

Low energy residences and their users

Predicted energy use vs. actual energy use

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Anne Cowan (1502492)
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Mentors

Dr. Ir. Martin Tenpierik
Ir. Siebe Broersma

“There’s no map to human behaviour”

Björk

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MSc Architecture, Urbanism and Building Sciences

Building Technology, Sustainable Design Studio

STUDENT

Anne Cowan
anne@annecowan.com

MENTORS

Dr. Ir. M.J. (Martin) Tenpierik

Ir. S. (Siebe) Broersma

EXTERNAL EXAMINER

Ir. E.J. van der Zaag



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ABSTRACT

Introduction

In the framework of the European Directive on Energy Performance of Buildings Directive (EPBD) energy labels are provided based on energy performance assessment methods, for both existing buildings and for new construction. For new construction in the Netherlands is affiliated with the Energy Performance Coefficient (EPC) will be used (NEN 7120+C2).

The developments in technology and regulations continue. Because of the social importance of reducing CO2 emissions and energy consumption, the government has gradually reinforced the energy performance requirements over the last few years. The limit to the EPC for housing in new construction has now dropped to 0.6. The experience with the standardization of the energy performance assessment (EPN) and with the application of new technologies is increasing. There are now experiments with buildings with an EPC values far below the current limit values.
The government proposed to further reduce the EPC by 2015 to 0.4.
Next step will be reaching a target of EPC=0 by the year 2020 (AgentschapNL, 2012a).

User experiences of recent years have shown that the actual energy use of homes with a particular EPC often do not correspond to the predicted energy use.
The factors explaining the difference between the actual and predicted use can briefly be described as:

- Technology – different than the predicted performance of the technical aspects of the house, such as the shell of the building and the applied systems (building performance)
- Socio-demographic factors – influence of household features
- Behaviour - influence of the behaviour of residents
- Weather conditions – Different weather conditions can lead to different performance. In calculations only a reference weather condition is taken into account.

The current literature is lacking in research that investigates houses with an EPC <0.4.
The main research questions of this study are:

1) What is the share of user behaviour in the difference between the predicted and actual energy use in low energy residences with an EPC<0,4?
2) And how can the variance in energy use in identical residences be explained?

For answering the first part of the main research question the following sub questions will be answered:

- What is the difference in the predicted and actual energy use?
- What is the relation between the calculated EPC for the building permission and the energy use of the realised residence.
- Which technical causes can explain the difference between the predicted and the actual energy use?
- What is the share of technical factors in the actual energy use?
- What is the share of the type of household in the actual energy use?
- What is the share of user behaviour in the difference of the predicted and actual energy use?
- What kind of behaviour can be found in the residences?

For answering the second part of the main research question the following sub questions will be answered:

- What is the share of technical factors in the actual energy use?
- What is the share of the type of household in the actual energy use?
- What kind of behaviour can be found in the residences?
- How large is the variance of the energy use of the identical residences?
- What are the explanatory factors behind this variance?

Method

The study includes two methods, user survey data and monitoring. First part of the study will be composing the user survey and collecting the user survey data. The collected survey data will be used for statistical analysis. The statistical analysis will include bivariate and partial correlation tests, to reveal which behavioural variables influence energy use.
Second part of this study will be focussed on selecting the appropriate houses for monitoring houses, installing monitoring equipment and collecting and analysing the monitoring data.
The houses that are investigated in this research are located in Almere-Poort, in a new developed district called Columbuskwartier.
After the selection process based on the survey results, the two most desirable houses are available for further research. I will execute measurements in these houses for several weeks to monitor physical conditions, energy use and behaviour of the users using a longitudinal questionnaire filled in by the occupants. I will analyse the data obtained in order to determine the most influential factor in the difference in predicted and actual energy use.
The conclusions that will be drawn from the analyses will be used to formulate conceptual design solutions that can be used by architects as a guideline to design low energy houses which are resistand the the effect of the dynamic nature of occupant behaviour.

Results

Literature
Uitzinger (2004) studied the relation between energy use and EPC commissioned by the Dutch Government. Figure 1 The study reveals that energy use decreases with a lower EPC, but that there is a significant variance in the energy use.
To reach a low EPC in general means that the building needs to have a good energetic quality. For this reason, the share of the technical performance of a building in the variance decreases. Other variables like household characteristics and occupant behaviour become more dominant in the explanation of this variance.

Based on literature into occupant behaviour and the factors of influence on this behaviour, a list of psychological factors is composed:

- Knowledge
    - *General knowledge*
    - *Specific knowledge*
- Motivation
    - *Goal-based*
        - *Hedonic goals*
        - *Normative goals*
        - *Gain goals*
    - *Needs-based*
        - *Thermal comfort*
        - *Ventilation comfort*
- Attitude
- Awareness

These underlying interrelated mechanisms result in specific occupant behaviour. In the total spectrum, the list of types of behaviours is endless. Framing behaviour for this study, we can make the following list of occupant behaviour:

- Habitual behaviour
    - *Heating behaviour (thermostat set-points)*
    - *Ventilation behaviour (closing and opening of windows for fresh air)*
- Incidental behaviour
    - *Purchase behaviour (purchase appliances, energy saving lighting)*

Survey results
The collected data from the user survey in Columbuswartier, with a response rate of 15 occupants, showed that the average actual heat use is 9% higher than the predicted heat use following from the EPC calculation of 12.7 GJ (based on EPN calculation by Mobius Consultancy).
54% of the occupants have a higher heat usage than the predicted.
In comparison with the PHPP results, the actual energy use is 52% higher than predicted with 62% of the respondents using more energy than the predicted 9.1 GJ (Based on data retrieved from Cauberg-Huygen).
Besides, it can be concluded that there is a big difference in energy usage among occupants. The difference between the lowest and the highest user

is 20.2 GJ and the standard deviation of all respondents is 6.3 GJ from the measured average actual heat usage of 13.8 GJ.

After making thermographic pictures and analysis of these pictures, the houses don't show any flaws in the technical performance considering the insulation performance of the building skin. The building skin showed its good insulating properties without any significant heat leakages. Based on this information this study didn't find technical factors that can explain the difference between the predicted and actual energy use or the variance in the individual energy use among the occupants.

Bivariate correlations tests revealed that the household characteristic household size is positively correlated with the electricity and total energy use, so a bigger household size results in higher electricity and energy use. This study didn't find other correlated household characteristics with energy use.

Concerning the behavioural factors, bivariate correlation tests showed that the following variables correlate with (or are likely to have a relation with) with energy use:

- Specific knowledge
- Motivation
- Awareness
- Attitude
- Influence previous building type

The results of the statistical analyses neither give an answer to the actual share of the user behaviour in the difference in the predicted and actual energy use nor in the extent to which they explain the variance in energy use among identical passive houses, mainly because of the small sample size.

Monitoring

The monitoring results are in accordance with the conclusions drawn from the statistical analyses. Concerning the electricity use the monitoring gave a more detailed view on the electricity use distribution in the houses. The previous found relations between behavioural factors and electricity use have been confirmed.

Concerning heat use, the results have been a little less satisfying due to the lack of radiator use in the monitoring period. The results did give insight into the indoor thermal conditions of the separate rooms, which are compared with the natural ventilation behaviour and presence of the occupants, and that a lot of natural ventilation causes a lower temperature with more fluctuations.

The monitoring results also didn't find a relation between the thermal preference of the occupants and the amount of natural ventilation. The assumption is made that occupants execute this behaviour for different reasons than from a thermal perspective. This specifically means that as a designer it is not possible to control or manipulate this behaviour, but it should be taken as given, in order to work with this knowledge and not work around it.

Design solutions

Focussing on design solutions for this typical Dutch terraced housing case study, there are a few design principles that need to be taken into account when integrating the results from this study. The given solutions will give residences a more robust character, meaning that the dynamic character of the building occupant has less effect on the energy usage.

It is important to understand the dynamic behaviour of occupants and see this as a given fact, instead of designing for a 'typical' and standardized occupant. This change of mind set is of importance if we keep using EPC or PHPP energy predictions as an indication tool for reducing the national residential energy demand. These prediction methods will develop over the years and probably become more accurate, but will always express an average energy usage for the designed houses.

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1. INTRODUCTION

1.1 Background

In the framework of the European Directive on Energy Performance of Buildings Directive (EPBD) energy labels are provided based on energy performance assessment methods, for both existing buildings and for new construction. For new construction the Netherlands is affiliated with the Energy Performance Coefficient (EPC) described in NEN 7120+C2.

The developments in technology and regulations continue. Because of the social importance of reducing CO2 emissions and energy consumption, the government has gradually reinforced the energy performance requirements over the last few years. The limit to the EPC for housing in new construction has now dropped to 0.6. The experience with the standardization of the energy performance assessment (EPN) and with the application of new technologies is increasing. There are now experiments with buildings with an EPC values far below the current limit values.
The government proposed to further reduce the EPC by 2015 to 0.4:

"*Since January 1, 2011, an EPC of 0.6. is required for housing, a reduction of 25% compared to 2007. From Januari 1, 2015 the Ministerie van Buitenlandse Zaken en Koninkrijksrelaties intends to oblige an EPC of 0.4 on housing. This is one of the most important events of the Lenta-akkoord 'Energieprestatie en Nieuwbouw' ('Energy Performance and New Construction'), from 2008, with the Energy Performance Coefficient (EPC) as prime measure*." (AgentschapNL, 2012a).

Next step will be reaching a target of EPC=0 by the year 2020.

1.2 Thesis

1.2.1 Problem Statement

User experiences of recent years have shown that the actual energy use of houses with a particular EPC often do not correspond to the predicted energy use.
Over the last few years, several studies have been done to explain this phenomenon and to optimize the performance of housing.
The factors explaining the difference between the actual and predicted use can briefly be described as:

- Technology – different than the predicted performance of the technical aspects of the house, such as the shell of the building and the applied systems (building performance)
- Socio-demographic factors – influence of household features
- Behaviour - influence of the behaviour of occupants
- Weather conditions – Different weather conditions can lead to different performance. In calculations only a reference weather condition is taken into account.

The point of the technical performance aspects can be viewed from two sides:
Design stage – no accurate simulation of applied techniques.
Execution - poor execution and detailing can lead to a disappointing performance. Or changes in construction methods by the contractors lead to different performance.

The four points together are responsible for the difference in predicted use and actual use.
In older housing, the share of the technical factors in this difference is by far the largest. However, in newer housing with lower EPC, the influence of the occupant has a greater share in this difference. This will be explained based on literature further in this study.

Where the performance of housing is relatively easy to measure, examining the influence of user behaviour is a more complex issue. Surveys and logs maintained by the residents must be connected to the measurements to find links between the different variables.

Problem definition

The predicted energy use deviates from the actual energy use in low-energy residences, and houses with an identical EPC show a significant variance in energy use.

1.2.2 Objective / Goal

The goal of my research is twofold:
The first goal is to find an explanation for the variation in the energy use in identical residences with an EPC <0.4 and to get insight in the difference between the predicted and actual energy use.
Besides that, based on data obtained from the analysis, I also want to look at the opportunities for design solutions to optimize the current building methods on technical and user level.
Depending on the information found, I want to see if there are decisions to make about the robustness of housing with an EPC <0.4, which might lead to design solutions for architects.

To take future steps in regard to reducing energy consumption and enhancing the EPC of houses, first we will have to understand the performance of the current realized projects and find the opportunities to optimize.

1.2.3 Research question

The current literature is lacking in research that investigates houses with an EPC <0.4.
Due to limited time for my graduation, I will not be able to give a statistically substantiated answer to the question of what is the cause of the variance in the energy consumption of housing with an EPC <0.4.
To find this cause, a prolonged research on a larger scale using monitoring and questionnaires needs to be done. What I *can* do at this moment is conduct an in-depth research with a smaller test group on the factors explaining the difference between predicted and actual energy consumption and draw a preliminary conclusion on the cause of the variation in energy use in identical low-energy housing.

Main research questions

1) What is the share of user behaviour in the difference between the predicted and actual energy use in low energy residences with an EPC<0,4?

2) And how can the variance in energy use in identical residences be explained?

Sub questions

For answering the first part of the main research question the following sub questions will be answered:

- What is the difference in the predicted and actual energy use?
- What is the relation between the calculated EPC for the building permission and the energy use of the realised residence.
- Which technical causes can explain the difference between the predicted and the actual energy use?
- What is the share of technical factors in the actual energy use?
- What is the share of the type of household in the actual energy use?
- What is the share of user behaviour in the difference of the predicted and actual energy use?
- What kind of behaviour can be found in the residences?

For answering the second part of the main research question the following sub questions will be answered:

- What is the share of technical factors in the actual energy use?
- What is the share of the type of household in the actual energy use?
- What kind of behaviour can be found in the residences?
- How large is the variance of the energy use of the identical residences?
- What are the explanatory factors behind this variance?

1.2.4 Method

I will examine two houses with an EPC <0.4 and determine the difference between the actual and the predicted energy use.
For this I will compare two identical houses with two different types of users so I can relate building performance and user behaviour to one another.
Preferably the two different occupants are of the same type of household, so I can specifically examine user behaviour (separate from household features).

The study includes two methods, user survey data and monitoring. First part of the study will be composing the user survey and collecting the user survey data.
The collected survey data will be used for statistical analysis. For this reason, the aim is to get as many respondents as possible to provide a sufficient sample size, with a preferable sample size of at least 20 respondents (which is about 25% of the total population). The statistical analysis will include bivariate and partial correlation tests, to reveal which behavioural variables influence energy use.
Second part of this study will be focussed on selecting the appropriate houses for monitoring, installing monitoring equipment and collecting and analysing the monitoring data.
After the selection process based on the survey results, the two most desirable houses are available for further research. I will execute measurements in these houses for several weeks to monitor physical conditions, energy use and behaviour of the users by using a longitudinal questionnaire filled in by the occupants. Furthermore, I will analyse the data obtained in order to determine the most influential factor in the difference in predicted and actual energy use.

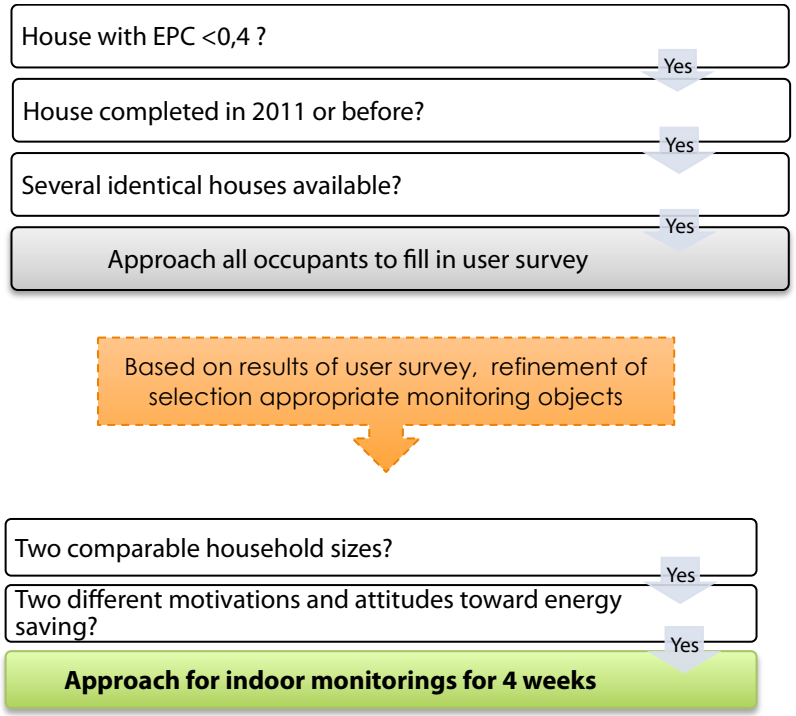
1.2.4.1 User survey

At the beginning of this research, 15 occupants filled in an extensive questionnaire. Based on the results of this questionnaire, the two most appropriate houses were selected and their occupants approached for cooperation for indoor monitoring.

The collected user surveys were also analysed in order to place the monitoring results of the two homes in a bigger perspective.
The survey data is also used to draw conclusions about the relationship between energy use and occupant behaviour.
Because the population of the survey is relatively small, I went door to door to introduce the research and ask for cooperation. The surveys could be filled in by the residents hardcopy or online (Collector).

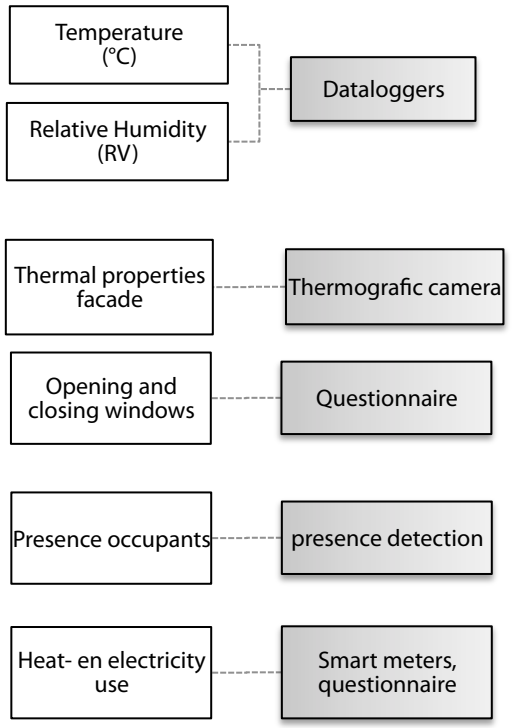
1.2.4.2 Selection process houses

In order to investigate the relationship between energy use (in houses with an EPC <0.4) and occupant behaviour, the selection of the two houses is a critical point.
The selection process reads in the following way



1.2.4.3 Measurements

The following parameters have been measured to determine the physical indoor conditions:



The detailed description of the used equipment will be discussed in section 7.3.1.

1.2.4.4 Measurement locations

The data loggers for indoor measurements have been installed on the following locations:

- living room and kitchen
- (main) bedroom
- (second) bedroom (opposite orientation of master bedroom)

1.2.4.5 Measurement periods

Due to the limited time available for this research, measurements should be as efficient as possible. The available time to measure during graduation runs from August to October 2013.
It is desirable to also take measurements during the 'heating' season. Therefore, the monitoring is executed in September and October 2013.

Thermographic pictures can best be taken when the difference in temperature between inside and outside is most extensive.
For this reason, the pictures are taking on 23 April 2013 on a cloudy and rainy day, with an outdoor air temperature of approximately 6 Celsius Degrees.

1.2.4.6 Daily log

To examine the influence of the type of household and user behaviour, an extensive questionnaire will be filled in by the occupants at the start of research. The occupants of the two monitored houses will also keep a daily log for seven days, that provides insight into:

- use of shower and/or bath
- presence of residents
- use of thermostat and/or radiator operation
- cooking behaviour
- use of hot water in kitchen
- use of washing machine, dryer and dishwasher
- use of lighting
- ventilation behaviour per departure
- heating behaviour per departure

The template of this daily log can be found in Appendix I.
This daily log is composed to get a complete as possible overview of the occupant behaviour. The specific questions are not able to collect by the monitoring equipment.

2. LITERATURE RESEARCH

2.1 Goals Europe

On January 2003, the European parliament introduced the Directive on the energy performance of buildings (EPBD) inspired by the Kyoto Protocol, which obliges industrialized countries to reduce emissions of greenhouse gasses.
The EPBD has been introduced in 2003, with the condition that all European Member States are obliged to implement the directive by 4 January 2006.
In order to meet the target of 20% energy efficiency by 2020 and preparations for future energy efficiency after 2020, the EPBD consists of a general framework of measures to promote energy efficiency in the European Union.
This means that all 28 EU countries are required to use energy more efficiently at all stages of the energy chain (European Commission, 2013b).

2.1.1 20-20-20

The Climate and Energy Package is a set of binding legislation, which aims to ensure the European Union meets its ambitious climate and energy targets for 2020.
These targets, known as the "20-20-20" targets, set three key objectives for 2020 (European Commission, 2013a):

- A 20% reduction in EU greenhouse gas emissions from 1990 levels;
- Raising the share of EU energy consumption produced from renewable resources to 20%;
- A 20% improvement in the EU's energy efficiency.

The targets were set by EU leaders in March 2007, when they committed Europe to become a highly energy-efficient, low carbon economy, and were enacted through the climate and energy package in 2009.

2.1.2 Built environment

The built environment contributes for 30% to the total energy consumption in the Netherlands and has therefore great potential to contribute to the European climate objectives (Ministerie van Binnenlandse zaken, 2011). With the European targets set, the Dutch government paid more attention to research and policies concerning this topic. One interesting policy subject to point out, is that the government also starts to recognize the importance of occupant influences on energy use.
The government commissioned several studies into occupant behaviour, in order to gain more knowledge about effective behavioural change programmes. Current interest goes to smart meters, price incentives and user-friendly designs that enable behavioural change (Ministerie van Binnenlandse zaken, 2011).
Besides occupant behaviour, the government also has set goals for the energetic quality of the existing and new building stock. An important policy tool that is used to value and assess buildings is the Energy Performance Standard for buildings (EPN). In order to receive a building permit, every building needs to have an EPC calculation.
A lower EPC means a more energy efficient building.

This calculation method is described in the Energy Performance Norm (EPN) NEN 7120 which since July 2012 replaced the older version NEN 5182. This method will be described in more detail later in this study.
The EPC requirement has been tightened over the past years and will continue to be tightened during the coming years (Table 1).

	EPC
1996	1.4
1998	1.2
2000	1.0
2006	0.8
2011	0.6
2015	0.4
2020	0

Table 1: EPC requirement

2.2 Variance in energy use

The EPC is not intended to use during the design stage of a building. The predicted energy use resulting form an EPC calculation gives an indication about the building-related energy use to value the energetic quality of a building. Because the tool is used as a policy tool to meet the new and future requirements for decreasing the energy use, Uitzinger (2004) investigated the relation between energy use and EPC.
Uitzinger (2004) studied this relationship commissioned by the Dutch Government. Figure 1 shows the variance in gas use as function of the EPC resulting from this study. It reveals that energy use decreases with a lower EPC, but that there is a significant variance in the energy use.

