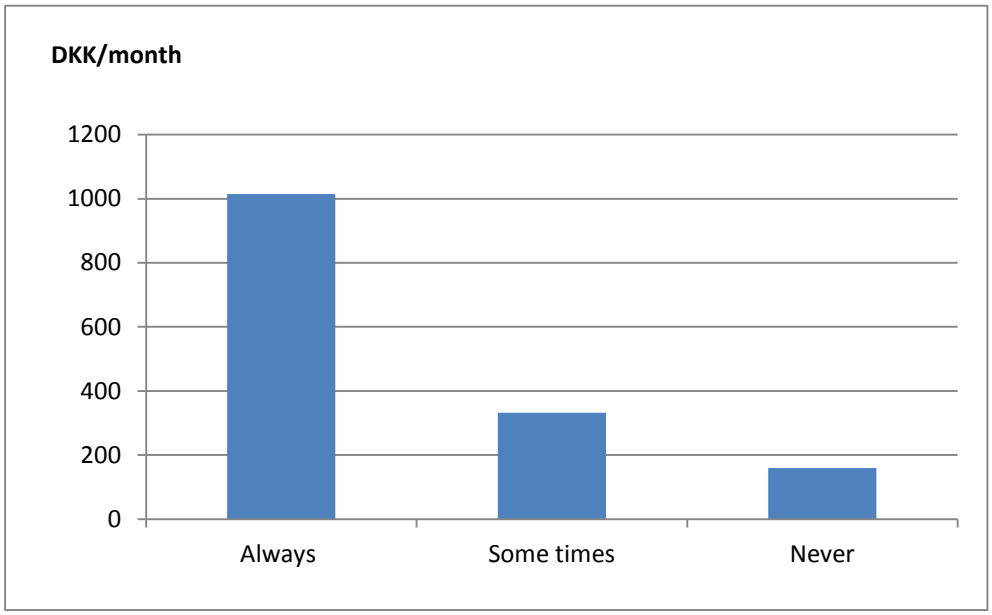
As mentioned already, the environmentally friendly Believers have proved to have a significantly higher willingness to pay for green energy compared to the other two segments. That does not mean that they will sit at home and freeze to help the environment.

The Sceptics have very much the same preferences for temperature fluctuations as the other segments. But their willingness to pay is lower, so they are less willing to pay to avoid temperature fluctuations compared to the other segments.

8.4 Environmental behaviour

We have used the frequency that respondents buy organic food as an indicator for environmental behaviour. People who always buy organic food would be willing to pay significantly more for green energy compared to other segments. This is perfectly in line with what one would expect.