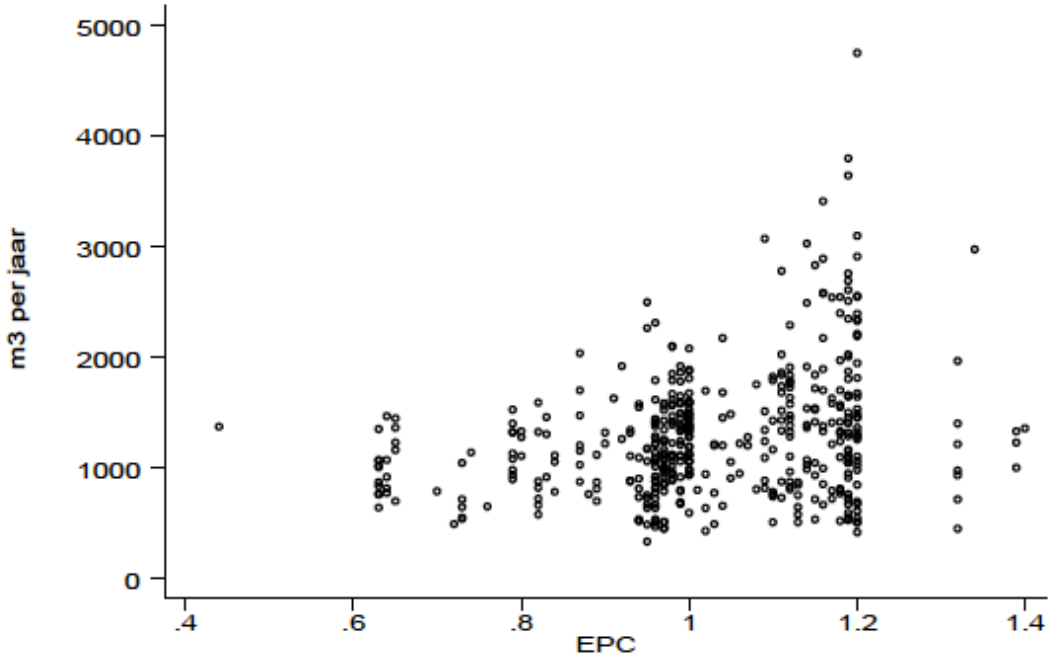


Figure 1: Yearly gasuse related to EPC source: Uitzinger (2004)

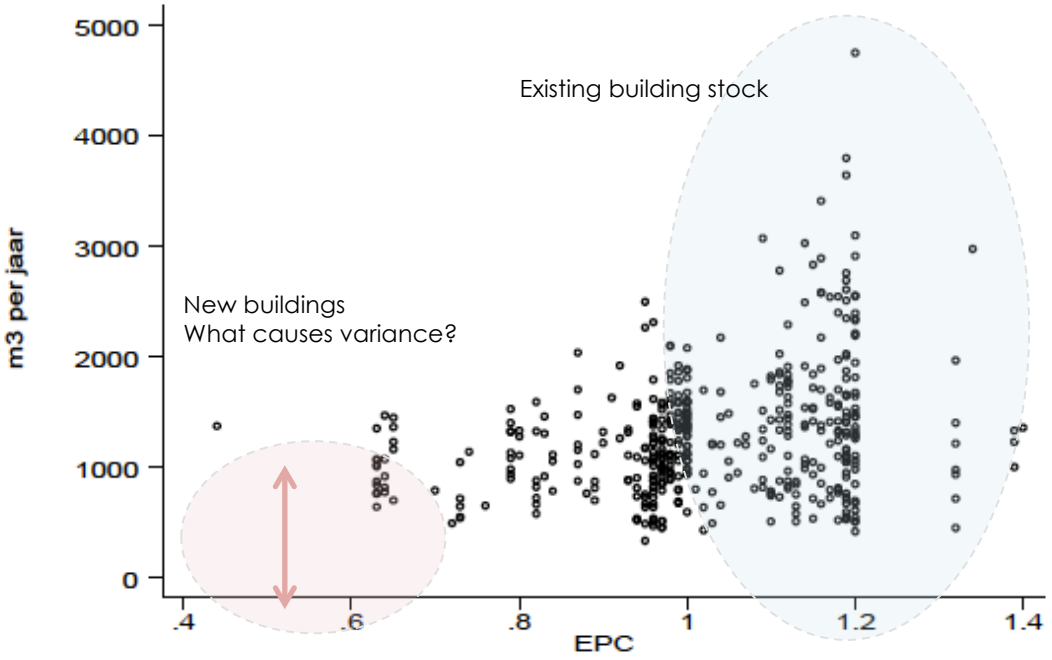


Figure 2: Yearly gas use related to EPC, old and new building stock. source: Uitzinger (2004)

Analysing this figure (Figure 2), the high spread at the right side of the graph (indicated in blue) belongs to the existing older building stock with a high EPC. It is clear that the energy use variance is large. The variance in this group is mainly caused by the poor energetic qualities of the buildings. Renovating these buildings in order to make them more energy efficient can decrease this variance.
A more interesting and complex question is to find an answer to the cause of the variance in the left side of the graph (indicated in red), for the newer buildings with a lower EPC. To reach a low EPC in general means that the building needs to have a good energetic quality. For this reason, the share of the technical performance of a building in the variance is likely to decrease. Other variables like household characteristics and occupant behaviour become more dominant in the explanation of this variance. A critical note regarding these results from Uitzinger is that the research is executed on random chosen buildings. This means that the houses with the same EPC can vary in building type, size and building period. These factors also need to be taken into account when drawing conclusions about the variance in this particular study. A second critical note is that the study is not focused on buildings with an EPC lower than 0.4. The sample size for houses with and EPC < 0.6 is relatively small.
Finding an answer for the cause of the variance for low energy buildings is necessary in order to meet the future requirements set by the national government and Europe.
As already mentioned in the first chapter of this report, there are several causes that may explain the variance in energy use:

- Technical performance
- Household characteristics
- Occupant behaviour
- Weather conditions

In the next sections, these different categories will be defined and discussed.

2.3 Household characteristics

The term household characteristic covers the socio-demographic characteristics of occupants. Previous studies have shown the influence of several household characteristics on energy use. Household size, the amount of people living in the residence, proved to have a positive relation with energy use. This means that larger household use more energy than smaller households (Jeeninga, Uyterlide, & Uitzinger, 2001; Uitzinger, 2004). This variable is closely related to the next variable, presence in the building. The chance that an occupant is at home increases with larger

household. A larger presence results in increased energy use (Papakostas & Sotiropoulos, 1996). Another variable that has been proven to influence energy demand is the age of occupants (Liao & Chang, 2002). Older households tend to use more energy especially for space heating than younger households (Liao & Chang, 2002).
Household income Is another variable that has been proven to be of influence (Biesiot & Noorman, 1999; Jeeninga, et al., 2001; Vringer, 2005). Vringer (2005) revealed that a 1% increase in income results in a 0.63% increase in energy use.
Guerra-Santin & Itard (2010) revealed that a higher education level is related to more hours of radiator use, and so does the presence of elderly people in the household (> 65 years).
Last variable is the difference between rented residences or owner-occupied residences. Comparing these different circumstances proved that more energy is used in rented buildings than in owner-occupied buildings (Leth-Petersen & Togeby, 2001).

2.4 Technical performance

Previous studies into the difference between predicted and actual energy use also revealed technical causes for this difference. These studies disregarded the household characteristics and occupant behaviour, but only focussed on building performance.
Branco, Lachal, Gallinelli, & Weber (2004) executed such a study by three year detailed monitoring in a new low energy building complex in Switzerland. They concluded that it is very important to control the (innovative) technical installations in every step from design, execution to exploitation and that innovative installation probably will not perform exactly as predicted. They also underline the importance of a highly insulated building skin as a key factor for energy efficient buildings, together with simple and consistent energy concepts.

Tommerup, J.Rose, & Svendsen (2007) summarize that realising a low-energy house with a good indoor climate calls for different measures in different fields:

- Building geometry and orientation
- Insulation of building envelope constructions
- Air tightness of building envelope constructions
- Utilisation of passive solar energy (elaboration, placement and orientation of windows)
- Regulation of passive solar energy; solar shading systems (passive or active)
- Ventilation system; high-efficiency heat recovery, fans and controlling electronics, insulation of air ducts and noise reduction
- Heating system; placement and insulation of heating pipe and hot water pipes and tank.

A failure in one or more of these fields will increase the difference between the predicted and actual energy use.

2.5 Behaviour

This research will not only focus on the technical and quantifiable parameters that are related with energy use, but will also take occupant behaviour into account. Behaviour is a term that especially belongs to the realm of psychology. To get a better understanding of the term behaviour and to create a suitable frame for this study, the next chapter will be focussed on the relevant literature that is mainly originated from the psychological field.

Oxford dictionaries:

behaviour
Pronunciation: /bɪˈheɪvjə/
(US behavior)

noun
[*mass noun*]
The way in which one acts or conducts oneself, especially towards others.

2.5.1 Defining behaviour

If we study the definition of behaviour given by the oxford dictionary, we can conclude that its scope is very wide and cannot directly be used to clarify the meaning of behaviour in this specific study.

Looking at behaviour in the framework of this study, first thing we need to get is an understanding of the meaning of environmental behaviour. Stern wrote an extensive article about this topic with the following description:
"We define environmental behaviour broadly as all types of behaviour that change the availability of materials or energy from the environment or alter the structure and dynamics of ecosystems or the biosphere" (Stern, 2000 p. 408).
"Through human history, environmental impact has largely been a by-product of human desires for physical comfort, mobility, relief from labor, enjoyment, power, status, personal security, maintenance of tradition and family, and so forth, and of the organizations and technologies humanity has created to meet these desires" (Stern, 2000 p.408).
Using this *impact-oriented* definition enables to formulate certain behaviours that are of influence on the environment (Stern, 2000).

"Environmental protection became an important consideration in human decision-making. This development has given environmentally significant behaviour a second meaning. It can now be defined from the actor's standpoint as behaviour that is undertaken with the intention to change (normally, to benefit) the environment. This *intent-oriented* definition is not the same as the impact-oriented one in two important ways: It highlights environmental intent as an independent cause of behaviour, and it highlights the possibility that environmental intent may fail to result in environmental impact" (Stern, 2000 p.408).

The important distinction that Stern makes is that there is a difference between the actual impact of the behaviour and the intent of the behaviour. First one implies behaviour that has actual impact on the environment, Second one says more about the intent of the behaviour without the explicit result it has for the environment. It refers to the perception people have of their behaviour in relation to the environment, without really knowing if this perception corresponds with the reality or not.

This explanation and distinction is of importance for this research to be able to determine and define which variables cause certain behaviour, and which actual occupant behaviour needs to be investigated in relation with energy use in the low-energy residences. Besides this, it is also important to keep in mind during the research that the actual behaviour of people is not always in accordance with their perception of their behaviour. The less these two deviate, the more *aware* a person is of the effects of his/her behaviour.
Steg and Vlek (2009) have summarized different theoretical perspectives regarding the underlying factors of environmental behaviour. They make a distinction between three lines of research into motivational factors (Steg & Vlek, 2009):

- Weighing costs and benefits
- Moral and normative concerns
- Affect

I will not go into further detail describing these three separate lines of research. For this study it is more relevant to appoint a more integrative perspective on environmental motivation.

2.5.1.1 integrative motivational perspective

"Goalframing theory explicitly acknowledges that behaviour results from multiple *motivations*. This theory postulates that goals govern or "frame" the way people process information and act upon it. When a goal is activated (that is, when it is the "focal" goal or "goal-frame"), it influences what a person thinks of at the moment, what information (s)he is sensitive to, what alternatives (s)he perceive, and how (s)he will act" (Steg & Vlek, 2009 p.311).
Using this theory we can more easily define which factors determine behaviour. The above described multiple motivations are categorized by Steg and Vlek as:

- Hedonic goal-frame (to feel better right now)
- Gain goal-frame (to guard and improve one's resources)
- Normative goal-frame (to act appropriately)

"Goal-framing theory proposes that motivations rarely are homogeneous. One goal is focal and influences information processing the most (that is, it is a goal-frame), while other goals are in the background and increase or decrease the strength of the focal goal. Thus, multiple goals are active at any given time. When background goals are compatible with the goal-frame, they strengthen it. But when the goal-frame and background goals are in conflict, the latter weaken the strength of the goal-frame" (Steg & Vlek, 2009 p.312).

Like the name of this theory clearly summarizes, motivations are driven by goals.
Not only goals form a basis for motivations, there are also needs underlying the emergence of motivation. Hull showed that physiological deficits, like a shortage of food, give rise to a physical need that activates a drive to satisfy this need (Hull, 1943). When investigating energy-related behaviour like this research, one must think of needs in terms of fulfilling a certain indoor *thermal comfort* level.

If we consider how to change certain behaviour, more related psychological terms will be revealed. Till now, we can conclude that if we want to change behaviour we need to change motivations. This sounds very clear at first, but the opposite is true.
Steg and Vlek describe two intervention strategies for changing behaviour:

- Informational strategies
- Structural strategies

"The first strategy is aimed at changing perceptions, *motivations*, *knowledge*, and norms, without actually changing the external context in which choices are made. Informational strategies can be aimed at increasing actors' knowledge so as to heighten their *awareness* of environmental problems and of the environmental impacts of their behaviour, and/or to increase their knowledge of behavioural alternatives and their pros and cons. It is assumed that new knowledge results in changes in *attitudes*, which in turn will affect behaviour" (Steg & Vlek, 2009 p.313). Whitmarsh et al (2011). also conclude that a barrier for changing behaviour is the lack of appropriate knowledge on this individual level (Whitmarsh, O'Neil, & Lorenzoni, 2011).

The interdependence between these terms is made clear by De Young (1993) who also acknowledges this informational strategy but states the opposite direction. Increasing awareness about an environmental issue can help an individual to gain specific knowledge about such an issue and is expected to alter the individual's attitude and beliefs about this issue, causing the individual to take appropriate action (De_Young, 1993).

Structural strategies are aimed at changing contextual factors such as the availability and the actual costs and benefits of behavioural alternatives (Steg & Vlek, 2009).

2.5.1.2 Resulting behaviour

Following from the theory described above, we can already deduce a few key terms that influence behaviour:

- Awareness
- Motivation
- Attitude
- Knowledge
- (Thermal) comfort

These underlying mechanism result in specific behaviour. In the total spectrum, the list of types of behaviours is endless. Framing behaviour for this study, it's necessary to define what types of behaviour related to energy use occurs in residences. First of all, it's necessary to make a distinction between incidental and habitual behaviour.

"Habitual energy use related actions, are all focused around everyday reductions in energy use that require either no or minimal structural adjustment. Such behaviours include: thermostat setting, closing off of unused rooms, altering room use, window closure when heating is on, using a clothes line rather than a tumble drier, not filling the kettle full before boiling, putting a full load of washing on rather than a half load. These behaviours are evidently related to the everyday habitual element of an individual's lifestyle as they undertake daily activities" (Barr, Gilg, & Ford, 2005 p.1425-1426).

These habitual actions can be simply described as 'doing without thinking', and are based on our previous experience.

Second type of behaviour is incidental behaviour, or purchase-related behaviour. "These behaviours are often long-term alterations to the structure of the home and include internal changes that will require financial and normally technical resources to be utilised. This group is more disparate than the first in the sense that the amount of financial and other resources can vary greatly. Typically, behaviours measured in previous work have included:

thermal insulation (wall, door and roof), double glazing, purchase of energy saving
products (appliances which are purchased with saving energy as a priority, such as washing machines, cookers, fires, dishwashers, etc.), using low-energy light bulbs and adjusting curtain heights in order to reduce energy loss (Barr, et al., 2005 p.1426).

Summarizing the output of the behaviour that is of importance for this research we can make the following list:

- Habitual behaviour
    - *Heating behaviour (thermostat set-points)*
    - *Ventilation behaviour (closing and opening of windows for fresh air)*
- Incidental behaviour
    - *Purchase behaviour (purchase appliances, energy saving lighting)*

Figure 3 gives a simplified impression of the underlying variables for behaviour and the resulting different types of behaviour specified for this study.
Chapter 5 in this report will provide a further understanding of the separate definitions and their interdepend relations.

2.5.2 Homeostasis

Within the context of occupant behaviour and energy use, there is another phenomenon that needs to be addressed that is called homeostasis. This phenomenon will be revealed and discussed based on the analysis results later in this study. This section will define and explain the term homeostasis, in order to be able to interpret and understand the output of the analysis.
To start with the direct definition of the term given by the Oxford dictionary, homeostasis means: "*The tendency towards a relatively stable equilibrium between interdependent elements, especially as maintained by physiological processes.*"
This general description is not explicit enough to put the term in context of this study, but it does underline the principle of a naturally established balance between two elements. Translating to this study, the two elements can be seen as on one hand occupant behaviour, and at the other hand energy use.
Previous study (VROM, 2010) proved that occupants who are aware of living in an energy efficient house tend to behave less energy efficient than occupants who live in a not-energy efficient house.
This implies that occupants with a higher awareness tend to use more energy than occupants with a lower awareness under the same conditions. This doesn't sound like a logical relation at first, because one would expect the opposite to occur.
Other literature confirms the existence of homeostasis but placed in another context. Study by (Wilde, 1998), focuses on risk homeostasis. He states that people adapt their behaviour to changes in environmental conditions, and for that reason a lot of measures to reduce traffics accidents don't have the desired effect. " Risk homeostasis theory posits that people at any moment of time compare the amount of risk they *perceive* with their *target level* of risk and will adjust their behaviour in an attempt to eliminate any discrepancies between the two" (Wilde, 1998, p. 89-90). The target level is the level of risk at which the benefit is expected to maximize.
Relating this to the results of the study of VROM (2010), when people move from a not-energy efficient house to a energy efficient house, they perceive a lower level of energy use that is below their target level. They adjust their behaviour (increased energy use) to eliminate the discrepancy.

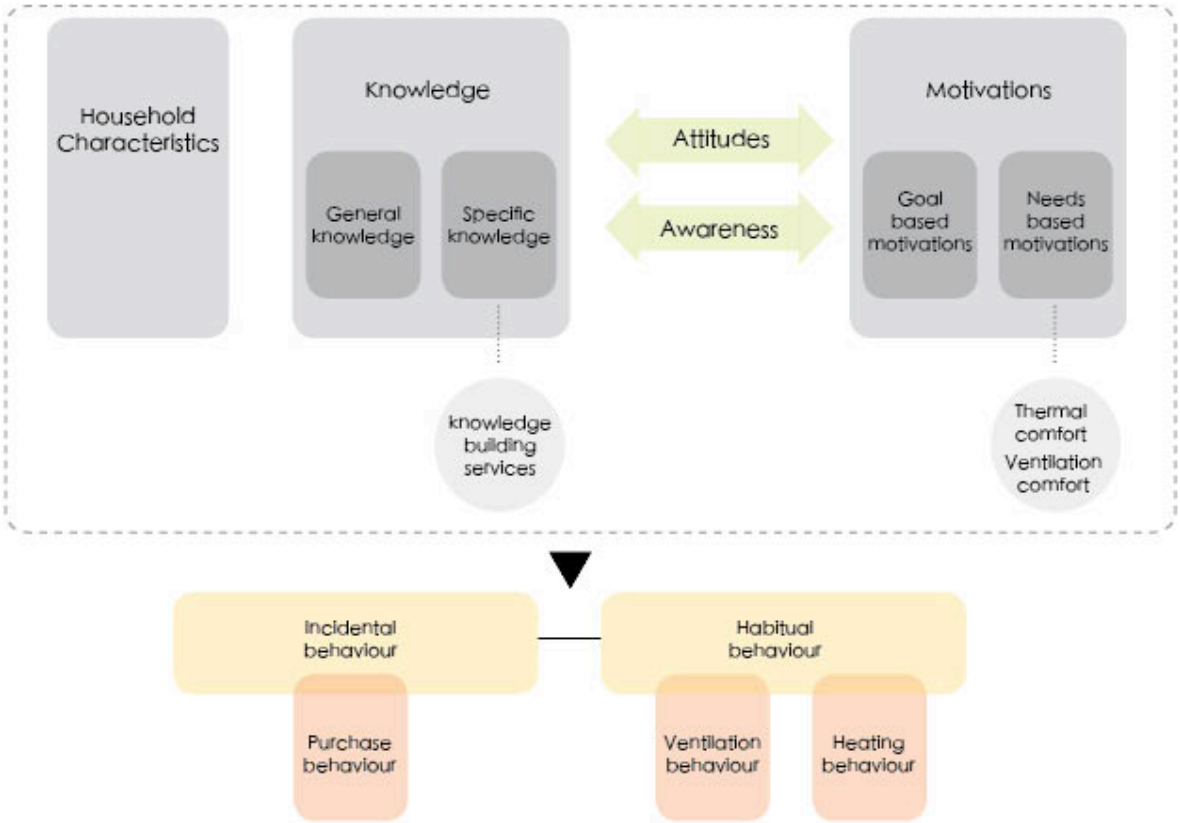


Figure 3: scheme of underlying variables and resulting behaviour

2.5.3 Conclusion

After the literature research into behaviour, it is possible to formulate an answer on the following sub question:

What kind of behaviour can be found in residences?

The actual behaviour that occurs in the specific residences for this study limits itself to ventilation behaviour and heating behaviour.
These two behavioural aspects are both habitual behaviours. Besides the habitual behaviour, there is also the incidental behaviour. For this study it is not applicable to further study incidental behaviour because the residences are rentals, that are owned and maintained by the housing corporation. The occupants are not allowed to adjust the construction or apply external extra energy-saving measures. The only incidental behaviour that is applicable is the purchase of energy-efficient appliances. Because of the relative short time period of this study it is not interesting or important for detailed investigation. This study will take this incidental behaviour into account by asking the occupants about their energy-saving behaviour during the user survey, which forms its own category for the analysis.

To give a more specific conclusion on the sub question, the literature research also revealed the underlying psychological variables that influence the occupant behaviour. These factors are:

- Knowledge
    - *General knowledge*
    - *Specific knowledge*
- Motivation
    - *Goal-based*
        - *Hedonic goals*
        - *Normative goals*
        - *Gain goals*
    - *Needs-based*
        - *Thermal comfort*
        - *Ventilation comfort*
- Attitude
- Awareness

The relation of these factors is presented in Figure 3.

2.6 Predicted energy use

This paragraph will explain two calculation methods that can be used to predict the energy use of houses:

- EPN method (Dutch)
- PHPP method (German)

2.6.1 EPN

The Dutch Bouwbesluit prescribes requirements for the maximum Energy Performance Coefficient (EPC) for new residential and utility buildings. Designers are free to choose the techniques and methods to meet the EPC-requirement. The EPC calculation is defined in the EPN (energiepresetatienorm) NEN 7120+C2.
The principle of the EPN method is that the EPC is determined by dividing the predicted energy use of the house in MJ by a reference energy use. This reference is calculated from the size and dimensions of the surfaces of a house.
The equation for the EPC of a new residence is:

$$EPC_{woon} = \frac{E_{pTot}}{310\ x\ Ag + 85\ x\ Av + 9000}$$

with:

EPC_{woon}	Energy Performance Coefficient for residences
E_{pTot}	Total energy use determined by NEN 7120 (MJ)
Ag	User area m^2
Av	Loss area m^2

The total energy use is determined by:

- Heating
- Secondary energy
- Cooling
- Ventilation systems
- Lighting
- Domestic hot water
- Pumps

The energy use can be compensated with self-generated electricity by solar-panels, and self-generated solar heat by solar-collectors.

An important principle of the EPN is that the type, size and geometry of the building are not of influence for the resulting EPC but the measures that are taken in the design determine the EPC. In other words, bigger houses with larger roof and façade surfaces can use more energy while having the same EPC as smaller and more compact buildings.
The EPC requirement only says something about the minimal energy performance a building needs to meet. The designer has the freedom to choose from different techniques to meet this requirement. Techniques that influence the EPC are for example:

- Insulation quality
- Building service installations
- Renewable energy sources
- Sunscreens
- Balanced ventilation with heat exchanger and bypass

Advantages EPN:

- The EPN is not a complicated calculation method to use due to the minimal amount of input parameters.
- There is a linear relation between the EPC and the primary energy use
- EPN enables to compare the energy performance of different buildings

Disadvantages EPN:

- The calculation method is less useful for low energy residences (Jansen, Boer, Joosten, & Boonstra, 2009)
- The calculation doesn't take renewable energy sources on district scale into account
- Steady-state assumptions for weather conditions
- Steady-state assumptions for indoor conditions
- Default use behaviour

2.6.2 PHPP

The passive house technology has a primary principle of reducing the heat demand by interventions on urban, architectural and technical scale. Central concepts for passive houses are:

- Compact building design
- Highly insulated building skin
- Beneficial sun orientation
- Sufficient day lighting
- Highly insulated glazing and window frames
- Airtight building skin
- Balanced ventilation with heat recovery

These measures together must provide a building with a maximum space-heating demand of 15 kWh/m^2 (Lagae & Franke, 2006).

If a design wants to obtain a passive house certificate, calculation with the Passivhaus Projektierung Paket (PHPP), a calculation method developed in Germany, needs to be done.
It is important to underline that the PHPP principle is based on reducing the energy demand with passive interventions, which is not the case in the EPN method.
The PHPP is also a steady-state calculation method and uses assumptions for weather conditions, indoor conditions and occupant behaviour.

The input parameters are more extensive than with the EPN method, so the PHPP method asks for more accuracy when performing the calculation, but the overall underlying calculation method is comparable (more in section 4.1) (Boer, Kondratenko, Jansen, Joosten, & Boonstra, 2009).

2.7 Actual energy use

Another important parameter in this study besides the predicted energy use is the actual energy use. This paragraph gives insight into how the actual energy use can be compared to the predicted energy use.

Actual energy use can be divided in two categories (Itard, Meijer, & Santin, 2009):

- Building-related energy use
- Non building-related energy use

Building-related energy use
Building-related energy use is mainly a result from the characteristics of the building like insulation, dimensions, glass surfaces, type of glazing and type of ventilation.
The building-related energy categories that can be distinguished are:

- Energy use for space heating
- Energy use for space cooling
- Energy use for ventilation
- Energy use for lighting
- Energy use for domestic hot water preparation

Besides the influence of the building characteristics, occupant behaviour is also of influence on these categories.

Non building-related energy use
This category covers the energy use of electrical appliances other than lighting. Major appliances (white goods) and small appliances (brown goods) are part of this category together with energy use for cooking. Because the use of both these categories produces heat, they are included in the prediction methods as internal heat loads to determine the heating and cooling demand.

2.7.1 How do we measure energy use

Figure 4 illustrates the structure of energy use, EPC and measured use. The left bar shows the subdivisions in building-related and non building-related energy use as explained in the previous section.

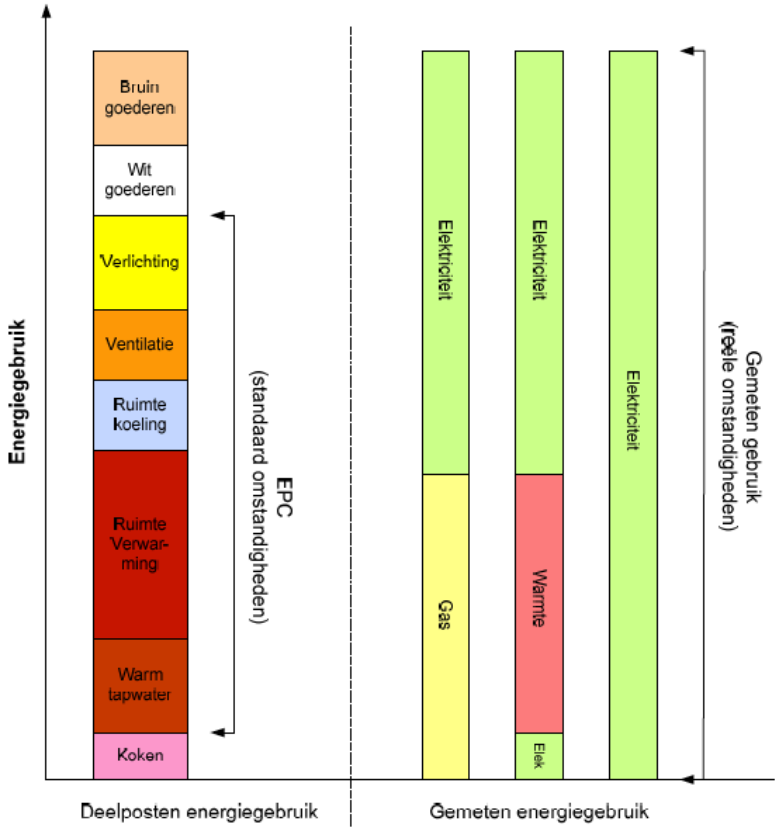


Figure 4: Structure energy use, EPC and measured use. source: Itard, Meijer & Santin (2009)

It also indicates the categories that are included in EPC calculations with assumed parameters.
The right bars represent the measured use for three different possible combinations. In the case of Columbuskwartier the middle bar is applicable. The houses have district heating, which means they use heat and electricity (no gas). This figure shows the difficulties that arise when comparing prediction methods (like EPC) with actual energy use. It shows that the measured use is only displayed in two numbers for total heat and electricity use, and makes no representation of the different allocation of the energy use categories. In order to get a better insight in the energy use related to the different categories, detailed monitoring is needed (Itard, et al., 2009)

As explained before, both building-related and non building-related energy use are influenced by occupant behaviour. Defining occupant behaviour and the underlying psychological influences already proved to be a complex thing to do (section 2.5). The dynamic nature of behaviour is for this reason difficult to model and difficult to include in energy use prediction methods.
The EPN method is intended as a tool to test the energy performance of buildings and installations and not the influence of occupant behaviour. This is also a reason why EPN (and PHPP as well) assumes standard parameters.
The relation between household characteristics, building and installation characteristics, occupant behaviour and the different energy use categories is illustrated in Figure 5.
EPC calculation uses standard parameters for the following categories:

- Temperature settings
- Amount of ventilation
- Internal heat load
  Hot tap water demand
- Lighting

It can be concluded from this, that the EPN (and PHPP) method only gives a simplified representation of the complex reality, which automatically can lead to differences between predicted and actual energy use. In order to minimize this difference and minimize domestic energy use, more detailed research into the influence of occupant behaviour needs to be done.

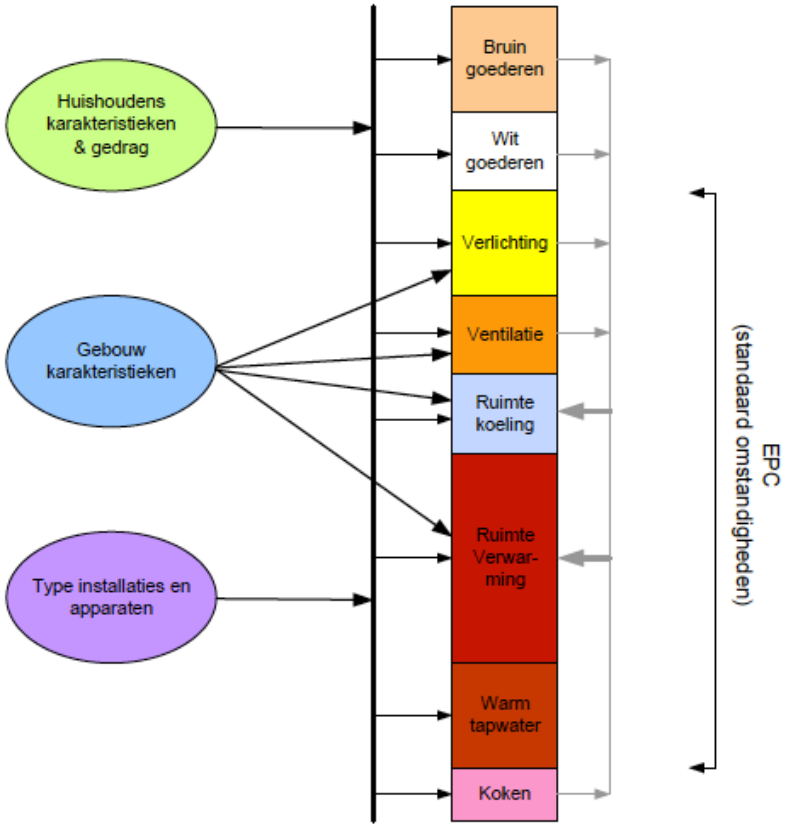


Figure 5: Relation EPC, energy use categories, building, installations, and household characteristics and occupant behaviour. source: (Itard, Meijer & Santin (2009).

2.8 Theoretical approaches

The range of previous studies focussing on domestic energy use is extensive. This section will give an overview of the different research approaches and methods. In general, 4 approaches can be distinguished: Top-down, bottom-up, technical and psychological approach.

2.8.1 Top-down approach

The studies that have been executed based on a top-down approach use general census data, retrieved from national databases. In most cases, the focus of these studies is on the socio-economic variables or household characteristics in relation to average energy use on macro level (Biesiot & Noorman, 1999; Liao & Chang, 2002; Vringer, 2005; Vringer, Aalbers, & Blok, 2007).
The results of these studies are valuable for my study as starting points indicating which variables have been proved to influence energy use. However, this approach doesn't take into account the character of individual houses and occupant behaviour, and the results are not specified for low energy houses.

2.8.2 Bottom-up approach

The bottom-up approach uses specifically collected survey data. The parameters that are investigated are mainly demographic, socio-economic and technical variables (Caldera, Corgnati, & Filippi, 2008; Catalina, Virgone, & Blanco, 2008; Guerra-Santin, 2011; Guerra-Santin & Itard, 2010; Guerra-Santin, Itard, & Visscher, 2009; Leth-Petersen & Togeby, 2001). Some of these studies have proven some occupant behaviour variables to be of influence on energy use, like motivation, temperature settings and operation of the windows. Most of the results however, stay limited to general household characteristics. The investigated houses are not comparable in terms of EPC, size and other technical variables.
The results of these studies have the same value for my study explained for the top-down approach. Although the data is specifically collected, the used houses are not low energy houses, thus the results don't give an answer to the question of the influence of occupant behaviour in these low energy houses.

2.8.3 Technical approach

The group of studies using a technical approach focuses on the technical performance of houses, based on data retrieved from monitoring physical parameters (Branco, et al., 2004; Spataru, Gillott, & Hall, 2010; Thomsen, Schultz, & Poel, 2005; Tommerup, et al., 2007; Wall, 2006). Different technical variables have been correlated to actual energy performance of houses. Some studies have underlined the influence of behavioural activities like thermostat settings on energy use, but no other behavioural factors have been taken into account. An important conclusion from these studies is that a highly insulated building skin is very important for building energy efficient houses. Besides the lack of behavioural aspects in these studies, they also don't include EPC levels of houses.

2.8.4 Psychological approach

The final group has its origins in the psychological science and focuses on behaviour science ((Lindenberg & Steg, 2007; Nordlund & Garvill, 2003; Poortinga, Steg, & Vlek, 2004; Steg & Vlek, 2009; Stern, 2000). These studies give insight in environmental behaviour and the willingness to reduce energy In relation to attitudes, motivations and emotions. The results are based on collected survey data. They are not focussed on low energy houses and don't provide an answer on the cause of variance in energy use.

3. CASE STUDY ANALYSIS

3.1 Building analysis

3.1.1 Location

Building Information

Location:	Willem Barentszroute, Almere-Poort
Built in:	2010 - 2011
Function:	Residential houses
Building type:	Terraced houses
Living area:	92,80 m^2
EPC:	0.31



Figure 6: Location Columbuskwartier

The building block is situated in the area Almere-Poort in the city Almere. This area has been developed recently - with the first building completed only in 2005 - and is still under construction. The area is located on the western bank of the IJmeer. Almere Poort was not in the original city plans, but is rather a result of revised urban planning in accordance to Almere's more recent development plans assuming much higher target population and a more prominent role as a satellite urban centre to Amsterdam.
Almere Poort is divided in several neighbourhoods. The studied building block is located in the neighbourhood Columbuskwartier.
This neighbourhood features both high-density apartment buildings, terraced houses, as well as land parcels available for free private housing development.

Because of the isolated location of Almere Poort next to the IJmeer, you can find a lot of windmills that currently provide 12.500 households with renewable energy.
The buildings in Almere Poort are connected to a district heating plant for domestic heating.
The heat that is used is waste heat of the Diemercentrale that is located at the other side of the IJmeer.

3.1.2 Initiative

In 2009, the real estate development department of the BAM took the challenge to develop the first large-scale passive house project in the Columbuskwartier.
The ambition for the project is high. The aim is to develop a standard passive house technique, which allows a large scale and housing-cost neutral method for building passive houses, as a broad market introduction of the passive building concept.

Parties involved	
Municipality	Almere
Development	AM en Ballast Nedam (collaboration De Vijfde Stad VOF)
Architect	INBO
Contractor	BAM Housing W&R
Installation engineer	Breman, Bemar, Van den Berg
Completion	2010
Number and building type	103 terrace houses (rental)
Owner (rental) properties	Housing corporation GoedeStede
Financial	
Average construction costs	€ 167.000
Costs energy measures	Circa € 25.000
Subsidies	€ 7000 (EOS-DEMO en EU-CONCERTO)

Table 2: Parties involved Columbuskwartier (AgentschapNL, 2012)

3.1.3 Building occupants

The 103 residences in the Columbuskwartier have now been occupied for approximately 3 years. The owner of the residences is the housing corporation GoedeStede. The corporation uses the buildings as social housing. This means that the income of the households must not be more than €34.678 (Rijksoverheid, 2013). The houses are designed for starters on the housing market and young families. Because it concerns social housing, those who are interested to live in these houses, must first register themselves with the corporation, which then determines whether the person qualifies for renting the house. As a result of this social housing concept, the choice to inhabit these passive houses is not always a voluntary choice for the people.
The impact of this fact on this study, is that most of the occupants do not make a deliberate choice for living in a passive house, but base their choice on other conditions like living space and location, or in some cases they did not opted for this house but got it involuntarily assigned by the corporation.

3.1.4 Building block

Figure 7 shows the layout of the Columbuskwartier. The coloured buildings are the ones that are owned by Goedestede. The different colours define the different building types.

- Mid-terraced houses
- Corner houses
- Coupled houses

This research will only investigate the mid-terraced houses (green), because the corner and coupled houses have a different layout and different EPC values. All mid-terraced houses have an identical layout and identical installations. Only the orientation of the houses can differ.



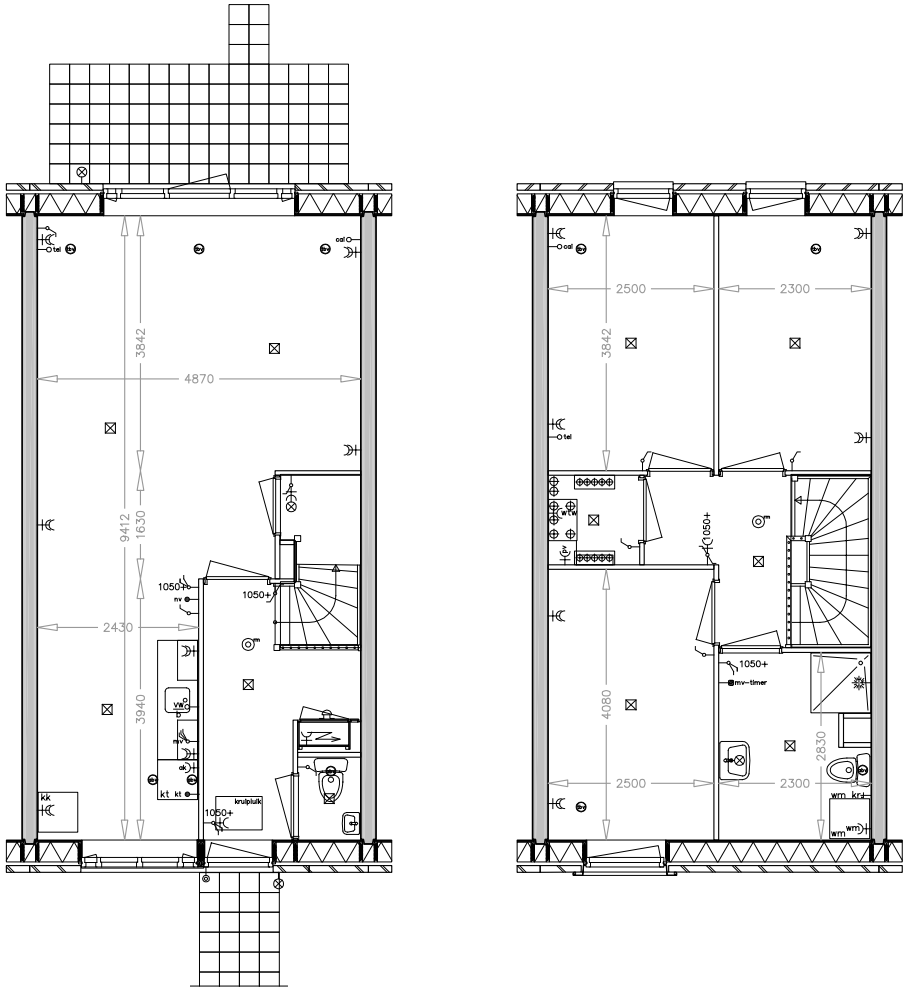
Figure 7: location building block



Figure 8: 3D impression Columbuskwartie. source: www.stedebouwarchitectuur.nl

3.1.5 Floor plans

As said before, all the terraced houses have identical floor plans. They all have a small front yard and a garden at the back of the house.
The living area has an open connection with the kitchen which are both located on the ground floor. The first floor offers room for three bedrooms, a bathroom and a building services room (Figure 9).



GROUND FLOOR FIRST FLOOR

Figure 9: Floorplan

3.2 Applied passive house strategies

Because it concerns houses that are designed according to a passive house concept, special care is given to the used building installations and construction methods, in order to achieve an EPC value lower than 0,4 that meets the requirements set for 2015.

3.2.1 Construction method

To minimise infiltration losses through the building skin, it is important to avoid infiltration cracks. For this reason the concrete walls of the houses are also the loadbearing structure that is executed in a tunnel forming method. By using this method, the construction details are minimized, which are always a weak point for ensuring an airtight building skin.
The building skin is provided with more passive house techniques.
For insulating the roof, 380 mm EPS insulation is used. EPS (Expanded polystyrene) foam is a closed-cell insulation that's manufactured by "expanding" a polystyrene polymer.
The ground floor is constructed with prefabricated waffle slabs.
The end facades are provided with PIR insulation panels, allowing reduction of the thickness of the insulation.
For the inner cavity walls, 300 mm mineral wool is used as insulation.
The windows are executed in three-layered glass with a sun reflecting coating and Swiss-spacers. (Kalkman, 2008)
All these measures together must ensure an annual heating demand as calculated with the Passivhaus Planning Package of not more than 15 kWh/m² per year, and an air-tightness of at most 0,15 dm³/sm² (Figure 10).



Figure 10: f.l.t.r: Tunnel forming method, Roof insulation EPS, End facade insulation PIR, prefabricated inside leaves cavity walls, Three-layered glass with spacers. Source: (Haas, 2012; Kalkman, 2008)

3.2.2 Ventilation

Besides the highly insulated envelope, the buildings are also provided with a balanced ventilation system with a heat exchanger for ventilation air heat recovery (Figure 12).
Minimizing the heat loss via air is very important in passivehouses. While doing this, one must also make sure that there is enough fresh air to breath in the house. In order to achieve this, as a general rule, one needs mechanical ventilation, ventilators and a heat exchanger. The heat exchanger makes sure that the air in the rooms is exchanged every two hours and that the exiting air delivers its warmth to the entering air (Vauban, 2013).
The heat exchanger is provided with a bypass, which means that during summer time the air does not pass the heat exchanger but the air comes directly from outside, so the supply air is not pre-heated before entering the living space.
In order to prevent noise nuisance, sound absorbing ducts are used for the supply- and exhaust air. Besides, the ventilation unit is installed in a sound-insulated closet on the first floor (AgentschapNL, 2012).

In addition to the mechanical ventilation system, the buildings also have a natural ventilation system.
At the sides of the windows narrow, vertical panels are placed that can be opened during the night to exhaust the accumulated warm air (night-time ventilation) (Figure 11).
The combination of the mechanical and natural ventilation systems should be sufficient for providing a cool indoor climate during summer, so that no additional cooling would be needed.



Figure 11: natural ventilation panels source: (Haas, 2012)



Figure 12: Mechanical ventilation unit with heat exchanger. Source: www.warmteservice.nl

3.2.3. Heating and Cooling

As indicated before, the houses are designed so there is no need for an additional active cooling system.

The municipality Almere made a contract with NUON that obligates all new developed houses in Almere-Poort to be connected to the district heating plant from NUON (Figure 14).
This was a disappointment for the project developer AM, because they preferred to design the houses with an autonomous heating system.
Being connected to the district heating plant implies that the occupants of the houses now pay too high fixed charges for the too heavy heat delivery infrastructure.

The applied energy-efficiency measures led to a calculation that showed it would be sufficient to only provide the living area, hallway and bathroom with centrally heated radiators.
Because of the open connection between the hallway and the first floor, the bedrooms are not provided with a radiator. According to the calculations, internal transmission should be sufficient to heat the bedrooms on the first floor (Haas, 2012).

3.2.4 Renewable energy generation

On top of every building are PV panels (Figure 15). With the available surface, 14 PV panels were placed on top of every building, which equals 10 m^2, with an annual generation of 840 kWh per building.
The PV panels are connected to the electricity net. The generated electricity is transferred to the main electricity net. At the end of the year, when the occupants receive their annual overview of their energy use, the total generated energy is subtracted from the total consumed energy. The difference between these two is the actual energy used by the occupants.



Figure 13: Low temperature radiators source: www.icdubo.nl



Figure 14: District heating plant Almere Poort. source:www.schutter-eth.com



Figure 15: PV panels on roofs. Source: www.lente-akkoord.nl

3.2.5 Concept performance

The performance of the concept is assessed (executed by the consultancy company Cauberg Huygen) from three perspectives: comfort, energy performance and annual energy costs. In order to meet summer comfort in passive houses, it is necessary to have enough natural ventilation facilities. For this reason, narrow vertical ventilation panels were installed next to the windows. Besides this design strategy, also outdoor blinds were installed on the southern orientations.
With a temperature simulation calculation, Cauberg-Huygen investigated the effects of these measures, and concluded that summer comfort meets all current requirements.
With regard to the energy performance of the buildings, the design has been calculated using both the EPC method NEN5128 (previous version NEN7120) and the PHPP calculation method (PassivhausProjektierungsPaket) from the Passivhaus Institut Darmstad.
With PHPP can be tested whether the design meets the heating demand requirement of 15 kWh/m^2/yr. This calculation requires a high accuracy, because the heating demand in a passive house is the resulting difference between two larger parameters: the heat gains (solar radiation and internal heat) and the heat losses (transmission, infiltration and ventilation losses) (Kalkman, 2008).

3.2.6 Summary

The following tables give an overview of the used techniques and the achieved results.

Technique	Value	Technique
End Facade	R_c = 9 m^{2}K/W	200 mm PIR hard foam
Roof	R_c = 9 m^{2}K/W	380 mm EPS
Floor	R_c = 5 m^{2}K/W	Waffle slabs + EPS prefab
Facade	R_c = 7,2 m^{2}K/W	300 mm MW, I-profiles
Windows	U_{raam} = 0,85 W/m^{2}K	Three-layered glass, isolated window frames, Swiss-spacers
Air-tightness	$Q_{v,10,kar}$ ca. 0,15 dm^3/sm^2	Gap sealing
Heating	District heating (NUON)	CV radiators middle temperatures
Ventilation	HR-WTW 95%	- Balanced ventilation (Stork) - Incl. summer bypass - sound absorbers
Renewable energy generation	PV-panels	Wurth - 14 per building - annual generation: 840 kWh per building
EPC = 0,31 (terraced houses) - 0,43 (corner houses)		

Table 3: Used techniques and property values

Building type	EPC (NEN5128)	Heat demand PHPP (kWh/m^2)
Corner house	0,43	15
Terrace house	0,31	9

Table 4: EPC and PHPP results

	Reference	Passive house with sunboiler, districtheater and PV
Gas use (m^3)	1411	15
Electricity use (kWh)	Ref.	Ref. -781
Heat (GJ)	-	14,1
Energy costs variable	€ 891	€ 177
Energy costs fixed	€ 271	€ 484
Energy costs total	€ 1162	€ 661
Energy costs savings	-	€ 501

Table 5: Comparisson with refference regaring to energy costs savings

It should already be noted that the sunboiler never got installed during the realisation of the project. This means that the values in Table 5 can deviate from real values.

3.3 Technical performance residences

Before starting with the field study, that collects all the wanted information from the occupants and their behaviour, this chapter will give insight in the technical performance of the houses. First I will explain the main energy concept that is designed for these houses. After that I will present the results of the performance of the building envelope.
The end of this paragraph will give insight in the resulting difference between the predicted and actual energy use and in the variance.

3.3.1 Energy concept

As summarized in the previous chapter, the houses are equipped with several technical installations that need to provide a warm indoor climate during winter and a cool indoor climate during summer. In short, the following principles are responsible for providing thermal comfort inside the houses:

1. Heating system, with mid-temperature radiators (heat source is the district heat network from NUON)
2. Mechanical ventilation (including heat recovery)
3. Natural ventilation (windows and ventilation panels)

These systems have to work together in a certain way to provide a comfortable indoor climate, and there is only one optimal combination that results in the best thermal performance of the house.
The consequence is that the occupants need to know how to combine these concepts in order to let the building function as it is supposed to function. If these systems are not used in the proper way, it can result in higher energy usage than predicted during the design stage.

Investigating whether or not the occupants use the installations like intended can only be done by monitoring or user surveys. The next chapter will present the user surveys done after one year of occupation, and the results of my own survey, that both give insight into the way the occupants use the installations.
First I will explain in which way the installations need to be combined in order to reach the optimal performance for the winter and the summer situation.

Winter
During winter the most complex situation arises, because all three concepts need to work together for heating the building in the most efficient way.
It is obvious that during cold days, windows and panels should be closed to keep the cold air outside. This principle is fundamentally connected to the passive house concept, which is based on the principle of reducing the heat demand by keeping outside air outside combined with a good insulated building envelope.
Refreshing the indoor air and circulating this air to maintain a healthy air quality is ensured by the mechanical ventilation with a heat recovery system. When all windows are closed and the occupants are at home, they need to put the mechanical ventilation on level 2. When they are not at home, the level can stay at 1, but during cooking and showering the ventilation should work on level 3. Correctly operating the ventilation system should provide the occupants with a sufficient airflow.
If the above measures are not enough for providing thermal comfort, the occupants can use the radiators. For common houses in the Netherlands, this is a very traditional way of space heating during winter. Putting radiators on results in a direct and obvious experience of heating the adjacent spaces. In this case however, the principle of heating the spaces becomes a little more complicated. The whole house is provided with only three radiators, two downstairs in the living room and hallway, and one upstairs in the bathroom (Figure 98). The ground floor heats up directly from

the radiators downstairs. The first floor however, is designed to be heated in an indirect way, because the bedrooms are not equipped with a radiator. In order to warm up the bedrooms, the occupants must keep the bedroom doors open and the door of the bathroom open as well, because this room is the only one on the first floor with a radiator and thus functions as the main heat source here. Besides the heat from the bathroom, the upstairs level has an open connection with the downstairs hallway, which also has a radiator.
Summarized this means that if the occupants want to heat the bedrooms upstairs they have to keep the bedroom and bathroom doors open, and the radiators in the hallway downstairs and in the bathroom on.
It is obvious and predictable, that errors easily occur with this design principle. Opening and closing doors in a house where occupants are present occurs on a regular basis with a lot of different personal reasons. As a designer it is not possible to assume that occupants will keep doors open to fulfil a basic need, in this case providing thermal comfort.
To make sure the occupants know how this heating principle works, the housing corporation made a hand-out which visualizes and explains in short how to combine these different systems to let the house perform optimally which again should result in the least energy usage (Appendix A).