Figure 8-9 Willingness to pay for green energy

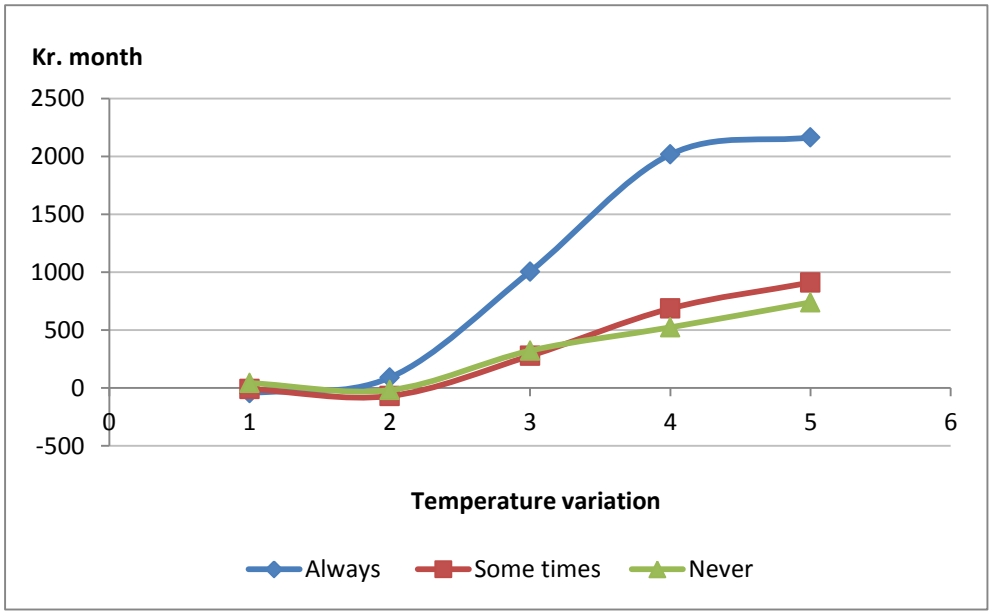


The high willingness to pay for green energy is the result of two factors:

- First of all, this segment is willing to pay more to get exactly what they want. This is also seen in the preferences for temperature variations, where they are willing to pay more to get the temperature they want.

- Secondly, this segment in general has a higher willingness to pay. Thereby increasing the impact of the first factor. This is also illustrated in the temperature preferences for this group which reveal a much higher willingness to pay to avoid temperature variations compared to the other segments.

Figure 8-10 Willingness to pay to avoid temperature variations



9 References

Hole (2008) Estimating mixed logit models using maximum simulated likelihood. The Stata Journal.

Appendix A Estimation method

The standard estimation of the stated preference (SP) data can be described as follows:

We assume that consumers choose alternatives with highest utility. The utility consists of a systematic part related to the characteristics plus an unobserved part ε.

$$U_i = V_i + \varepsilon_i$$

The systematic part may be written as

$$V_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

Assuming utility maximisation and independence of irrelevant alternatives, we can assume to have a logit density function.

In this case, we can estimate the n'th respondent's probability for an alternative 'i' in question t, by the following formula:

$$P_{nit}(\beta_n) = \frac{\exp(\beta_n x_{nit})}{\sum_j \exp(\beta_n x_{njt})}$$

The above simple fixed effect logit model has been applied in the initial estimations.

Final estimations have been based on a more advanced logit model allowing for unobserved heterogeneity and panel specification.

The probability of the observed sequence of choices conditional of knowing β^n is given by:

$$S_n(\beta_n) = \prod_t L_{ni(n,t)t}(\beta_n)$$

Where i(n,t) denotes the alternative chosen by individual 'n' on choice occasion t.

The unconditional probability of the observed sequence of choices is the conditional probability integrated over the distribution of β:

$$P_n(\theta) = \int S_n(\beta) f(\beta` | \theta) d\beta$$

The unconditional probability is thus a weighted average of a product of logit formulas evaluated at different values of β, with the weights given by the density f.

The mixed logit can be used to estimate a multinomial logit model with unobserved heterogeneity considered by Haan and Uhlendorff (2006).

The likelihood for the model is given by:

$$LL(\theta) = \sum_n \ln(P_n(\theta))$$

The simulated log likelihood is given by:

$$SLL(\theta) = \sum_n \ln\left[\frac{1}{R}\sum_{r=1}^{R} S_n(\beta^r)\right]$$

Where R is the number of replications and β^r is the r-th draw from the f(β|θ).

The final estimations have been based on the above formulation. Estimations have been made by STATA based on a programme file developed by Arne Rise Hole (Hole (2008)).

Appendix B Questionnaire

This questionnaire survey concerns the heating of your home.

It does not concern how warm you would like your home to be, but rather what heat fluctuations one would be able to live with.

It is entirely individual what temperature people find comfortable. According to the Danish Working Environment Service a temperature of 20-22 °C is suitable for light physical activities e.g. in schools, day-care institutions and in offices. The temperature for sedentary work and for normal climate and working conditions must not exceed 25 °C.