Summer
During summer the main goal is to keep the house as cool as possible. Most important principle for meeting this goal is the highly insulated and airtight building envelope to keep the heat outside. Keeping the windows and panels closed during daytime is thereby necessary. The accumulated warm air inside the house needs to be ventilated during the colder nights by means of the ventilation panels. This is called summer night ventilation. Keeping the panels closed during the night results in increased heat accumulation on the following day, which makes it more difficult to cool the house with ventilation.
During hot days when the windows and panels are closed, the mechanical ventilation needs to be applied, like in the winter situation, to provide a healthy indoor air quality. When the occupants are at home the level should be put on 2, and when using the shower or during cooking the level should be put on 3. In absence of occupants in the house, the level can be 1.

3.3.2 Building envelope

As explained before, an important principle for passive houses is a well-insulated and airtight building to keep the warm or cold air out. To check if thermal discomfort is caused by technical flaws in the building envelope, I made thermographic pictures with the Fluke TiR infrared camera from Mobius Consult. This camera has a resolution of 160x120 pixels. The pictures are made on a cloudy and rainy day on 23-4-2013 with an outdoor temperature of approximately 6 degree Celsius (KNMI, 2014).

3.3.2.1 Thermographic pictures

To check the thermal quality of the façade, extensive thermographic pictures were taken of several places of the façade of the building blocks (Appendix B).
Figure 16 shows a selection of the pictures taken from the various building envelope elements. Blue indicates the coldest parts of the façade, and red the warmest.
Analysis of the pictures showed that no important thermal bridges and air leaks were found. As can be concluded from the pictures, red spots can only be found at the seam of the entrance door, and at the windows that are opened. The rest of the solid façade doesn't show any leakages, which indicates at a proper installation of the building during construction. Even the window surfaces are showing good insulating properties.
This information is important to further investigate what the cause is of potential thermal discomfort, what the explanation of the variance in energy use is and what the cause of the difference between predicted and actual energy usage is.

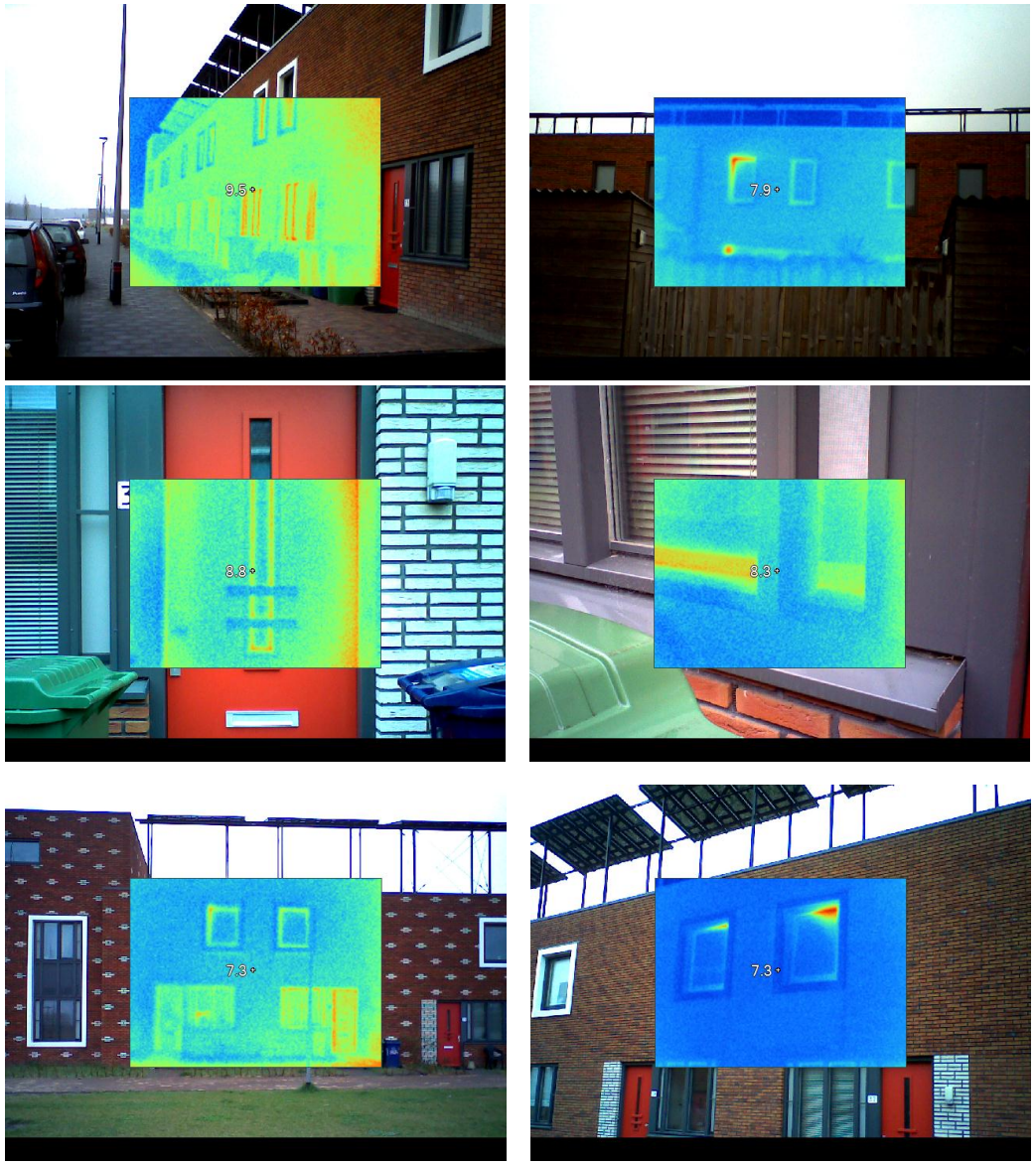


Figure 16: Thermographic pictures building envelope

3.4 Conclusions

The results presented in the previous paragraph give the answer to the sub question:

Are there technical causes that can explain the difference between the predicted and the actual energy use?

Based on the limited possible research methods into the technical performance of the houses, it can be concluded that the houses don't show any flaws in the technical performance considering the insulation performance of the building skin. After the analysis of the thermographic pictures, the building skin showed its good insulating properties without any significant heat leakages. Only the seams of the doors appeared to be a weak spot.
During this study it was not possible to perform more extensive and detailed investigation into the performance of the separate installations, like the mechanical ventilation unit, or to perform blower-door tests and U-value tests. Based on the information retrieved from the previous study by Cauberg-Huygen (Kalkman, 2008), there are no further clues that there are any relevant problems with the mechanical ventilation units.
Thus it can be assumed that there are no significant technical factors identifiable that can explain the difference between the predicted and actual energy use.
Moreover, since the houses are identical, it is also expected that technical factors only to a small extent explain the variance in energy use of these houses. Mainly differences in performance of the building services between individual houses may be responsible for this small extent.

4. DIFFERENCE PREDICTED VS. ACTUAL ENERGY USE

After explaining the energy principles of the houses, and the performance of the building envelope, I will now present the results of the predicted energy use and the actual energy use.
The actual energy use is obtained either from the occupants, or from the utility company with permission from the occupants, or from a previous study by Cauberg-Huygen (Appendix E1 and Appendix E2).
The predicted energy use is calculated according the EPC standard by Mobius Consult and the PHPP method by Cauberg-Huygen.
The two methods have some differences in their calculation to determine the heat demand. First, the most important differences between these two methods will be discussed. After that the predicted and actual energy use will be presented and compared.

4.1 Difference between EPC and PHPP calculation

A previous study proved that the predicted energy use for space heating
according to the EPN method systematically results in lower values than other calculation methods like PHPP (Lagae & Franke, 2006).
With the increasing energy efficiency of houses, the calculation method for incoming and outgoing energy flows becomes more critical.
Even though the EPN is primarily intended as a policy tool and not as a tool to determine the energy demand during the design stage, it is still important that the predicted energy use reflects the reality (Jansen, et al., 2009). Even more underlined by the fact that the EPN is commonly used during the design stage in The Netherlands. The PHPP method is specifically designed as a tool to be used during the design stage for passive houses (in contrast to the EPN) (Lagae & Franke, 2006).
Because both calculation methods have been used in the design stage of Columbuskwartier, it is interesting to get a better insight in the different outputs and most of all what the explanatory factors are for this difference.
Jansen et al. (2009) studied the difference between the EPN en PHPP calculation methods specifically focussing on low energy houses. They used reference buildings for this study and applied passive house techniques, which in turn are modelled according to the EPN method and the PHPP method. The difference between the results can be explained by:

- The underlying calculation method. The EPN is an easy to use calculation method where only a limited amount of input parameters need to be used. PHPP is a more extensive calculation method and requires more input parameters.
- The standard assumptions in the calculation methods differ. EPN uses default values as representative values for a typical Dutch residence. PHPP is developed in Germany and specially adjusted for low energy residences. These different background lead to different assumptions for instance the used internal heat loads. The weather conditions are the same for both methods.
- The input parameters differ. The modelling method is different for EPN and PHPP. The EPN method uses the interior dimensions of the residence, while PHPP uses the exterior dimensions.

By comparing a situation where the standard assumptions are identical for the EPN and PHPP method, they concluded that the main reason for the difference between the results of the two methods is the difference in the used standard assumptions and not the calculation method itself. The assumptions that showed to have the biggest influence on the difference are:

- Assumption of the internal heat load (higher in EPN than PHPP)

- Assumption of indoor air temperature (lower in EPN than PHPP)

It must be noted that the comparison in this study is based on the input data used in NEN 5128 from 2008. The results of this study have been used to develop the new NEN 7120. This new NEN version includes new input parameters for the internal heat load and indoor air temperature, which makes the difference between the EPC and PHPP results smaller.

In the case of Columbuskwartier, the heat demand (space heating and tap water heating) resulting from the EPN and PHPP method is presented in Table 6).

	Predicted heat demand	
	kWh/m2	GJ
EPC	38	12.7
PHPP	27.3	9.1

Table 6: heat demand EPN (NEN 7120) and PHPP retrieved from Mobius Consultancy Appendix D and Cauberg-Huygen

It shows that the heat demand calculated with the EPN method is higher than the heat demand resulting from the PHPP method.
The division in space heating and tap water heating for the different methods is presented in Table 7.

	space-heating *kWh/m2*	water-heating *kWh/m2*
EPN	13.4	24.6
PHPP	9	18.3

Table 7: space heating and water heating resulting from EPN (NEN 7120) and PHPP

	space-heating	water-heating
EPN	35%	65%
PHPP	33%	67%

Table 8: share of space heating and water heating in total heat demand (percentage)

Both the space heating and water heating demand are higher resulting from the EPN method compared to PHPP.
The share of space heating and water heating is in both cases almost the same (Table 8).
The reason for this difference between the space heating demand in this specific case is mainly caused by the share of ventilation influence. The EPN method takes into account a certain amount of natural ventilation, while the PHPP method assumes no natural ventilation at all (windows and doors always closed). For this reason the results from PHPP can be considered too strict in this specific case. The natural ventilation panels are part of the design, so this should also be taken into account in the calculation.

However, EPN and PHPP are steady-state calculation methods, which means they are not able to simulate dynamic circumstances. Other more complex software like TRNSYS is able to execute dynamic calculations, which gives a better representation of the reality than the steady-state calculation methods. Cauberg-Huygen modelled a residence of the Columbuskwartier in TRNSYS with a resulting space-heating demand of only 5 kWh/m^2. The numbers show that it is very difficult to make an accurate prediction of the energy use of houses, and small differences in the input can lead to relatively large differences in the output.

For this research I will focus on the heat demand resulting from the EPN calculation. Most important reason for this choice is that the background information of the EPN calculation is available for

Columbuskwartier, while there is no further information available about the used input data of the PHPP and TRNSYS calculations. Second reason is related to the fact that the influence of the natural ventilation is taken into account in the EPN calculation, which is a part of the design of the houses in the Columbuskwartier.

4.2 Predicted energy use

For comparing the predicted energy use with the actual energy use I will use the heat demand that follows from the EPC calculation in this case. The comparison will be limited to the heat usage of the houses. The data that is used is retrieved from the EPN calculation done by the consulting company Mobius (Appendix D).
To be able to make a comparison, first the predicted heat usage must be defined.
For these houses, the total heat usage exists out of space heating and domestic water heating, with the district-heating network as a heat source.
EPC calculation has resulted in the following energy uses for space-heating and domestic water heating (Table 9):

	MJ	GJ	kWh/m^2
Space heating	4460	4,5	13,4
Domestic water heating	8212	8,2	24,6
Total		**12,7**	

Table 9: Predicted heat usages according EPN (NEN7120) obtained from Mobius Consult

These two variables together make a total of 12,7 GJ annual heat usage.
This means that if the design is applied as intended, the houses should not use more than 12,7 GJ a year.

4.3 Actual energy use

To get insight into the actual energy usage of the houses, energy data is collected by the user survey. The results of this survey will be discussed in the next chapter, but the results of the energy usage will already be presented to determine the scope of the problem.
Out of the 75 identical houses, 7 respondents gave information about their energy usage from 2011 and 2012. The remaining energy use data is obtained from the utility company with permission of the concerning occupants (4 respondents) and 2 from previous study from Cauberg-Huygen (Appendix E1).

The data from these two years are averaged in order to make the comparison with the predicted usages (Table 10) (Appendix E2).

House	Average heat usage 2011-2012 (GJ)
A	27
B	9
C	9
D	15
E	8
F	17
G	21
I	7
K	10
L	7
M	14
N	16
O	20

Table 10: Actual heat usage

4.4 Predicted vs. Actual energy use

Comparing the previous data with each other gives the following result presented in Figure 17. The red line clearly marks the heat usage estimation following from the EPC calculation (12.7 GJ), while the green bars show the actual heat usages of the houses.
It shows that some houses have a heat usage that is below the predicted usage, but a small majority of the houses use more heat than predicted. To be accurate, 46 % scores lower and 54 % scores higher than predicted (Figure 18).
A closer look at the results shows that the lowest heat usage is 7 GJ, and the highest 27 GJ. This means that there is a difference of 20 GJ among the houses, and that the highest usage is almost twice the predicted heat usage.
The standard deviation of the heat usage is 6.3 GJ from the measured average actual heat usage of 13.8 GJ (Figure 19).

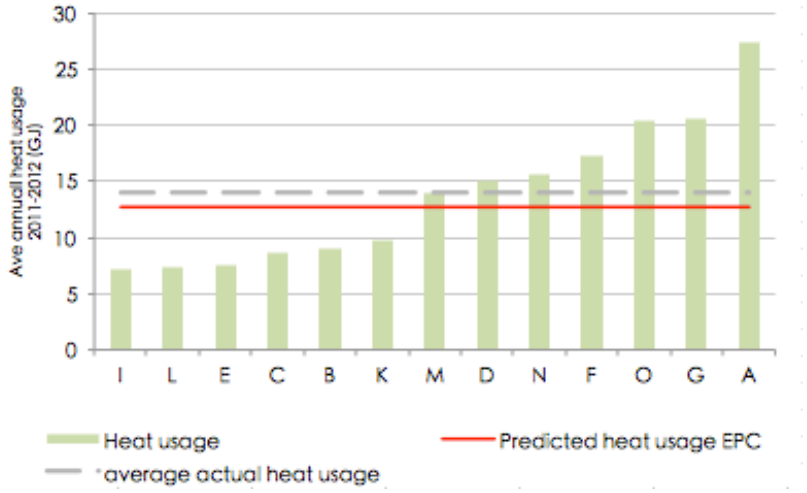


Figure 17: Actual heat usage vs Predicted heat usage EPC

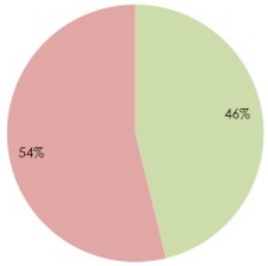


Figure 18: Percentage occupants above and below predicted EPC

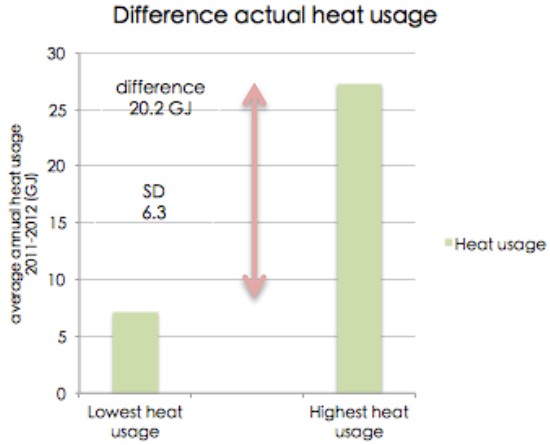


Figure 19: Difference actual heat usage

Although the difference between the individual actual energy usages of the occupants is significant, the difference between the predicted and average actual energy use is relatively small. Looking at Figure 17, the difference between the red line (predicted use) and the grey dotted line (average actual energy use) is not so big. The average actual energy use is 9% higher than the predicted energy use following from the EPC, which is not a bad result.
To emphasize the difference between the EPC and the PHPP heat demand calculation, Figure 20 shows the comparison of the actual heat usage and the predicted heat usage following from PHPP 9.1 GJ Table 6). The difference between the predicted and the average actual energy usage in this case is 52% showing a larger difference than the EPC calculation. In this case 62% of the occupants use more energy than predicted (Figure 21).

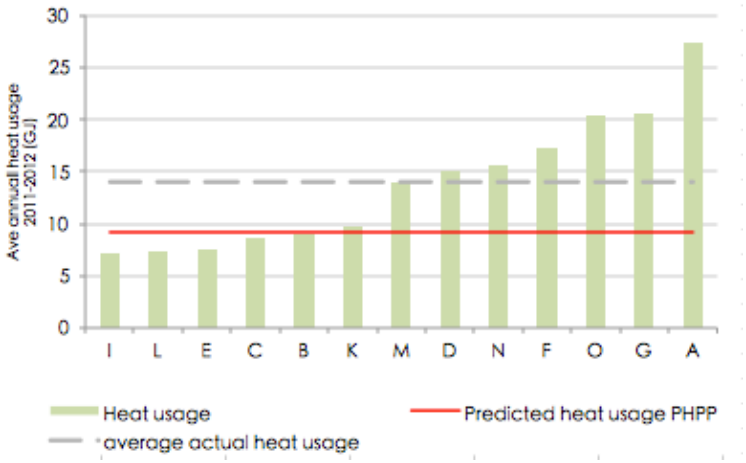


Figure 20 Actual heat usage vs. Predicted heat usage PHPP

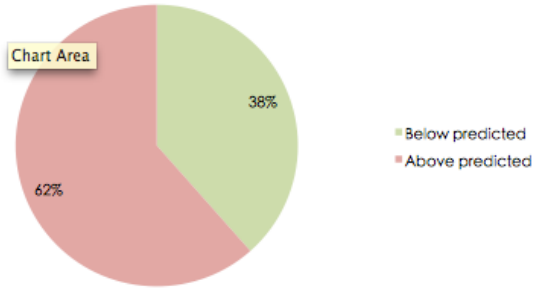


Figure 21: Percentage occupants above and below predicted PHPP

4.5 Conclusion

With the previously presented results, the following sub question can be answered:

What is the difference between the predicted and actual energy usage.

The average actual heat use is 9% higher than the predicted heat use following from the EPC calculation of 12.7 GJ.
54% of the occupants have a higher heat usage than the predicted.
In comparison with the PHPP results, the actual energy use is 52% higher than predicted with 62% of the respondents using more energy than the predicted 9.1 GJ.

Besides, we can conclude that there is a big difference in energy usage among occupants. The difference between the lowest and the highest user is 20.2 GJ and the standard deviation of all respondents is 6.3 GJ from the measured average actual heat usage of 13.8 GJ.

This result, together with the positive results from the thermographic pictures, which didn't indicate any thermal leakages, emphasizes the significance for further investigation into the causes of the variance and the share of the household characteristics and occupant behaviour.

With this information another sub question can be answered:

What is the share of technical factors in the actual energy use?

During this study I was only able to make thermographic pictures of the building skin of the houses. Analysis of the pictures showed no heat leakages in the building skin. The only conclusion that can be made is that the insulation has been properly installed during construction and that the difference in energy use can not be explained by heat leakages in the building skin.
A more comprehensive and detailed answer on this sub question cannot be given, because the installation performance and the skin's airtightness and U-value have not been investigated.

5. USER SURVEY

5.1 Previous research Columbuskwartier

From the beginning it was clear for the housing corporation GoedeStede that it was different to live in a passive house from living in a traditional house. For this reason they understood it was necessary that special care was needed for providing information and user guides to make the project work especially taking into account that it concerns social housing and (most of the) occupants do not make an explicit choice for living in a passive house.
In their ambitious start to fulfil this vision, they started making a FAQ, user guides and personal one-to-one information during the rental intake. Subjects they gave special attention to were:

- The use of the ventilation panels and energy friendly lighting.
- The use of the heating system, and how to warm the spaces without radiators.
- The use and maintenance of the ventilation system
- The use and crediting of the PV panels

After one year occupation of the houses, GoedeStede commissioned the consulting company Cauberg-Huygen in collaboration with OTB research institute to execute a user survey, in order to give insight in the user satisfaction and performance of the residences.

5.1.1 Previous survey results Cauberg-Huygen

The questionnaire studied occupant characteristics, their motivation to choose the house and their general satisfaction with the house. In more detail, the study examined end-user satisfaction regarding comfort (thermal comfort in winter and in summer, acoustics, air quality) and satisfaction with climate control and ventilation maintenance. The influence of occupant behaviour was also evaluated in winter and in summer, as well as the satisfaction with information provision.
The occupants showed awareness of - and positive attitude towards – several energy-saving measures, and defined possible technical deficiencies. While the study confirms general satisfaction, particularly cold bedrooms were found to be an item for concern, possibly caused by a combination of lack of heating in these rooms and window/shutter behaviour. The study found that user behaviour and information provision could be improved.
(Mlecnik, Schuetze, & Vries, 2012)
The used survey can be found in Appendix E1.

5.1.2 Summary results

Table 11 gives an overview of the most important results that match the aim of this specific study.

Thermal comfort
- Too cold during winter (bedroom and living room) - Missing a radiator in bedrooms - Bedrooms too warm during summer - Experiencing draft
Ventilation behaviour
- Use of extra natural ventilation in kitchen and bedrooms besides the mechanical ventilation - Natural ventilation during summer not applied as intended - Majority of respondents have the windows or ventilation panels open during the day.
Satisfaction building services
- Low satisfaction with heating system. Heating up the building takes too long. - Mechanical ventilation not sufficient to exhaust polluted air from kitchen and bathroom - Maintenance of ventilation system mainly positive experience.
Motivation
- Only 3 of the 21 respondents answered they explicitly choose this house because of the fact it is a passive house. - 52% do give a high value for the fact it is a passive house
Specific knowledge building services
- Very low knowledge about bypass - Little knowledge about heat recovery system on ventilation air. - Ambiguities about how to warm up the building during winter - Knowledge about working of the PV-panels and the crediting with the energy provider not sufficient.

Table 11: summary results OTB survey

5.1.3 Conclusions survey

OTB Research institute was responsible for the analysis of the collected survey results. The aim of the study was to learn about the meaning of this unique project for future developments.
The study showed that the respondents did know they lived in a passive house and generally valued this as an important characteristic of their house, even though in most of the cases this was not a motivational factor for choosing this house. Referring to the fact it concerns social housing, more important motives were decisive.
General satisfaction of the houses scores 8 out of 10 points, which indicates a positive general satisfaction.
The study did reveal dissatisfactions about thermal comfort and about knowledge about the use of building services. Besides, it also gave more insight in some behavioural aspects of the respondents regarding the use of the mechanical ventilation, natural ventilation and heating system (see Table 11).
The importance of this study lays in the fact that it was a first attempt to give insight in the experience and behaviour of the occupants in low-energy residences. Because this study was especially designed and executed for the housing corporation, it has an advising character concerning the provision of information from the housing corporation.
The results show that the knowledge about the mechanical ventilation, natural ventilation and heating systems together is insufficient. Thus, improvement of the information provision is the main tool of the corporation.
Besides showing the possibilities for information provision improvement, the study does also underlie that it may be possible that there are design weaknesses responsible for the experienced dissatisfactions. This study was not able to prove exactly the relation between (dis)satisfaction and the correct use of the building services, but does give suggestions what the underlying design weaknesses could be.

The main conclusion stays limited to the advice that the information provision about the building services and applied energy concepts should be improved.
These suggestions form a good basis for this study; as a starting point to investigate in more detail the occupant behaviour in relation to the performance of low-energy residences.
Besides this OTB study as a starting point, it is also interesting to compare some results from this study with the OTB study to see if there is a different level of satisfaction or a different behaviour noticeable.

5.2 Structure new survey

The start of my own study means starting with constructing the user survey. The first step for making this survey was to determine was determining which specific topics/variables were desirable to investigate, and which matching questions would provide the appropriate answer. These topics/variables form the structure of the resulting survey:

- Household characteristics
- General knowledge
- Specific knowledge about building services
- Satisfaction with building services
- Motivation
- Thermal comfort
- Ventilation comfort
- Awareness
- Attitude
- Current energy saving behaviour
- Influence previous type house
- Ventilation behaviour

Each category contains one or more questions that need to make it possible to make conclusions in the end. The subdivision of the questions in categories will be made clear in paragraph 6.3.

Formulation these questions was a process of compiling useful questions from the previous study by Cauberg-Huygen and OTB, and survey questions set up by AgentschapNL regarding this topic (Appendix E1).

The final survey that I developed and used can be found in Appendix E2.

5.3 Definitions

5.3.1 Household Characteristics

The survey included only a few socio-demographic variables that had been proven to influence energy consumption in previous studies (Biesiot & Noorman, 1999; Jeeninga, et al., 2001; Vringer, 2005).
Because of the fact that the main research question focuses on the relation between occupant behaviour and energy use, information about the socio-demographic variables were minimized.
The variables that were gathered are: household size, presence of children, presence at home, education level and age. The variable income was not collected, because the studied objects are social housing residences, which means the occupants cannot earn more than €34.229 gross annually. Thus even though previous studies have shown a relation between income and energy use (Guerra-Santin & Itard, 2010), it is not relevant to take this into account for this study.

Corresponding questions survey:

Question number	Subject
3	Age
5	Education level
6	Household size
11	Presence

5.3.2 General knowledge

According to previous studies, it has been shown that there is a relation between education level and energy use. To make this variable a bit more specific, the survey included several questions to indicate the level of knowledge specified for energy-saving measures. General knowledge can be defined in this study as: *The knowledge level about how to save energy in residences.*
The relevance of this variable is based on the assumption that more knowledge will heighten the awareness of environmental problems and of the environmental impacts of behaviour, and/or will increase their knowledge of behavioural alternatives and their pros and cons. It is assumed that new knowledge results in changes in attitudes, which in turn will affect behaviour (Steg & Vlek, 2009) (Lindenberg & Steg, 2007).

Corresponding questions survey:

Question number	Subject
55	Several general knowledge questions

5.3.3 Specific knowledge

Besides information on general knowledge, the survey also gathered information about the respondents' specific knowledge of how to use the building services that are present in the studied residences. Specific knowledge in this study can be defined as: *The level of knowledge the occupant has about the use of the building services in his/her own house.*
The previous occupant survey in these residences showed that there was a lack of knowledge about how to use the applied climate installations. After that first study, the housing corporation took measures to improve the information available for the occupants on this topic.
This survey will show if these measures resulted in a better understanding of how to use the passive houses (occupant information chart in Appendix A).

Corresponding questions survey:

Question number	Subject
21	How do you ventilate during summer
31	How do you ventilate during winter
33	How do you use the ventilation panels
36.3	I know how to use the present installations

In order to be able to compare the survey results of the occupants with each other, the results of the separate questions are converted and rescaled based on the correct and incorrect answers of the occupants, and are finally combined in one total score for specific knowledge in a ranking from no knowledge to a lot of knowledge (Appendix G1 Table G-1 and Table G-2).

5.3.4 Satisfaction with building services

Besides the knowledge about how to operate the building services, the survey also contains questions about the satisfaction of the occupants with the building services.

Corresponding questions survey:

Question number	Subject
27	Are there enough radiator present
34	Satisfaction several installations
35	Satisfaction ventilation system

5.3.5 Motivations

According to Vringer et al. (2007), motivation is a central concept for consumer behaviour.
They state that "*motivation activates and maintains certain behaviour; it also determines the direction and strength of this behaviour*" *(Vringer et al. 2007 p.554)*.
In the theoretical framework concerning the term motivation, we can distinguish two main perspectives:

- Needs-based theories
- Goal-based theories

Regarding needs-based motivation, Hull showed that physiological deficits, like a shortage of food, give rise to a physical need that activates a drive to satisfy this need (Hull, 1943). This description clearly points out that this theory is based on the biological process of fulfilling basic necessities, which forms a motivation for acting a certain way.

One goal-based theory is goal-framing. This theory explicitly acknowledges that behaviour results from multiple motivations. This

theory postulates that goals govern or "frame" the way people process information and act upon it. When a goal is activated (that is, when it is the "focal" goal or "goal-frame"), it influences what a person thinks of at the moment, what information (s)he is sensitive to, what alternatives (s)he perceive, and how (s)he will act (Steg & Vlek, 2009).
Three general goal-frames are distinguished:

- Hedonic goal-frame (to feel better right now)
- Gain goal-frame (to guard and improve one's resources)
- Normative goal-frame (to act appropriately)

Goal-framing theory proposes that motivations rarely are homogeneous. One goal is focal and influences information processing the most (that is, it is a goal-frame), while other goals are in the background and increase or decrease the strength of the focal goal. Thus, multiple goals are active at any given time. When background goals are compatible with the goal-frame, they strengthen it. But when the goal-frame and background goals are in conflict, the latter weaken the strength of the goal-frame (Lindenberg & Steg, 2007).

For this study motivation must be interpreted according to the goal-frame theory, because this study is not specifically asking about one's motivation to fulfil a certain physical need. The only physical need that is studied is the thermal comfort of the occupants, which will be explained further on.
Motivation for saving energy is a normative goal.
If consumers are motivated to save energy, it can be expected that a higher motivation of the occupants results in a lower energy consumption. If consumers act as they think about societal problems, those who think that energy-related societal problems, such as climate change, are more important than other problems are expected to use less energy (Vringer, et al., 2007).
Corresponding questions survey:

Question number	Subject
9.6	You preferred living in a passive house
10.1	Importance of Environmental friendliness
10.7	Importance of living in a passive house
47	Future plans concerning saving energy

The separate questions that form the category motivation are combined in a total score for motivation (ranked from no motivation to very much motivated) for the individual occupants to be able to compare the results. The answers are converted and rescaled based on this ranking, so the combined questions can give insight in the level of motivation for each occupant (Appendix G2 Table G2-1 and Table G2-2).

5.3.6 Thermal comfort

Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment (NEN-EN-ISO 7730).
The topic of thermal comfort alone is extensive, and to investigate this properly, detailed research needs to be done. For this study, thermal comfort will only be studied from the occupant's perspective, i.e. if they experience thermal comfort or not and whether it affects behaviour as a need-based motivation.

Corresponding questions survey:

Question number	Subject
18	Temperature experience summer
19	Temperature preference summer
25	Temperature experience winter
26	Temperature preference winter

5.3.7 Ventilation comfort

In this study, ventilation comfort is closely related to thermal comfort. The questions about ventilation comfort are limited to how the supply air of the mechanical ventilation is experienced.

Corresponding questions survey:

Question number	Subject
20	Experience ventilation air summer
28	Experience ventilation air winter

5.3.8 Awareness

Defining the word awareness brings some difficulties due to its versatile and abstract meaning especially from a scientific perspective.
Problem awareness has been shown to be an important antecedent for pro-environmental behavioural intentions and behaviour (Stern, Dietz, Abel, Guagnano, & Kalof, 1999)
General problem awareness is important for pro-environmental behaviour to occur, and specific problem awareness may be seen as dependent on this general awareness. Thus, general problem awareness was expected to positively influence the degree to which the individual has specific awareness about the environmental consequences of energy use an about the seriousness of these problems (Nordlund & Garvill, 2003).
For this study, the specific problem awareness as described above, is defined as *the specific perception and knowledge of an occupant concerning his/her energy use, and the consequences of his/her actions. Whether (s)he in the end decides to really act pro-environmentally does not matter*

Corresponding questions survey:

Question number	Subject
38	How much do you do when it comes to saving energy in home
39	Do you think you van save more energy than you currently do
40	If you compare yourself with the people around you, do you save more or less energy
48	How energy friendly do you think your house is
49	Do you know your annual electricity use by heart
51	Do you know your annual heat use by heart

To get insight into the level of awareness of the individual occupants and to be able to compare this level of awareness, the separate questions in this category are converted and rescaled based on a ranking from not aware to very much aware (just like the motivation category). The total awareness score of the occupants is used for the statistical analyses (Appendix G3 Table G3-1 and Table G3-2).

5.3.9 Attitude

Attitudes are closely related to motivations. It is even justifiable to say these two terms are interdependent and can increase or decrease each ones strengths.
The term attitude refers to *a personal settled way of thinking or feeling about the general perspective on saving energy.*

Several studies found a relation between energy use and consumer attitudes. These studies have mainly been executed in the field of the social sciences. Pointing out one of these studies, Lutzenhiser mentions the intentions and behaviours as the result of a dynamic balance between the individual decision maker's attitudes and the influence of his or her social environment (Lutzenhiser, 1993).
This study also shows the interdependent (dynamic) relation between motivation, attitudes and the resulting environmental behaviour. Important is the notion of the influence of the social environment on attitude. The social influence plays also a part in the goal-framing theory.

Because the definition of motivation and attitudes differ in subtle ways, the difference can be described as:

Attitude refers to a personal settled way of thinking or feeling about the general perspective on saving energy.

Motivation activates and maintains certain behaviour; it also determines the direction and strength of this behaviour.

Motivation contains a more resulting action in its definitions than the term attitude alone does.

Corresponding questions survey:

Question number	Subject
56	Multiple questions about attitudes towards energy saving measures.

Although the attitude category is only based on one question in this survey, the results of the survey also need to be modified in order to get a total score on attitude for the individual occupants. The used question consists out of multiple sub questions that need to be answered with agree or disagree on a five-point scale. These answers are manually converted to a five-point ranking from a negative to a positive attitude towards energy saving measures (Appendix G4 Table G4-1 and Table G4-2).

5.3.10 Current energy saving behaviour

Besides the variables attitude and awareness of energy use, the survey also included questions about the current energy saving behaviour of the occupants. Most of these survey questions concerned incidental behaviour. Comparing the actual energy saving behaviour with the occupant's awareness and attitude will also give a better insight in their perception of behaviour related to their actual behaviour.

Corresponding questions survey:

Question number	Subject
38	How much do you do when it comes to saving energy in home
41	What energy saving measures to you take
42	Do you use energy saving lamps
43	Do you use an energy saving showerhead
44	Do you pay attention at the energy label when buying new appliances
46	What is the average living room temperature during winter

Just like several previous categories, the results of this category need to be combined in order to get a final ranking of the occupants who take no energy saving measures to occupants who take a lot of energy saving measures. Because of the different ranking scales of the separate questions, the questions are manually converted and rescaled based on the raking from no energy saving measures to a lot of energy saving measures. Summing the scores gives a total score for the individual occupants and enables the comparison (Appendix G5 Table G5-1 and Table G5-2).

5.3.11 Influence of previous type house

Investigating the relation between habits and building-related energy use is a big topic, which can be a whole study on its own. Guerra-Santin and Itard (2010) showed that the type op previous house was associated with the hours the radiator was on in the living room, the bedrooms, the bathrooms, and the entrance. Because they showed that behavioural patterns in a previous house could influence behavioural patterns in a new house, the question of type of previous house and building period has been included in this survey. Based on the building type and period, a scale has been made from not energy efficient buildings to very energy efficient buildings. Theoretical frameworks largely imply that individuals make reasoned choices. However, in many cases, behaviour is habitual and guided by automated cognitive processes, rather than being preceded by elaborate reasoning (Steg & Vlek, 2009).

Corresponding questions survey:

Question number	Subject
15	Previous building type
16	Previous building period

In this category, we want to know if the level of energy efficiency of the previous building is related to the current energy use. First step that needs to be taken is to rank the results of these two survey questions into not energy efficient buildings at all to very energy efficient buildings. The building period and building type together determine the energy efficiency of the previous building. For example, family houses built between 1930-1950 are ranked as not energy efficient at all, and apartments built after 2005 are ranked as very energy efficient (Appendix G6 Table G6-1 and G6-2). Critical not is that there remains an uncertainty in the results, because of the fact that it is unknown if the previous houses have been renovated or not.

5.3.12 Natural ventilation behaviour

After indicating the level of ventilation comfort, occupants will also be asked about what kind of ventilation actions they take, to determine their ventilation behaviour. Ventilation will include mechanical and natural ventilation actions. This category forms the only one which involves the actual behaviour that occurs within the residences.

Corresponding questions survey:

Question number	Subject
21	How do you ventilate during summer
22	Frequency opening windows summer
23.2	Opening windows when living room is too hot
24.2	Opening windows when bedroom is too hot
29.3 & 29.4	How ventilating when living room too cool
30.2 & 30.3	How ventilating when bedroom too cool
31	How do you ventilate during winter
32	Frequency opening windows winter

5.4 Survey results

The following paragraph will give the first results from the user survey. The results will be categorized in the same sequence as the definitions description in the previous paragraph. This step forms the first step in the analysis process. The results are presented in the form of bar charts with a short description substantiated with boxplots when needed. The collection and summary of these results need to give insight and a starting point for the most significant factors that are related with energy use, and which factors thus are of importance for further detailed analysis, which will be executed with SPSS (Appendix E2 and Appendix F). Out of the 75 available houses, I collected 15 useful filled-in questionnaires (sample size N=15, response rate 20%), and 13 of these results are related to the average energy use details of 2011 and 2012. 7 respondents gave information about their energy usage from 2011 and 2012 in the user survey themselves. The remaining energy use data is obtained from the utility company with permission of the concerning occupants (4 respondents) and 2 from a previous study by Cauberg-Huygen. This means that from 2 of the 15 surveys the energy details were unknown. The general characteristics of the response group are illustrated in Figure 22 to Figure 24.
The target sample size was 30 useful surveys. This amount would have been large enough for the population to be representative for the executed statistical analysis. Unfortunately, it was not possible to collect more than 15 surveys during this study. A sample size of 30 would mean that the sampling distribution could automatically be considered as normally distributed (central limit theorem). The approximation of normal distribution increases as the sample size increases. With a sample size of 19 to 15 respondents, the sampling distribution is only by approximation normally distributed if the distribution of the original variables is symmetric (a roughly even amount of observations left and right of the average) (Field, 2013; Grotenhuis & Weegen, 2011).

Bias

Before starting with presenting the results of the first analysis, some critical notes about the possible bias in this study needs to be addressed. It is important to know how well the results of this study fit in the context of low energy houses in general. In other words we want to know how representative the response group of this research is for the total population of low energy houses.
First important characteristic of this sample group is that it concerns social housing with pre-selected occupants by the housing corporation. This means that the results can differ in another research including privately owned homes, where the characteristics of the occupants are more diverse than in this specific study.
Second important thing to address is the data collection method. In this research the survey data is gathered by door to door visits on different times during the week. The occupants have been approached on a Saturday afternoon, Sunday afternoon, Tuesday morning and Thursday evening. Although the attempts have been spread over different days and time, there is still a chance that a larger amount of occupants with different characteristics can be reached with more attempts on different times.
The third critical point is related to the used survey method. Using a survey, which is filled in by the occupants alone, brings along the risk of occupants not interpreting or understanding the questions correctly. This error always needs to be taken into account when using a survey.
The last factor that can bias the results is the location of the studied houses (Almere-Poort, The Netherlands). When performing this study on a larger scale, it is recommendable to collect data in more regions of the country, in order to get a more diverse occupant group that would be more representative on a national scale. For this study however, it is important to also investigate two identical houses (including monitoring), which makes it impossible to approach occupants from different districts.

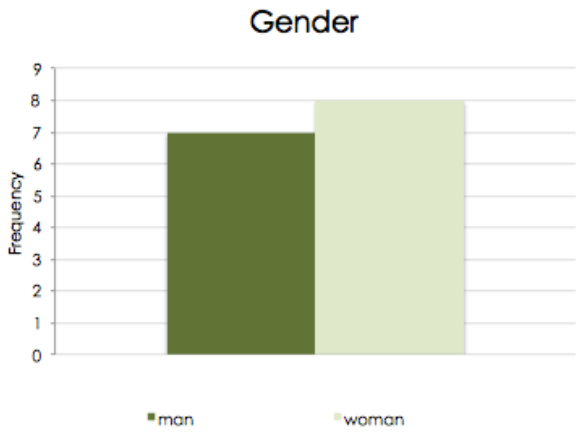
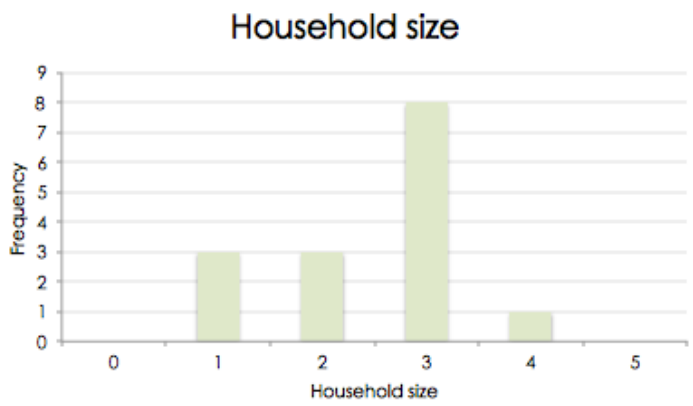


Figure 22: Gender distribution response group



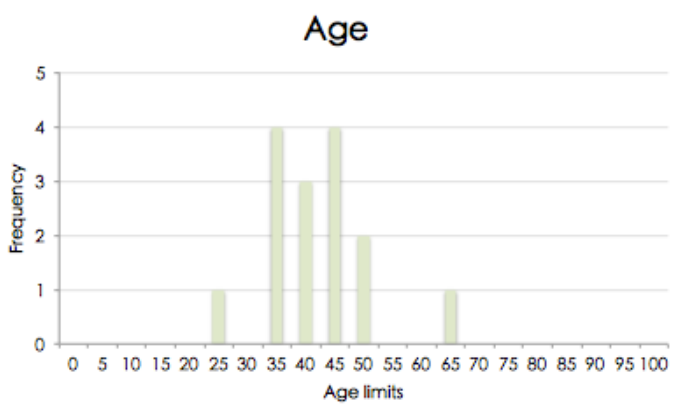


Figure 23: Household size and Age distribution response group

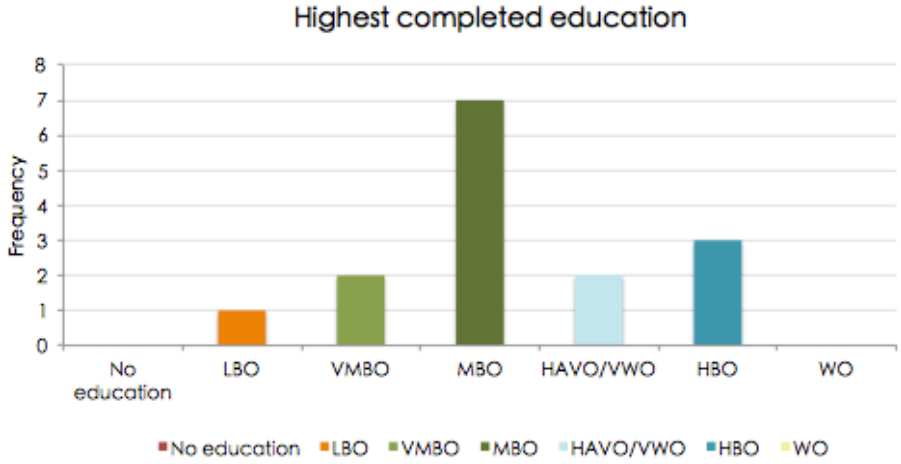


Figure 24: Education distribution response group

5.4.1 Household characteristics

Figure 25 and Figure 26 show the age and education level of the respondents compared to their average annual total (electricity and heat in MJ) energy usage. If we look at the results of age, we can see that in contrast with the results of previous studies (Liao & Chang, 2002) more energy is used by younger occupants. This can be explained by the fact that the oldest respondent is 65, and cannot be counted as an elderly, as meant in these previous studies. Besides, it can also be dependent on the fact that the younger respondents are part of a bigger household than the older respondents. Controlling this by making a boxplot of the data (Appendix H, Table H-1), it shows that the younger respondents indeed have a larger household than the older respondents (with one exception of a household of four).

If we look at education level versus total energy usage (Figure 26 and Appendix H Table H-2), we cannot directly see a clear relation. The expected result would be that the higher educated respondents show a lower energy use (Santin & Itard, 2010). In this study, there is only a peak of highest energy use visible in the group of respondents with a HAVO/VWO education. The lowest energy can be observed in the higher education category, but the difference with the lower educated group is very small.

The reasons for not finding a relation between the two variables can be dependent on a lot of different parameters. For this reason the variable education is made more explicit in the categories general knowledge and specific knowledge for this study, which will be presented in the next two paragraphs.

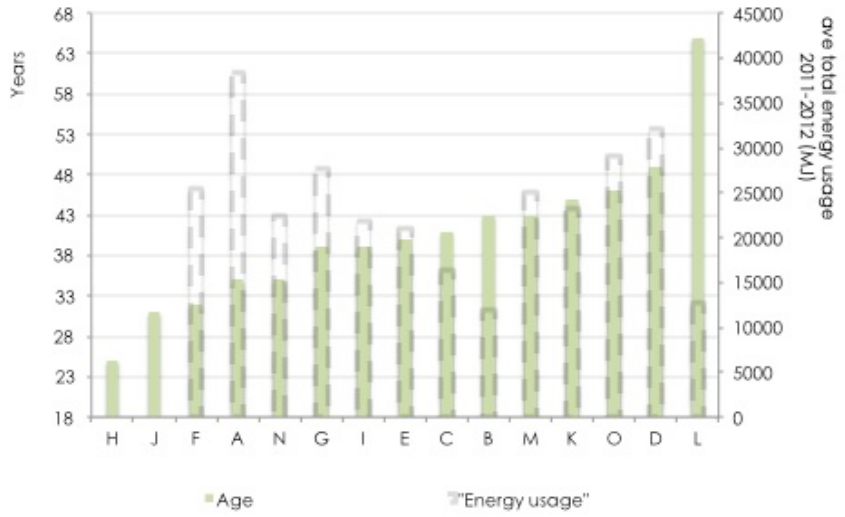


Figure 25: Age vs Energy use

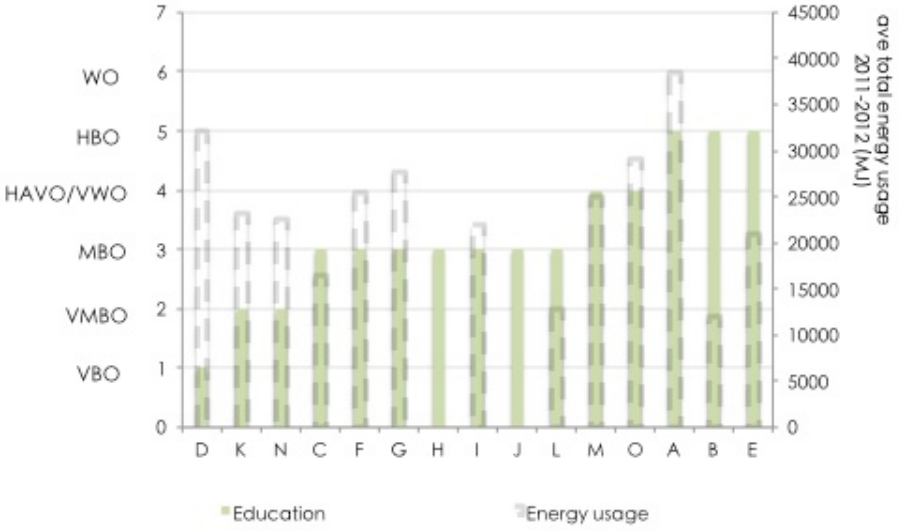


Figure 26: Education vs Energy use

Figure 27 and Figure 28 present the results of the presence at home and household size versus heat usage.
From the results of presence at home versus heat usage we cannot clearly conclude that the more people are at home, the more energy is being used, which has been proven in previous studies (Jeeninga, et al., 2001). This has everything to do with the fact that it's difficult to accurately answer this question in a questionnaire, which only gives a rough indication of reality. Presence needs to be monitored in the real situation in order to make conclusions for this variable. For this reason I will also monitor the presence at home in the two selected houses and will look at this relationship again further on this study.
An important household characteristic in relation to energy usage is household size. It is obvious that the more persons live in one house, the more energy is being used. Figure 28 and Appendix Table H-3 seem to underline this statement, with an outlier noticeable in house A. The households with two and three occupants use more energy than the single households, but a significant linear relation between the two variables cannot be deduced from these graphs.