Temperature scale:

- 28 degrees: Heatwave
- 20 - 22 degrees: Room temperature
- 10 - 12 degrees: Cellar temperature
- 5 degrees: Refrigerator

First, some preliminary questions about heating in your home:

Q17.
How do you live? (Choose one)
1. Detached house or terraced house
2. Summer house
3. Apartment
4. Farmhouse
5. Other –Please describe

Q17NEW.
How do you live? (Choose one)
1. Single-family house / farmhouse
2. Terraced house, linked house or two-family house
3. Apartment
4. Holiday house
5. Other – Please describe

Q16.
What type of home do you live in? (Choose one)
1. Owner-occupied home
2. Rented home
3. Co-operative home
4. Other – Please describe

Q1.
What size is your home? (Please enter heated floor space in m^2)

Q2.
What temperature do you normally have in your home, when you are at home? (Choose one)
1. 17 degrees
2. 18 degrees
3. 19 degrees
4. 20 degrees
5. 21 degrees
6. 22 degrees
7. 23 degrees
8. 24 degrees
9. 25 degrees

Q3.
What is the primary form of heating in your home? (Choose one)
01. Central heating with oil burner
02. Central heating with natural gas boiler
03. Central heating with solid fuel (wood briquettes or similar)
04. District heating
05. Electric heating
06. Heat pump (Dirt to water)
07. Heat pump (Air to water)
08. Heat pump (Air to air)
09. Fire place/wood burner
10. Other

Q4.
Do you use additional heating in your home? (Choose one)
1. Yes, electric heating
2. Yes, fire place/wood burner
3. Yes, solar heating
4. Yes, other
5. No

How old is your heating system?
Year

Q5.
What is your average heating consumption per month? (Please enter DKK per month)
Your annual consumption is calculated as #ANNCOST# DKK

Q6SP1.
The future heating of homes can be different from what we see today. This is due to more focus on efficient and climate-friendly heating.

In the future it is likely that in some periods heating will be more expensive or more environmentally unfriendly than in others. Furthermore, that the heating system will automatically shut down or lower the heating of your home, if - for shorter periods of time – it is particularly expensive or environmentally unfriendly.

You will notice this when the temperature in your home drops by a few degrees compared to your desired temperature.

Does your heating system have night-time setback function?
1. Yes
2. No
3. Don’t know

The following questions concerns future heating systems. Please refrain from reflecting on how your heating system works today. Instead, please imagine that the future heating system is more automatic/self-managing than what we know today.

The next section will focus on the following subjects:

Cost of heating your home. Both increase and decrease in monthly costs compared to present cost level could be the case.

Lower temperature. Please imagine that heating is controlled by a heating company. For shorter periods of time (one or two hours) a few times a week the temperature can be a few degrees colder than the temperature you have asked for.

* Please avoid lower temperature. By pressing a button you may avoid the temperature drop that would otherwise have been the case for the following six hours. The button can only be used a limited number of times per month.

* Information about consumption. On a small panel or on your computer you will be able to see your heating consumption. E.g. compared to same month previous year or total year-to-date consumption.

* Green energy for heating. The share of renewable energy or green energy used for heating of your home.

Please imagine that you have a choice of three heating options.

The options are fabricated, but we ask you nonetheless to consider them as real options. In particular this applies to costs or savings for heating and drops in temperature.

We ask you please to consider the three options carefully and then to choose your preferred option.

SP question. In this section the respondent is presented with SP choices. These are not shown here.

Q6R How important were below issues to how you answered the previous question?

Q6R1.Savings DKK per month
Q6R2.Additional costs DKK per month
Q6R3.Temperature fluctuations when you are at home
Q6R4.Poissibility of manual operation
Q6R5.Info panel on consumption and savings
Q6R6.Percentage of green energy for heating

1 Extremely important
2
3 Some importance
4
5 Without importance

Q6X.
When answering the previous questions, you chose the most inexpensive alternatives every time. What is your primary explanations for this?

1. I cannot afford to pay more for heating
2.All payments were higher than what I find the altered service to be worth
3. I cannot imagine paying more
4. Temperature fluctuations and energy consumption are not important to me
5. I didn't know what else to choose
6. Other – Please describe
Please state other explanations, if any.