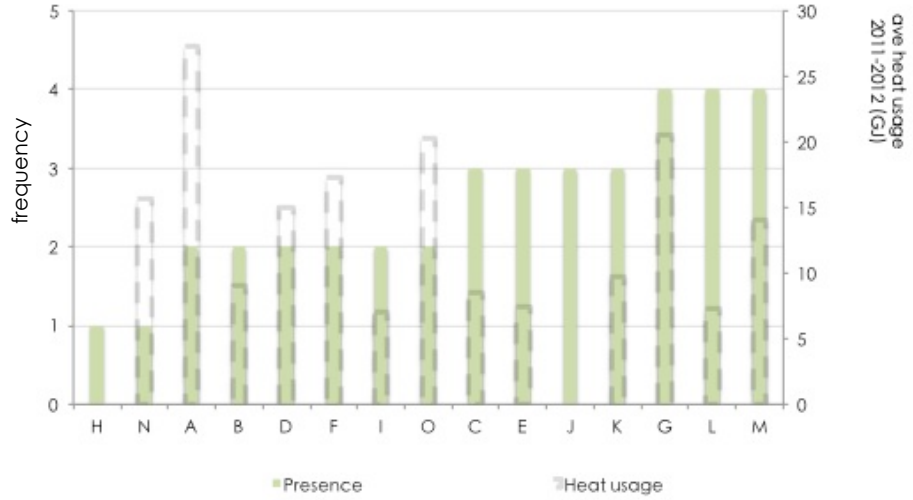


Figure 27: Presence vs Heat usage

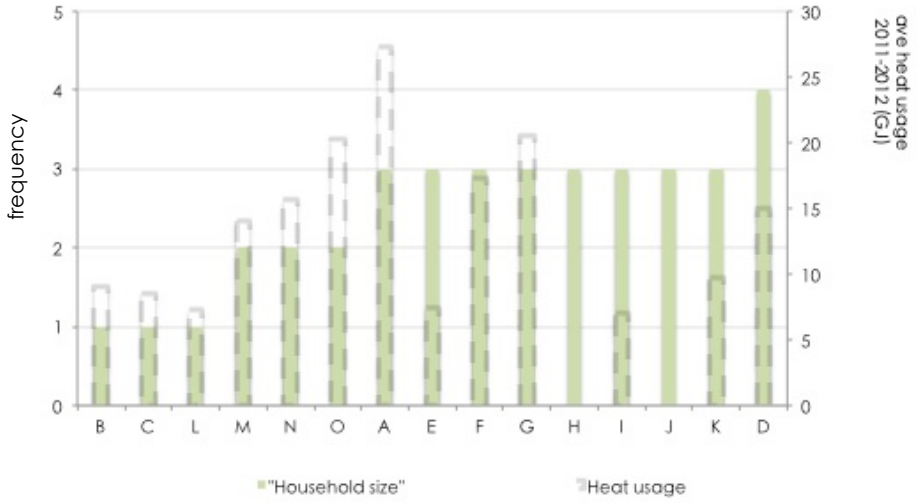


Figure 28: Household size vs Heat usage

Because of the fact that household size is an important variable that has a direct relation with energy usage, I compared the results of education level and presence at home with household size in Figure 29 and Figure 30.
For education level in relation to household size (Figure 29 and Appendix H Table H-4), we cannot see in this graph that the higher educated respondents have smaller or bigger households than the lower educated respondents. The bigger households can be found in both categories lower and higher educated respondents.
This is why, in this case, we cannot say that the higher educated respondents have (a slightly) lower energy usage caused by a smaller household size.
Controlling household size with presence of the occupants (Figure 30 and Appendix H Table H-5), the boxplot shows that the single households are the ones with the highest presence and the households with two occupants have the lowest presence. An explanation can be that the households with two occupants are both employed and for that reason spend more time from home than in home. The households with three occupants show an 'average' presence (compared to single households and a household with two occupants). In this case it is assumable that the three occupants rotate their presence at home, more than the households with two occupants, because of children.

This simple first comparison already underlies the complexity of the data analysis and the presence of multiple interdependent variables related to energy usage. The correct assumptions or conclusions can only be made based on combined variables, which requires a more detailed statistical analysis than the software Excel offers.
As said at the beginning of this paragraph, these first graphic results will be used to form first assumption of which variables are interesting for further extensive analysis for this study. Thus, it is important to keep in mind that these and the following graphs have no conclusive meaning.

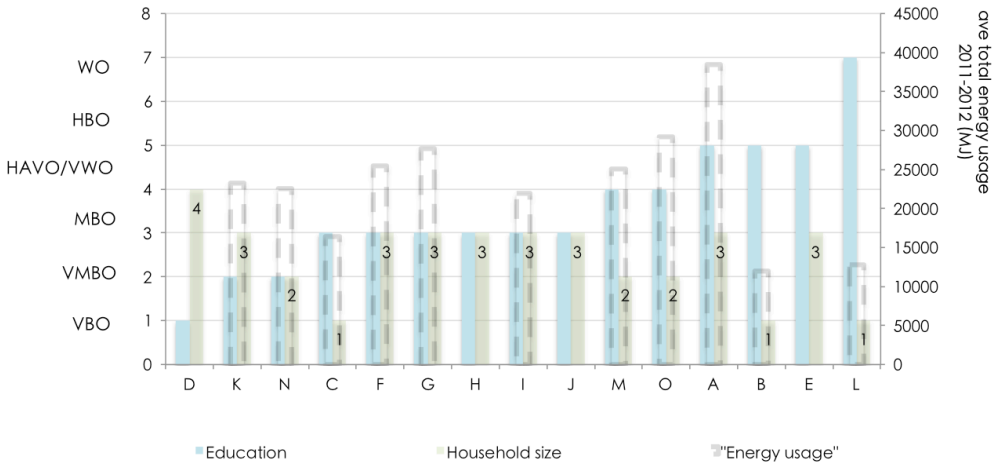


Figure 29: Education & Household size vs Energy usage

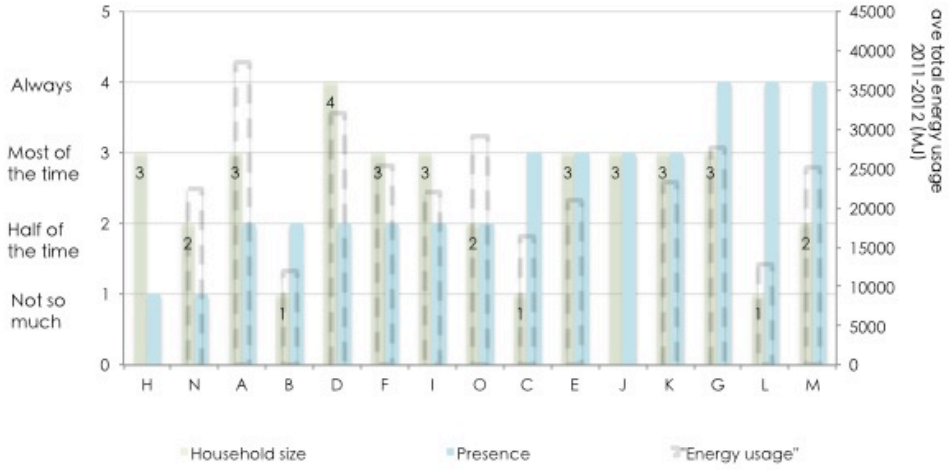


Figure 30: Presence & Household size vs Energy usage

5.4.2 General knowledge

In order to give a better impression of the knowledge level of the respondents besides their education level, the survey contained several questions about energy saving measures, which needed to be answered with correct or incorrect. The knowledge level scale is based on the amount of correct answers given by the respondents. The total score is the average of the given answers.
Figure 31, Figure 32 and Figure 33 all present the general knowledge level filtered from 'no knowledge' to 'a lot of knowledge' compared to the average electricity usage, heat usage and total energy usage respectively.
From a first look at electricity usage (Figure 31), we can see a positive relation with increasing knowledge, meaning that increased knowledge leads to increased energy use, whereas this correlation seems less positive for heat usage (Appendix H Table H-6 and Table H-7).
Again we would expect that the lower usage values would be found among the higher knowledge level group. This assumption that follows from literature (Jeeninga, et al., 2001; Uitzinger, 2004) cannot be confirmed by these survey results. The reason for this may depend on the influence of several (unknown) variables.

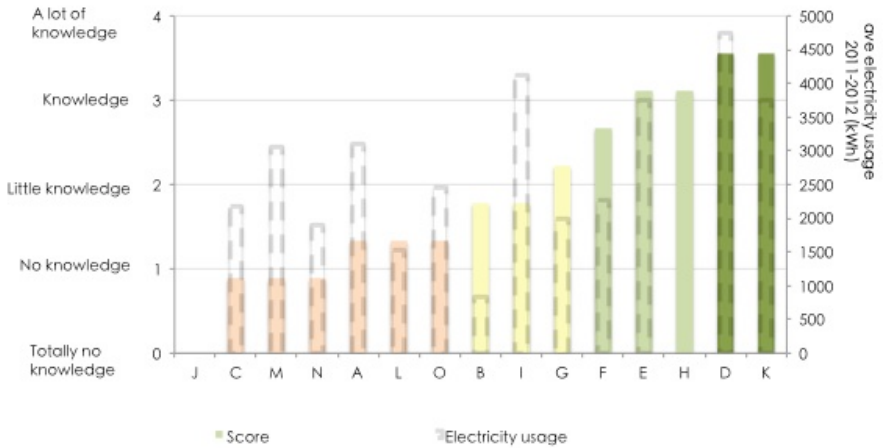


Figure 31: General knowledge vs Electricity usage

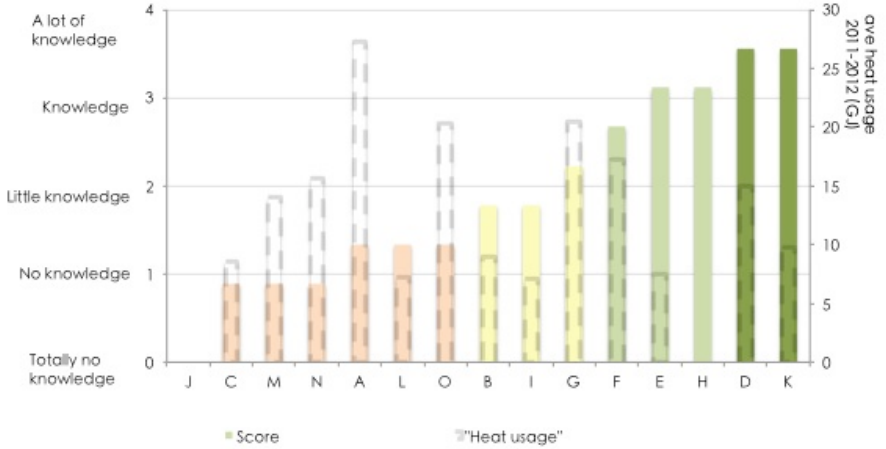


Figure 32: General knowledge vs Heat usage

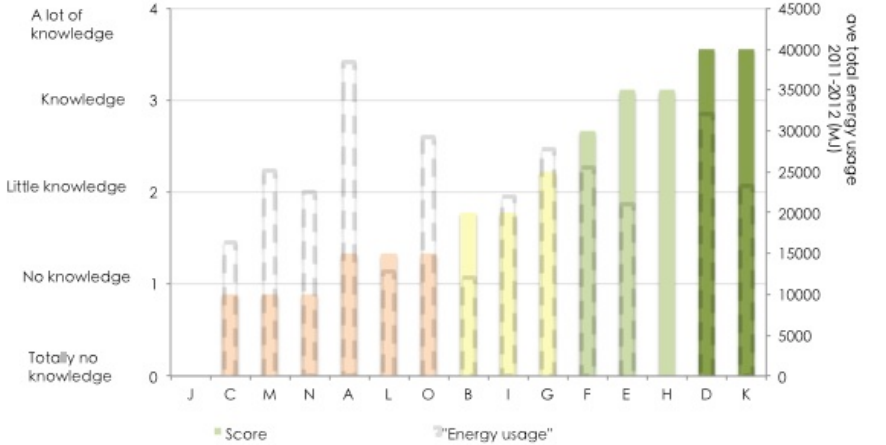


Figure 33: General knowledge vs Total energy usage

5.4.3 Building services knowledge

The last knowledge category zooms in on the specific knowledge concerning the building-related climate installations. The residences have a specially designed energy concept to keep the building cool during the hot summer days and warm during the cool winter days. This concept consists out of three separate systems: radiators, mechanical ventilation and natural ventilation. For keeping the houses cool and warm when needed, there is only one optimal way of combining the three energy systems. This fact makes it necessary for the occupants to possess the proper knowledge about how to adjust the systems in order to let the building function like it is designed. If there is a lack of this knowledge, it would logically result in a higher energy use than calculated during the design stage.
The survey contained several questions about the heating and ventilation systems to give insight in the knowledge level about the optimal operation of the installations.
Figure 34 and Figure 35 show the relation with resp. heat and total energy usage. The Electricity use is left out of consideration, because the subject of the questions in the survey is only of influence on the heat usage.
Even though the assumption made before sounds very logical, the results for heat usage however, show a more diffuse pattern among the different knowledge levels. The boxplot in Appendix H Table H-8 reveals that the respondents with no knowledge have the lowest energy use, while the respondents with little knowledge and knowledge have a comparable (higher) heat use.
More detailed analyses must be used to see if a relation can be revealed.

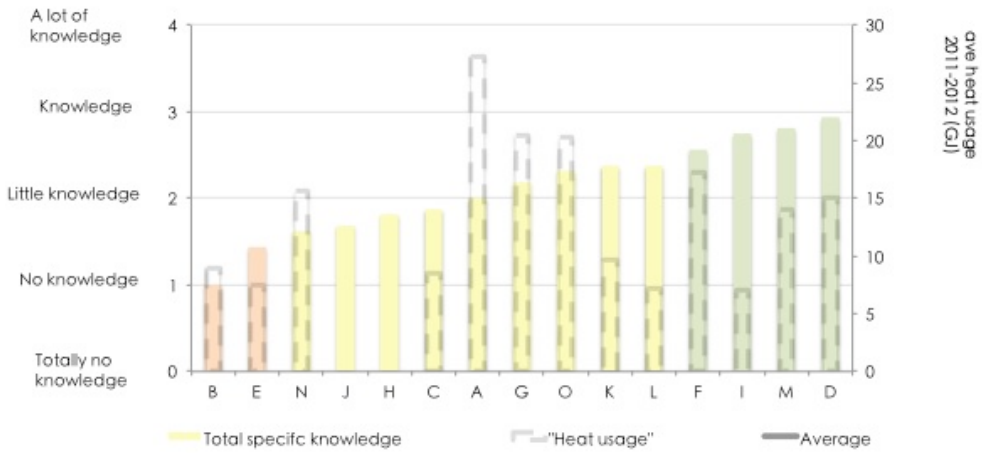


Figure 34: Specific knowledge vs Heat usage

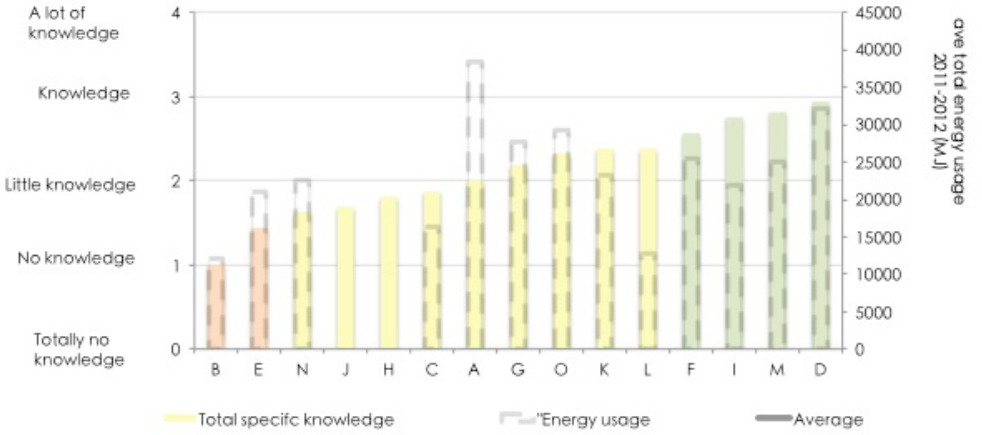


Figure 35: Specific knowledge vs Total energy usage

5.4.4 Satisfaction building services

The first survey that was executed after one year of occupancy and was analysed by OTB, gave insight in the satisfaction about the houses and the specific building-related installations. Some of these same questions are also included in this survey to compare these results with the previous results of two years ago, and see if there is a difference or not in the appreciation and satisfaction about the building services.
Because the different variables that are investigated have no direct influence on the energy usage, the graphs only show the results of the satisfaction regarding each topic and for that reason the energy usage is disregarded.
Figure 36 to Figure 40 show the results of the satisfaction with the different heating system elements. It shows that the general satisfaction about the heating system is positive. Subjects that show some unsatisfied respondents are the thermostat and the amount of radiators in the house.
Figure 41 to Figure 45 present the results of the satisfaction with the ventilation system. The general satisfaction for this system is also positive. The topics maintenance and ease of operation show a few respondents who are unsatisfied.
The separate topics for heat and ventilation are summed in two main categories for heat and ventilation satisfaction (Figure 44 & Figure 46). The overall ventilation satisfaction is related to the total energy use and the overall heat satisfaction with the heat usage. As we can see, the satisfaction category is not showing any direct relation with the energy usage. Thus, this category will only be used to compare these results with the previous survey.

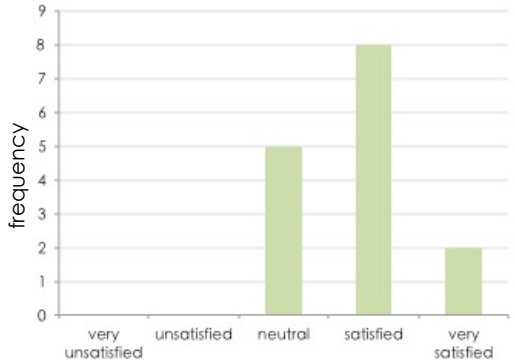


Figure 36: Domestic water heating

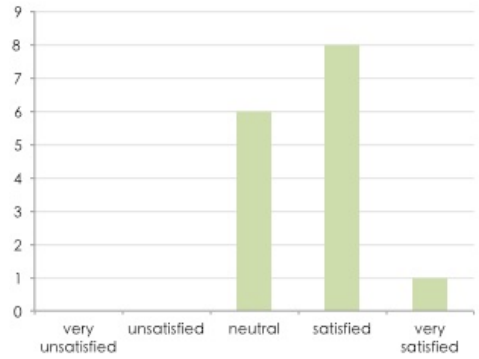


Figure 37: Heating system

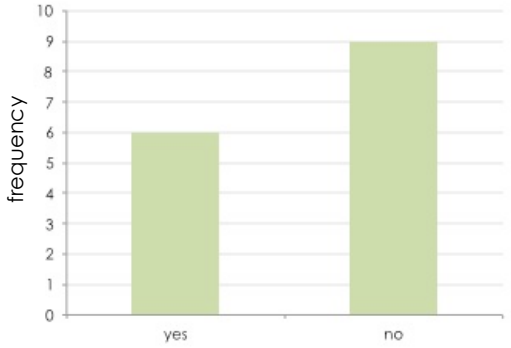


Figure 38: Enough radiators

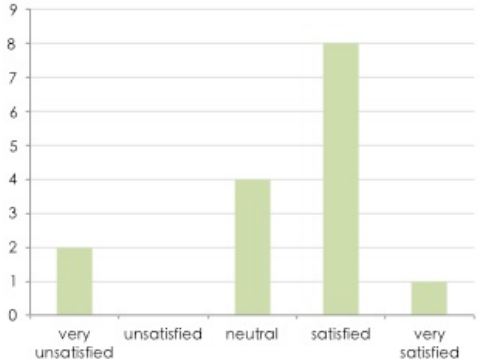


Figure 39: Radiators

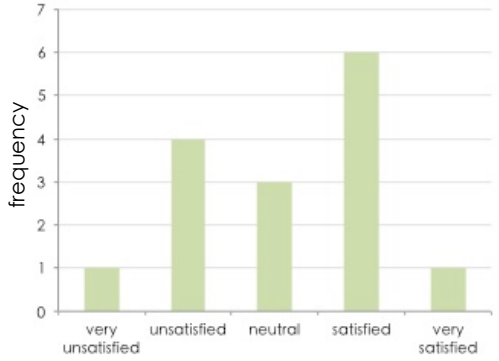


Figure 40: Thermostat

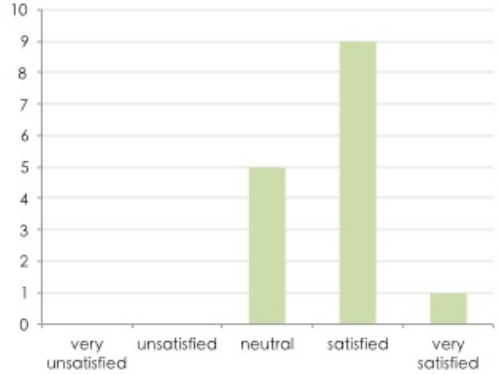


Figure 41: Ventilation capacity

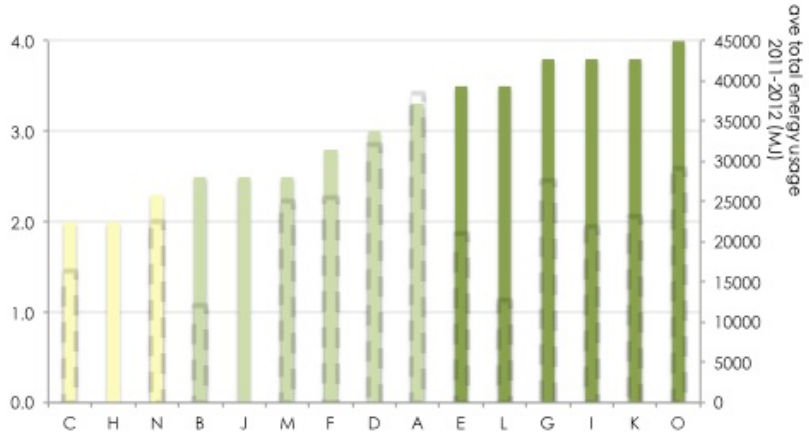


Figure 44: Overall satisfaction ventilation

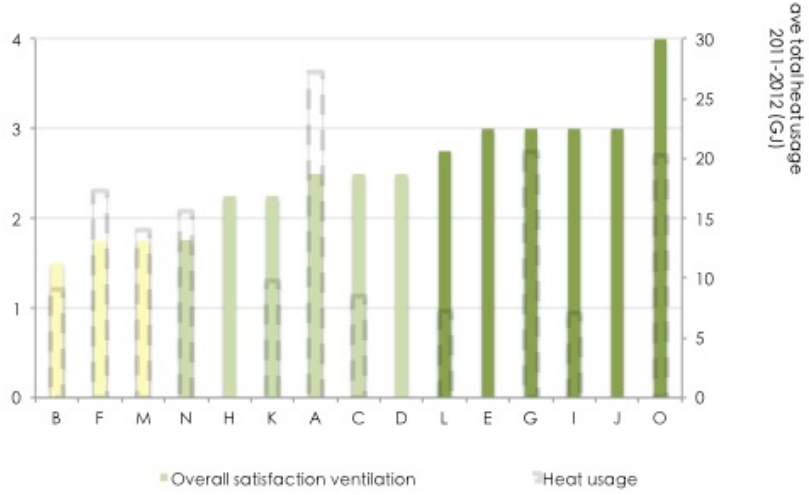


Figure 46: Overall satisfaction heat

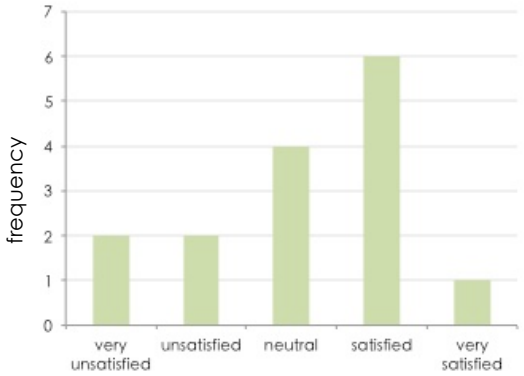


Figure 43: Maintenance ventilation

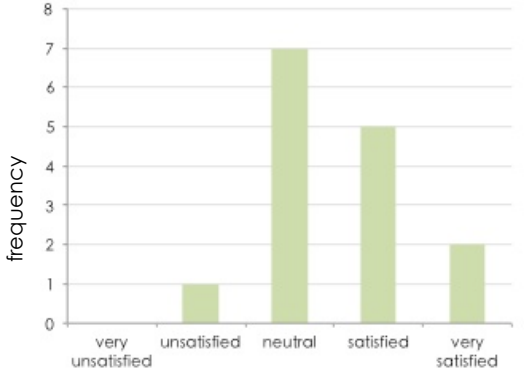


Figure 42: Noise ventilation

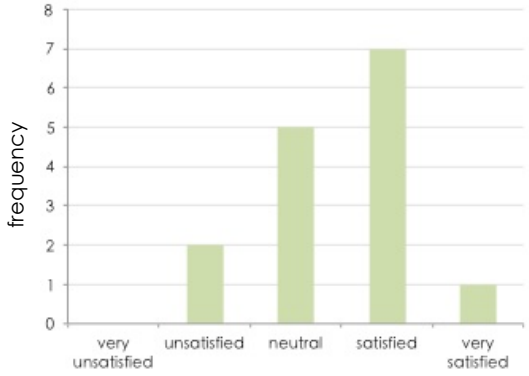


Figure 45: Ease of operation ventilation

5.4.5 Motivation

Formulating the right questions for the survey to investigate motivations of the occupants has proven to be a complex issue. This is caused by the fact that the differences between the definitions motivation, awareness and attitude are very subtle. That's why it is important to have a good understanding of the definitions set in the previous section in order to interpret these results in the correct way.
In this study, motivation must be seen as a goal-based motivation. The questions that form this category give insight in the level at which the respondents show environmental behaviour.
One would assume according to literature (Vringer, et al., 2007), that a person who is more motivated to live in a passive house and to save energy, is more likely to use less energy than a person who doesn't have high motivation for these topics.
Figure 47 to Figure 49 present motivation in relation to resp. electricity usage, heat usage and total energy usage.
We can see in this case, that the least motivated respondents have the lowest electricity and heat usage. It seems that the respondents with a higher motivation use more electricity than respondents with no motivation (Appendix H Table H-9). For heat use, the same phenomenon is visible, only the group that is very motivated is showing a lower heat usage than the motivated group (Appendix H Table H-10).
Thus, in this stage of the study, the results are in contradiction with most literature about this topic. Only the study by VROM(2010) found a similar relation.
It must be further analysed if this is caused by household size (or other variables) or not.