Q6XC.
When answering the previous questions, you chose the most green alternatives every time. What is your primary explanations for this?

Q6Y.
What are the two most important aspects for you if you were to contribute to a more efficient and climate-friendly heating method? (choose two)

Please, tick off the two most important statements
1. That other households also contribute to more climate-friendly heating
2. That there is financial gain
3. That other countries also contribute to climate-friendly solutions
4. That it is not too difficult in everyday life
5. That I am kept informed about my climate contribution
6. Other – Please describe

Please state to what extent you agree with the following statements:
Q6AR1.I regularly check my heating consumption and compare it to that of previous months
Q6AR3.I leave adjustment of my heating system to someone who knows something about it
Q6AR4. I am aware of how much electricity, water or heat we use in my household for different things
Q6AR5. I prefer to pay so that my heating system automatically operates as efficiently as possible
Q6AR6. I have checked the price of a new heating system

Please state to what extent you agree with the following statements:
Q6BR1. I am not interested in the climate debate
Q6BR2. Energy savings is not about the climate, but rather about not being dependant on coal, oil or natural gas
Q6BR3. I will only conserve energy if it means reduced costs
Q6BR4. It is important to me that other people (neighbours and colleagues) see me as environmentally conscious
Q6BR5. I do not believe that here is a connection between my energy consumption and the effect on the climate
Q6BR6. Even though the Danish energy consumption is small on a global scale, it is important that we are front-runners in the efforts to reduce emission of climate gases.

Q6E.
How often do you buy organic foods?

Q6C.
What kind of car do you have?
1. Petrol
2. Diesel
3. Battery-driven
4. I don’t have a car

How far can your car go on a litre? km/l

Q6F.
How often do you take your car to work?

Always						Never
❒	❒	❒	❒	❒	❒	❒

Q7.
when were you born? (Write year)

Q8.
Are you… (Choose one)
1. Married or cohabitant
2. Single
3. Other

Q9.
In which local authority do you live? (Choose local authority)

Q10.
What is your gender? (Choose one)
1. Female
2. Male

Q11.
What is your highest education level? (Choose one)
1. Basic school (primary or lower secondary education)
2. Vocational training (e.g. Administrative assistant, craftsman training)
3. Upper secondary school, Higher Preparatory Examination Course, Higher technical examination or similar
4. Short-term further education (op to 2 years)
5. Higher education (2 to 4½ years)
6. Long-cycle higher education (5 years or more)
7. Other – Please describe

Q12.
How is your connection with the labour market? (Choose one)
01. Employed within the local government
02. Employed within the public sector in general
03. Private employment

04. Self-employed
05. Student, trainee or apprentice
06. Unemployed
07. On job release scheme or retired
08. On disability retirement or on rehabilitation
09. Non-working (self-supporting or on leave of absence)
10. Other – Please describe

Q13.
How many hours per week do you work on an average? (Choose one)
1. Less than 20 hours
2. 20 - 29 hours
3. 30 - 37 hours
4. Over 37 hours
5. Not relevant

Q14.
What is the total, annual household income pre-tax (husstandsindkomst)? (Choose one)
01. Less than 100,000
02. 100,000-199,999
03. 200,000-299,999
04. 300,000-399,999
05. 400,000-499,999
06. 500,000-599,999
07. 600,000-699,999
08. 700,000-799,999
09. 800,000-899,999
10. 900,000-999,999
11. 1,000,000 or more
12. Prefer not to disclose
13. Don’t know

Q15.
How will you describe the area where you live? (Choose one)
1. Rural area
2. Town with between 200 and 1,000 inhabitants
3. Town with between 1,000 and 5.000 inhabitants
4. Town with between 5,000 and 30.000 inhabitants
5. Town with between 30,000 and 100.000 inhabitants
6. City with more than 100,000 inhabitants
7. Other – Please describe

Q18.
Please write any comments you may have to the previous questions.