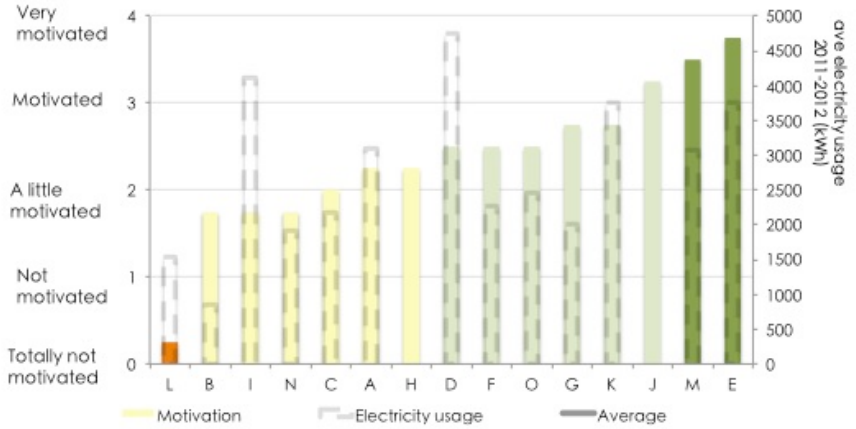


Figure 47: Motivation vs Electricity usage

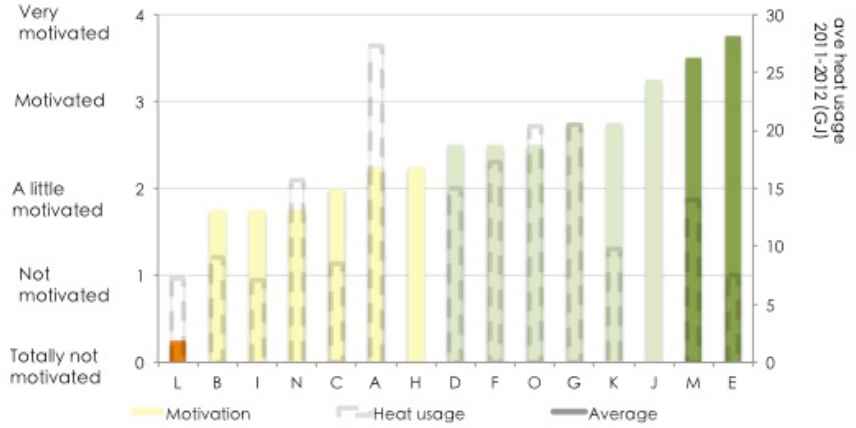


Figure 48: Motivation vs Heat usage

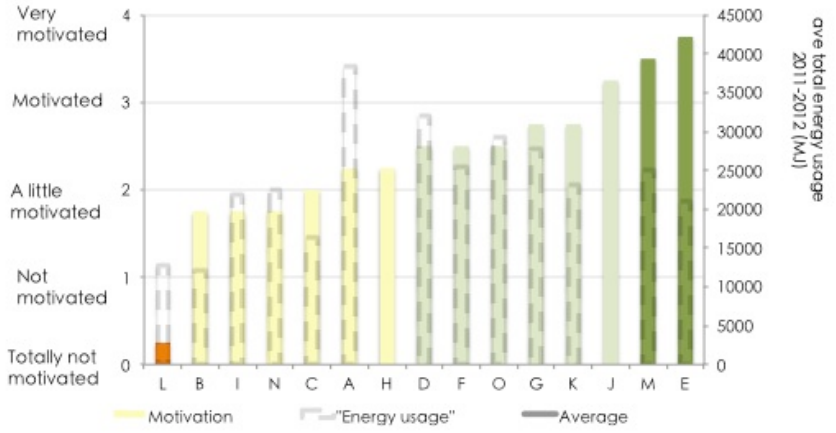


Figure 49: Motivation vs Energy usage

5.4.6 Thermal comfort

The category thermal comfort is used in two different perspectives. First, thermal comfort is also a subcategory of motivation, but in the form of needs-based motivations. Thermal comfort is a basic human need that needs to be fulfilled. The comfort thresholds are very subjective and differ from person to person. From this perspective, it is only useful to bring winter comfort in relation to the energy usage. Because the heating system is mainly used in winter to warm the spaces up that are being experienced as too cold.
Figure 50 and Figure 51 show the overall experience during winter and summer. According to most respondents, the temperature is experienced as pleasant. Though, there are some respondents who find the houses cold during winter and warm during summer.
Figure 52 Shows the winter experience and preference in relation to the heat usage. It does show that a few high-energy users experience the house as cold and prefer a warmer temperature (Appendix H Table H-11 and Table H-12). Though, the output shows no significant result with the assumption made.

The second perspective for investigating the thermal comfort is to check if the occupants now have a different thermal comfort experience as compared to the first survey from two years ago. This way it is possible to check if the occupants got a better understanding of how to use the installations to provide a comfortable indoor climate, or that they maybe 'got used' to the indoor climate of their house.

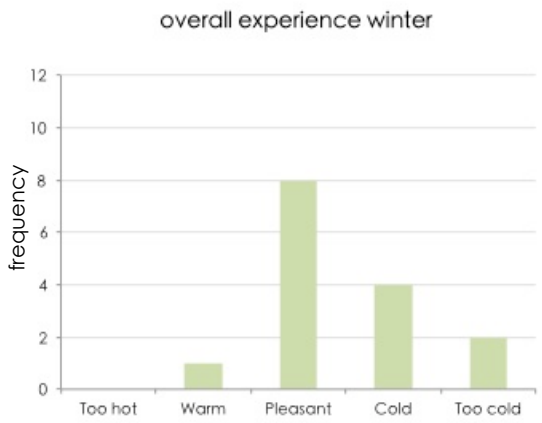


Figure 50: Overall experience winter

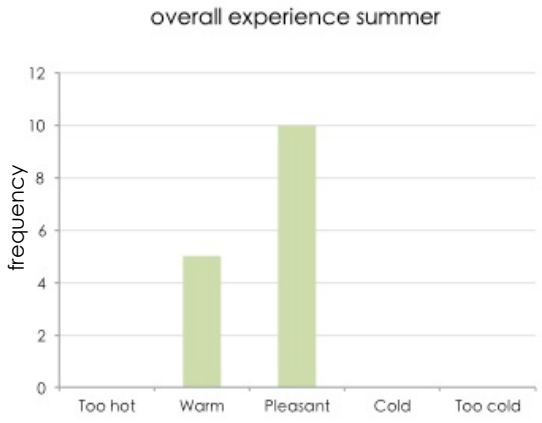


Figure 51: Overall experience summer

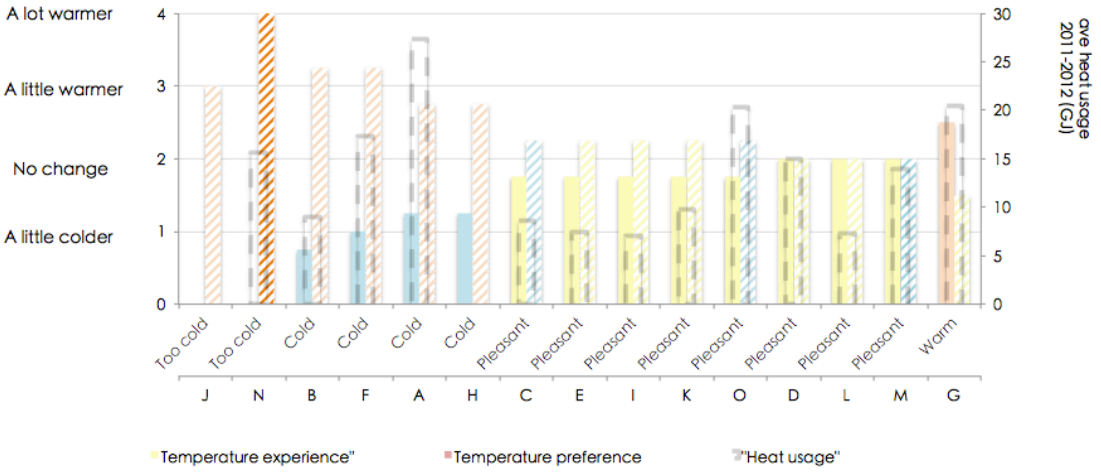


Figure 52: Winter experience & preference vs energy usage

This also gives insight into which spaces the occupants still experience problems with the temperatures. This information is necessary in order to provide design solutions in the end.
Figure 53 to Figure 56 present to experience of the temperature in the different spaces as found in my survey and in the previous survey by OTB (Mlecnik et al., 2012). Most of the respondents experience the temperature of the separate spaces also as pleasant. It is notable that in the kitchen, most of the respondents find the temperature cold or too cold. This can be caused by the fact that the kitchen is situated next to a window, and staying in the kitchen means thus staying close to that window. During cooking, this window may be opened for additional ventilation to exhaust unwanted smells caused by cooking.
The living room and bedroom show a small amount of occupants who indicate the space as cold during winter and warm during summer.
Based on this information, we can see that there is still room for improvement, and for some areas even recommended.



Figure 53: experience livingroom



Figure 54: experience bedroom



Figure 55: experience bathroom



Figure 56: experience kitchen

5.4.7 Ventilation comfort

Besides the thermal comfort, I also included more specific questions about the experience of the ventilation air temperature during summer and winter. Figure 57 shows that most of the respondents also experience the mechanical ventilation air as pleasant during summer and winter. Some of them however do note that they find the air warm during summer and cold during winter.
The mechanical ventilation air in summer during warm days is entering the house through a bypass in the ventilation system. This means that the incoming air is not pre-heated by the heat exchanger, but is directly coming from outside. On warm days, this can result in a warm experience of the mechanical ventilation air, because the indoor air temperature is lower than the outside temperature.
During winter, some respondents mark the ventilation air as cool. The supply air is pre-heated, but the efficiency of the ventilation unit is not 100%. This means that the supply air can be lower than the indoor air temperature, causing the occupants to experience the mechanical ventilation air as slightly cool.
To check if this cold air experience has a relation with the heat usage Figure 58 shows both variables.
It shows that the respondents, who indicated the air as cold, also have a higher than average heat usage. But on the contrary, respondents who experience the air as warm during winter have an even higher heat usage. So till now this variable is also inconclusive.

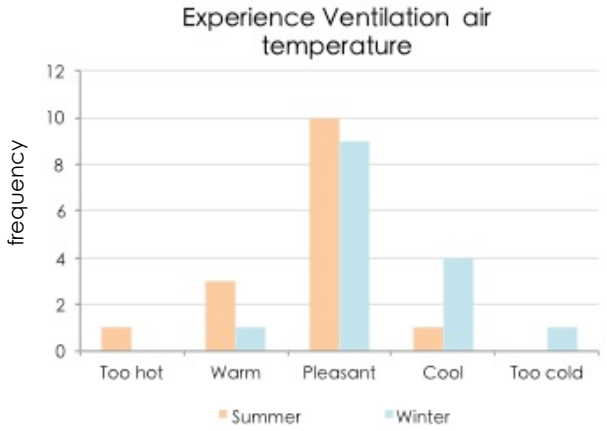


Figure 57: experience ventilation air

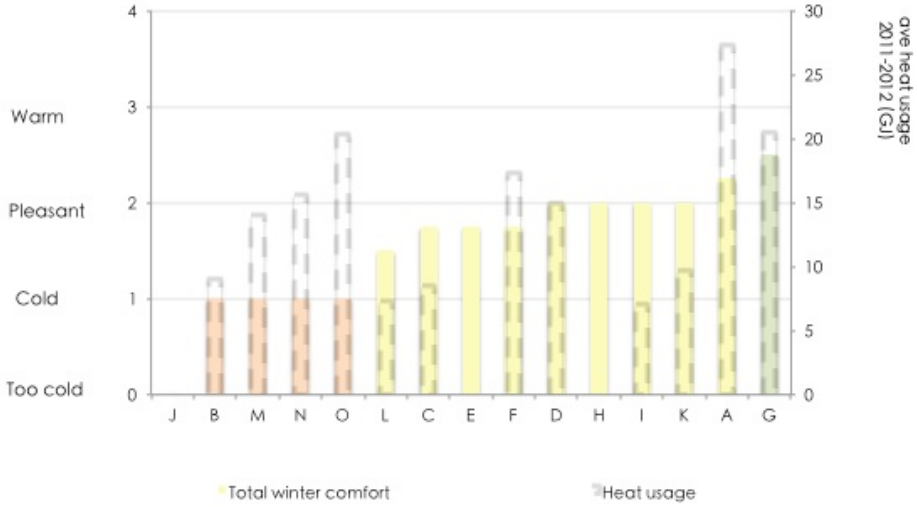


Figure 58: Winter comfort vs heat usage

5.4.8 Awareness

The questions asked about the awareness of the respondents don't have the character to collect information about their actual behaviour, but they show if the occupants know the consequences of their actions.
Previous studies have shown that most of the occupants of low energy houses do realise they live in a low energy house, but a lot of people tend to create a perception that their behaviour is not relevant anymore for the energy usage of the house (VROM, 2010).
For this study, the questions asked are aimed at collecting information about the awareness of the occupants of their energy usage. Energy usage is a consequence - as stated in the previous mentioned definition – of behaviour which is influenced by awareness.
Figure 59 to Figure 61 show the awareness in relation to resp. electricity, heat and energy usage.
If you look closely, it seems the results confirm previous results presented by (VROM, 2010). Especially the relation with the total energy usage seems to reveal an obvious trend, that the lower the awareness of the occupants is, the lower their energy usage is (Appendix H Table H-13 and Table H-14).

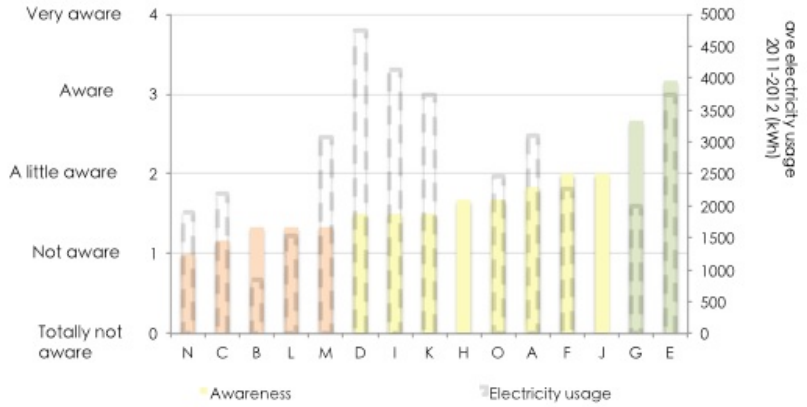


Figure 59: Awareness vs electricity usage

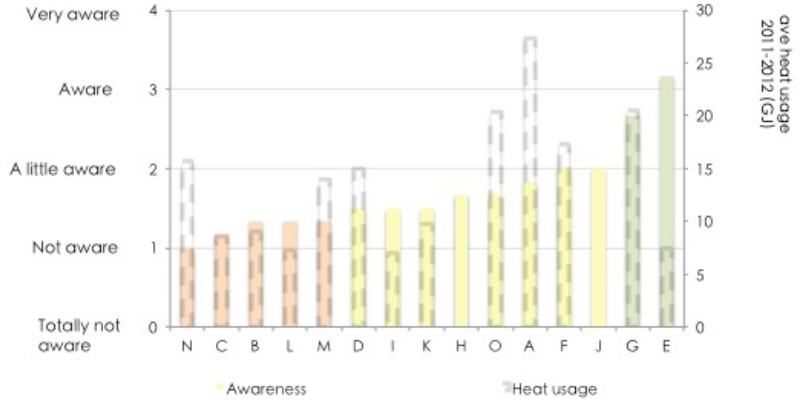


Figure 60: Awareness vs heat usage

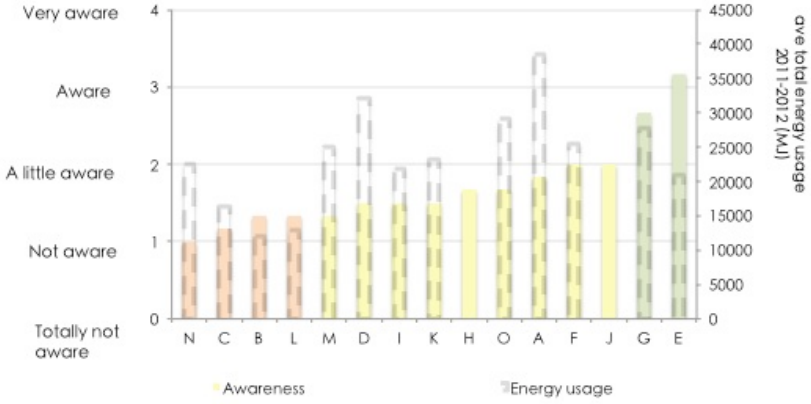


Figure 61: Awareness vs energy usage

5.4.9 Attitude

The category attitude is based on eleven questions where the respondents needed to agree or disagree with. All the questions are about the attitude of the respondents concerning energy saving measures.
Looking at Figure 62 to Figure 64, it can be noted that the overall attitude of the occupants is neutral to positive concerning energy saving measures. In general this is of course a good result, but for interpreting the results in relation to the energy usage, it is not easy to find a relation between these two variables, because of the low amount of variation in the attitudes of the respondents.
Only the total energy usage relating to attitude shows that there might be a correlation. The boxplots in Appendix H Table H-15 and Table H-16, indicate that the respondents with a positive attitude have a higher energy use than the respondents with a neutral attitude. However, practically there are only two categories: neutral and positive which makes it difficult to draw conclusions.
Further detailed analyses however must prove this assumption.

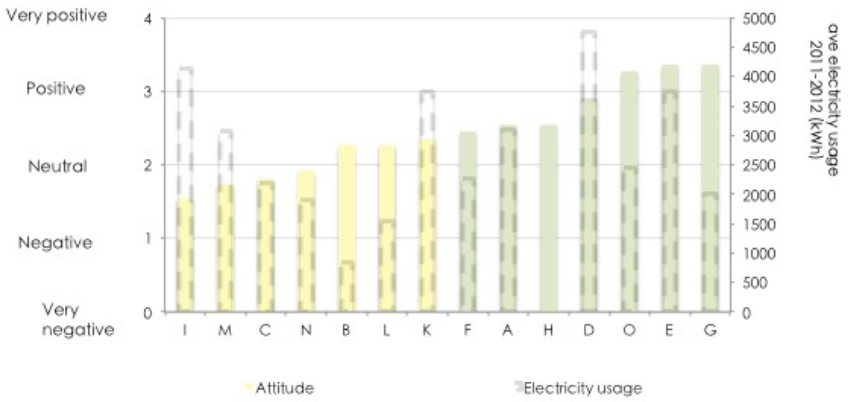


Figure 62: Attitude vs electricity usage

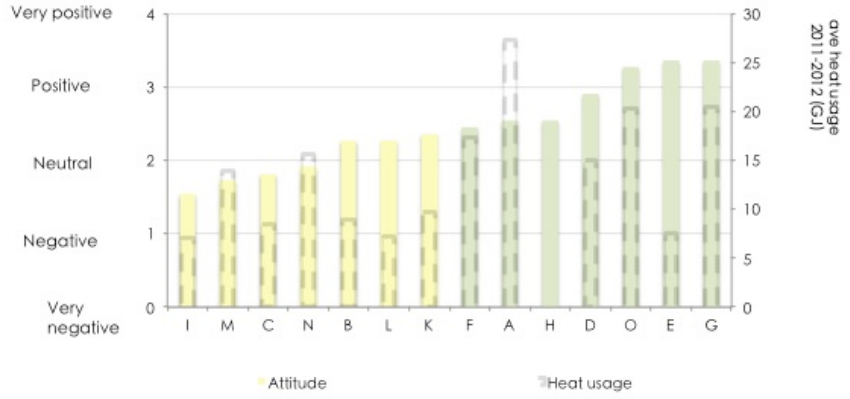


Figure 63: Attitude vs heat usage

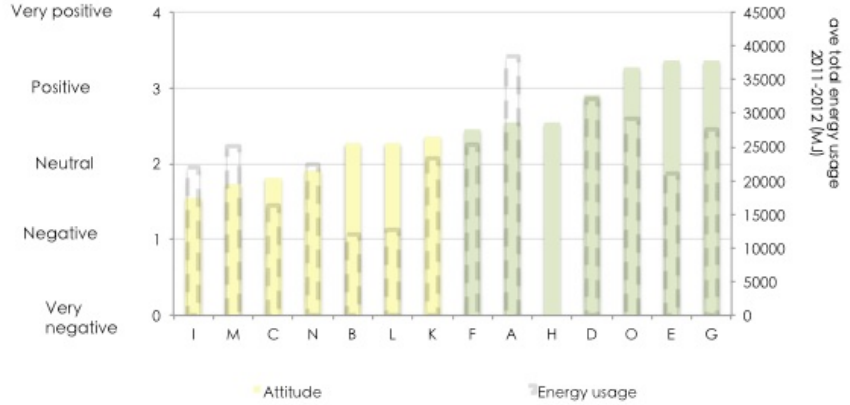


Figure 64: Attitude vs energy usage

5.4.10 Current energy saving behaviour

Important information to collect is the current level of energy saving behaviour of the occupants.
It is obvious that the more energy saving measures the occupants currently take, the lower their energy usage should be.
The results in this category are a combination of several questions about energy saving measures and whether the occupants apply these measures or not.
If we look at the results presented in Figure 65 to Figure 67, it is difficult to find a relation between the variables. Presenting the results in boxplots (Appendix H Table H-17 and Table H-18), it is still difficult to find a relation, because of the small group of respondents in most categories. For electricity use it is only visible that the respondents who score much on energy saving measures also have the lowest energy usage, but for the other categories it is difficult to say anything about the results.
As for heat use, the highest heat use is visible in the respondent group that score little or much energy saving measures (Appendix H Table H-18).
Thus, till now this category stays unclear in relation to the energy use.

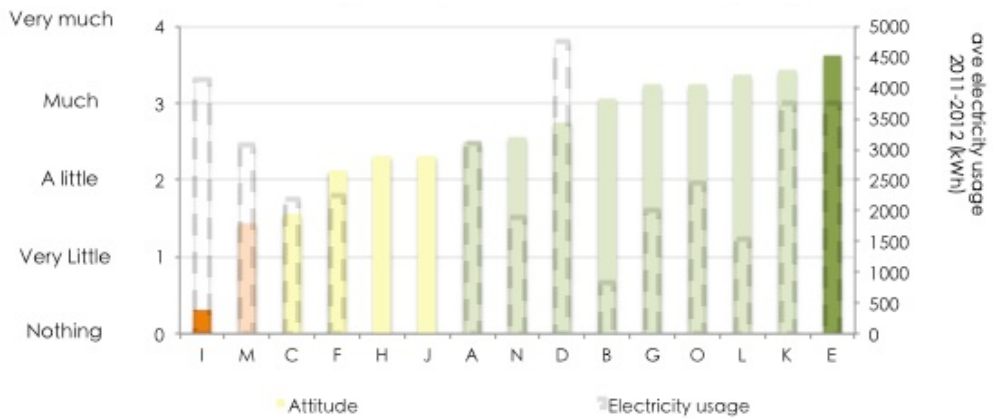


Figure 65: Current energy saving behaviour vs electricity usage

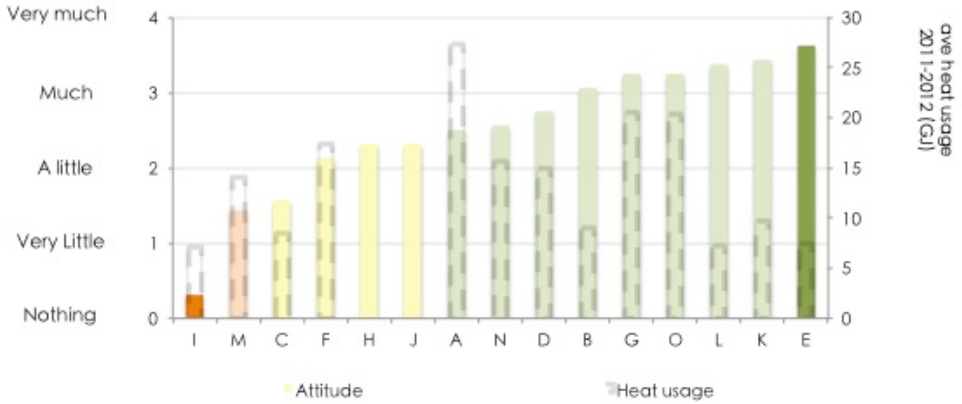


Figure 66: Current energy saving behaviour vs heat usage

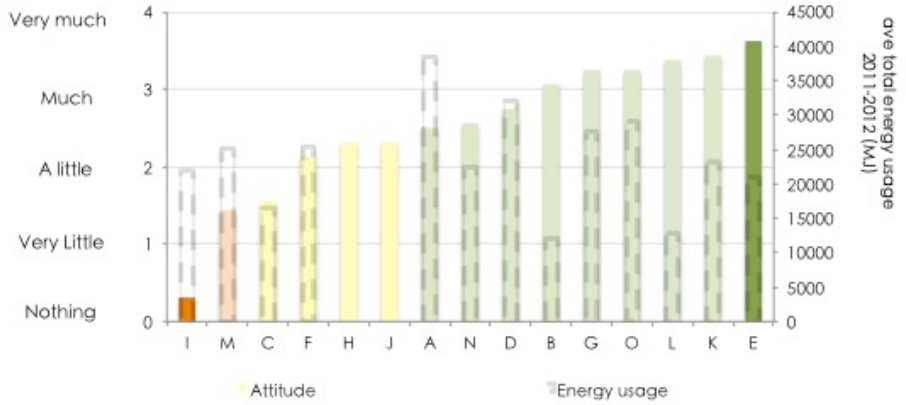


Figure 67: Current energy saving behaviour vs energy usage

5.4.11 Influence previous building type

As mentioned before, previous studies revealed that behavioural patterns in a previous house could influence behavioural patterns in a new house (Guerra-Santin & Itard, 2010). Describing habits in detail, and investigating which habits result from a specific building type is a very interesting but big topic, which unfortunately cannot be investigated during this study.
A certain building type is closely related with its building period. Every period in time has its own dominate building type. Besides that, technique evolves as well in time, so each building period has some building and climate techniques that were mainly used during that specific time.
So even though this study is not able to give a detailed and substantiated analysis on this topic, in general we can say that houses have been build more energy efficiently over the years.
Based on this, two questions have been included in this survey:
What was the building type of the previous house of the respondent, and in which period has this house been built.
The results of these two questions are combined and categorized on a scale from a very energy efficient house to a not energy efficient house.
Comparing this with the current energy usage of the respondents, we can see if there is any relation between the energy efficiency of their previous house and their current energy usage.
Figure 68 and Figure 69 show the energy usage in relation to resp. the building period of the previous house and the building type of the previous house. Looking at the relation between building period and energy usage, assuming that newer buildings are more energy efficient than older ones, the results don't show a significant trend that the respondents that lived in a relatively new building before this house use less energy than respondents that previously lived in an old (not energy efficient) house. However, the results give an indication that there might be a more significant relation, if this will be studied in more detail and on a bigger scale.

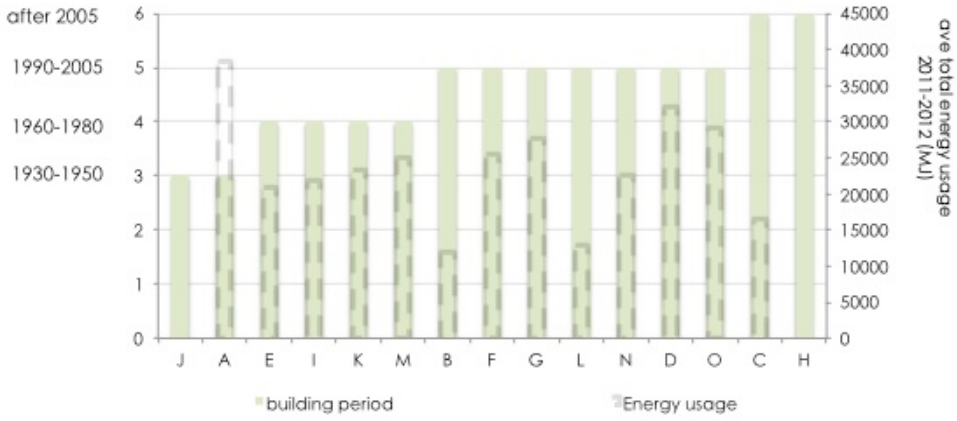


Figure 68: Building period previous house vs energy usage

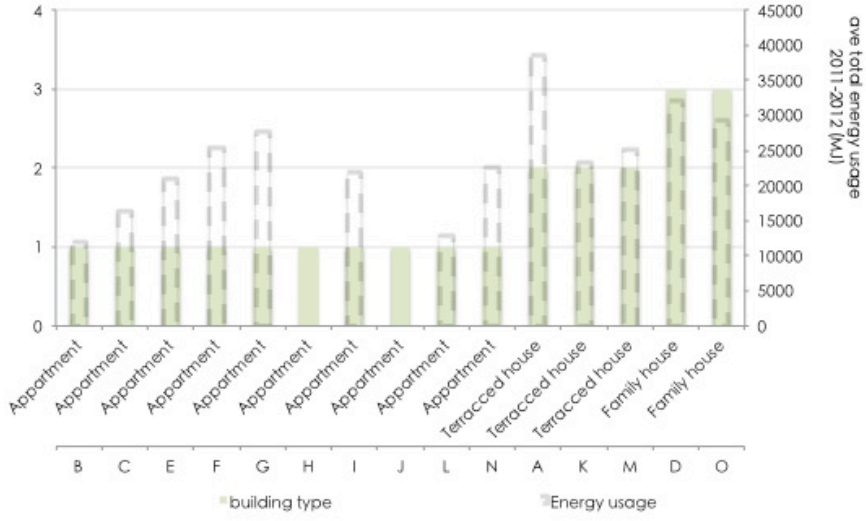


Figure 69: Building type previous house vs energy usage

For the relation between building type and energy usage, the trend seems a lot more interesting. The respondents who previously lived in a terraced house or bigger house show a more than average energy usage than the respondents who lived in an apartment before.
Final step is to combine these two categories and scale the previous houses from very energy efficient to not energy efficient at all. Figure 70 shows the combined results, which shows that it seems there is indeed a relation visible between the level of energy efficiency of the previous house and the current energy use (Appendix H Table H-19 and Table H-20). This would indicate that people carry a set of energy usage related habits with them from the previous house into a new house. Further research is however needed.
How these habits arise, and how long it takes for these habits to adjust to a new environment is an interesting subject for future studies. Besides that, it is of course also interesting to think from this point of view, how we can accelerate this process of adjusting habits and which techniques are most appropriate, based on a better understanding of the underlying nature of this phenomenon.

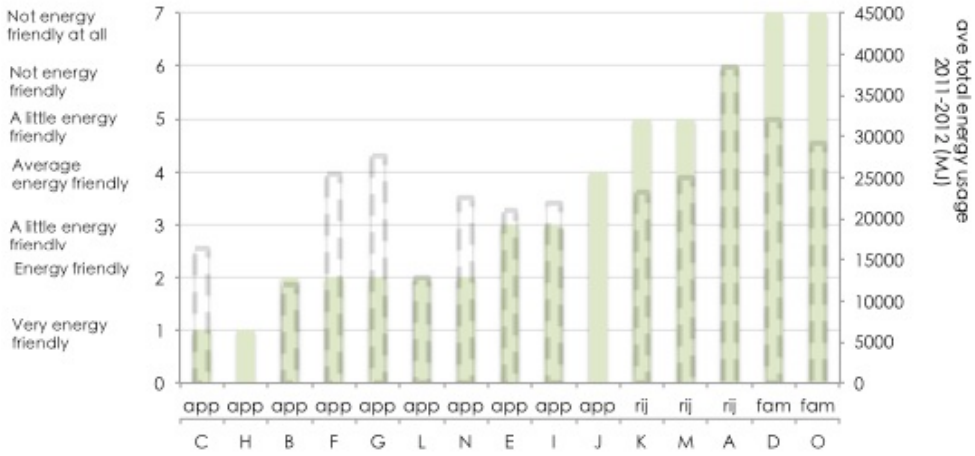


Figure 70: Building type & period previous house vs energy usage

5.4.12 Ventilation behaviour

The last category will give an overview of the results of the ventilation behaviour of the occupants during summer and winter. In this stage, this behaviour will not directly be related to the energy use, but will be used in the next paragraph to compare with the results of the previous survey to see if there are any changes in behaviour (positively or negatively).

Summer

As shown in Figure 71, it is clear that during summer most of the people open the windows for additional natural ventilation besides the mechanical ventilation. Relating this to the design of the building and how it is intended to keep cool during summer, the amount of natural ventilation during the day should not be this high. In order to keep this house cool the outside air needs to stay outside as much as possible. The thick layer of insulation should be sufficient to provide a comfortable cool indoor climate during summer. Opening the windows and bringing air inside means that the 'self-regulating' indoor climate gets disturbed, which means that the house is not performing as it is supposed to perform.

On the contrary, opening windows and bringing fresh air in the space is also needed to maintain a good air quality. These results show that it is natural human behaviour wanting to open windows for letting fresh air in despite of the outside circumstances.

It is good to see that the summer night ventilation is applied by most of the people (Figure 74). The panels are designed to be opened during the night, to exhaust the warm inside air and cool the spaces. Figure 72 and Figure 75 also present good results. Most of the people tend to close the windows during the day and close the bathroom door upstairs while having a shower. Closing the bathroom door during showers is positive, because the warm and humid air will not circulate through the bedrooms (thus warming

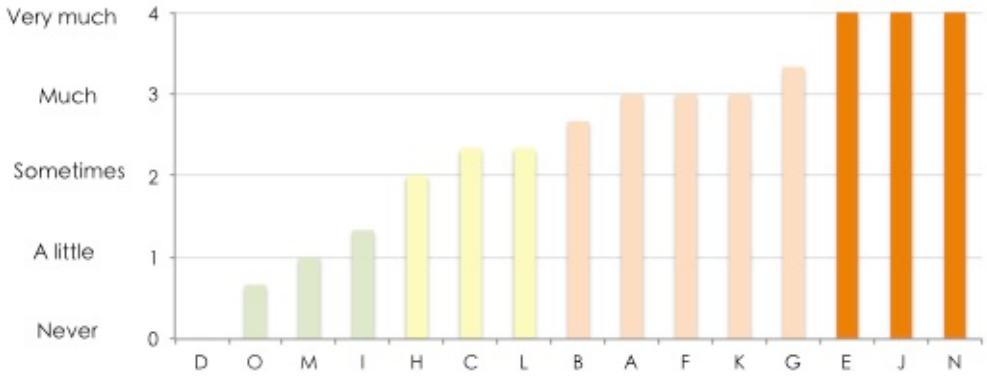


Figure 71: Frequency natural ventilation during summer

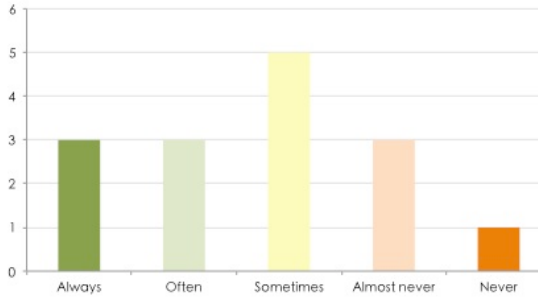


Figure 72: Keeping windows closed during day

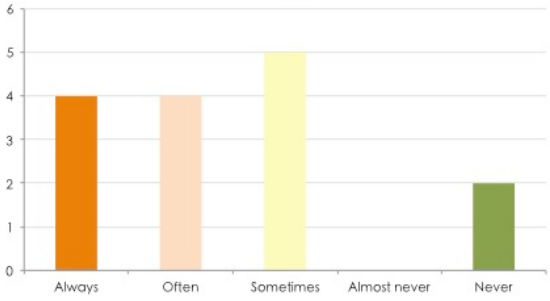


Figure 73: Bedroom windows/panels open during day

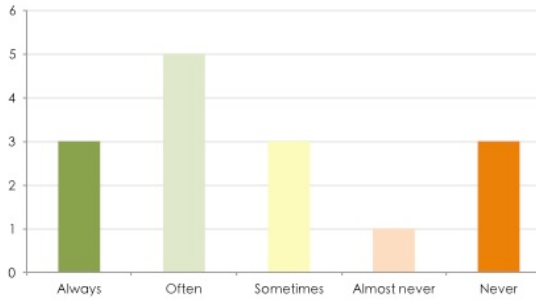


Figure 74: Ventilation panels open during night

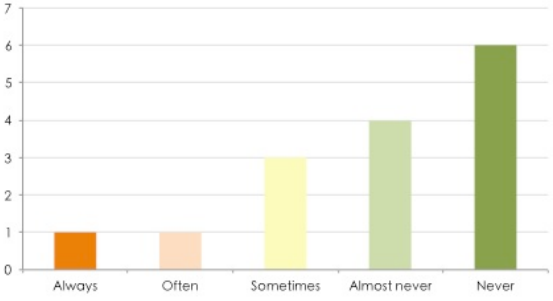


Figure 75: Door bathroom open

these up), but gets exhausted with the mechanical ventilation in the bathroom.
What also can be seen in Figure 73, is that most of the occupants do open the bedroom windows during the day. This explains why the thermal comfort in the bedrooms during summer can be valued as warm or too hot.
The last question asked was if the occupants open the windows in the living room and bedroom when they find it too hot. Figure 76 and Figure 77 show that a lot of people answer this with no, but most of the people do answer this with yes, and that is not the solution for this house to achieve a cool indoor climate.

Winter
Figure 78 and Appendix H Table H-21 present the natural ventilation frequency related to the annual heat usage. First thing that is notable, is that the amount of natural ventilation during winter is less than during summer. It shows that the occupants who ventilate naturally in the 'sometimes' range show the largest heat usages. It is interesting to see that the respondent who ventilates 'very much' has one of the lowest heat usages of all the respondents. This indicates that is also important to relate this category to the thermal comfort of the respondents. Thermal comfort is subjective, and the thresholds differ for each person. It could be possible that this occupant has a low temperature as preference temperature, which than results in a higher amount of natural ventilation during winter. This is of course the quickest way to cool down a building during winter.
Despite of the fact that the amount of natural ventilation in Figure 78 scores relatively positive during winter, we can see in
Figure 79 that most of the people do tend to open their windows during the day. If these opening times are limited to short opening times, there is not a big temperature impact inside the house. This

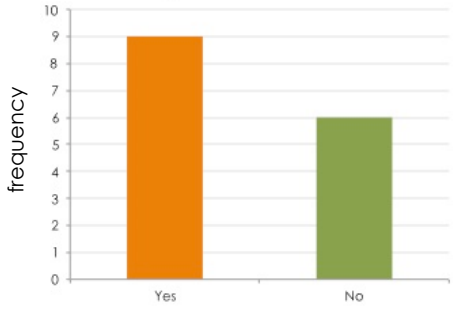


Figure 76: Do you open the windows when livingroom is too hot

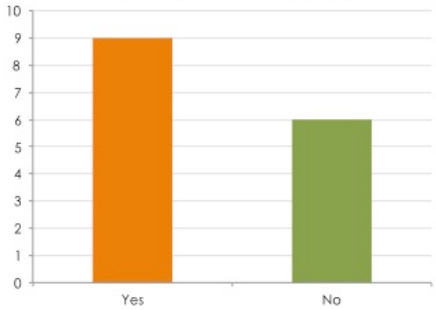


Figure 77: Do you open the windows when bedroom is too hot

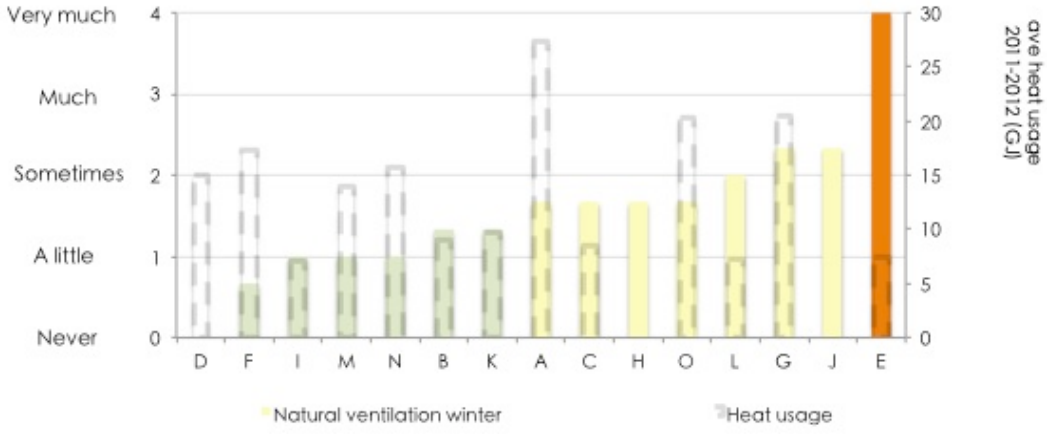


Figure 78: Frequency natural ventilation during winter vs heat usage

detailed information, however, could not be gathered with this survey, but needs monitoring which will follow in the later stage of this study.

Regarding the bedroom, Figure 80 shows that most of the occupants open their bedroom windows 'sometimes' or less during the day. This is a positive result, because the previous survey already showed that warming up the bedrooms upstairs was a problem due to the fact there are no radiators installed. Keeping cold air out is thus a prior (and one of the only) when wanting to provide a comfortable temperature. Another positive result is the bathroom door, which is kept open by most of the people (Figure 81). The bathroom is the only room upstairs with a radiator, so keeping this door simultaneously open with the other bedroom doors, makes a warm air circulation on the first floor possible.

What is not so positive is the fact that the majority of the occupants have the ventilation panels open during the night in winter (Figure 82). This causes the building to cool down during the night, so more energy is needed to warm the building up again during the day.

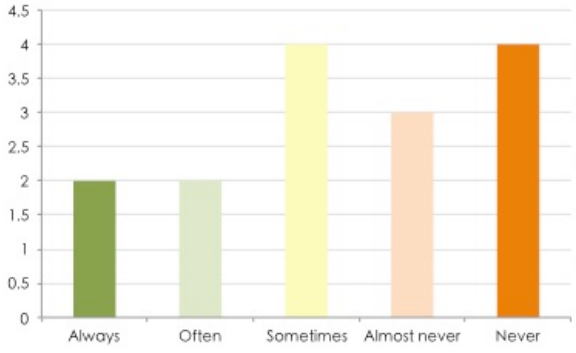


Figure 79: Windows closed during day

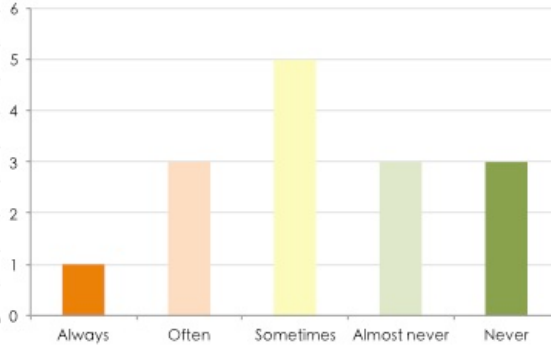


Figure 80: Bedroom windows open during day

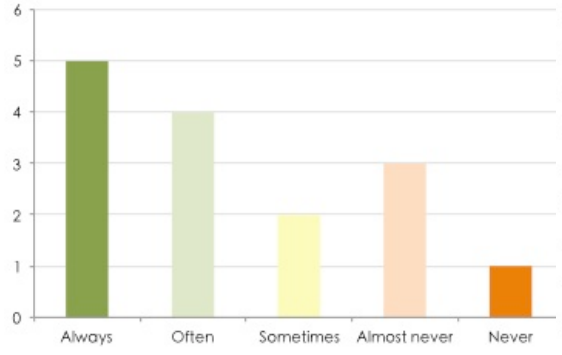


Figure 81: Bathroom door open

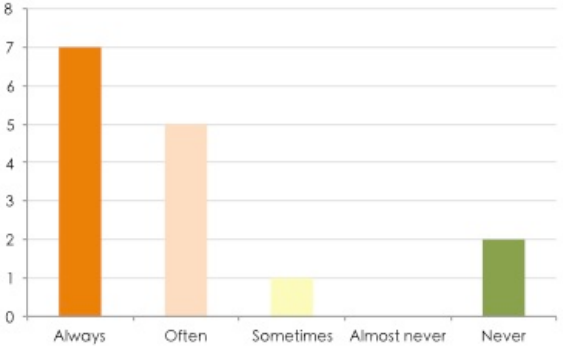


Figure 82: Panels open during night

5.5 Comparison previous survey and current survey

This paragraph will compare the results of some categories with the result of the previous user survey executed by Cauberg-Huygen of which the results were analysed by the OTB institute (Mlecnik et al. 2012). The categories that will be compared are:

- Satisfaction with building services
- Thermal comfort
- Ventilation comfort

Because the number of respondents of both surveys is not equal, the results have been converted to percentages in order to be able to compare the results. Besides, the respondents group is not exactly the same in both cases.

5.5.1 Satisfaction building services

Figure 83 to Figure 86 present the comparison between the results of my survey data with the survey data collected by Cauberg-Huygen from two years ago. The subject of these figures is the satisfaction with the building services by the occupants. For the heating systems for water and space heating, it can be concluded that the occupants now value the systems more positively than indicated in the previous study (Figure 83 and Figure 84).
The draft experience, noise, ease of operation and capacity of the ventilation system (Figure 85 and Figure 86) are also valued more positively during the current study.
A reason for these more positive attitudes, can lay in the fact that the occupants are now more adjusted and used to the new installations, because they have lived in the houses for a longer period now than they did during the survey of the previous study. It could be that the memory of the installations of their previous house has faded, and that they stopped comparing their new situation in this house with their old situation in the new house.

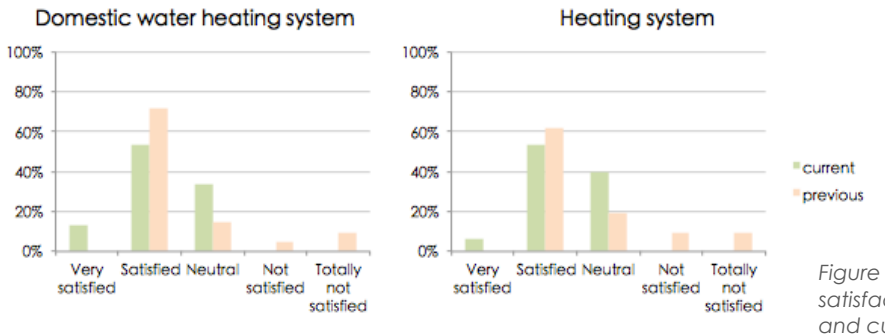


Figure 83: satisfaction previous and current study water and space heating

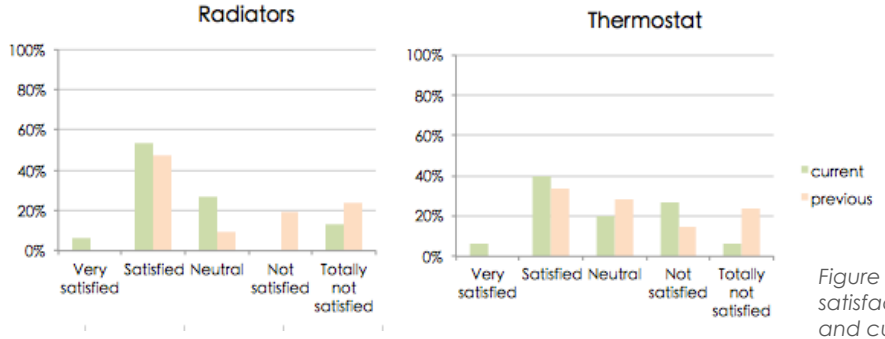


Figure 84: satisfaction previous and current study radiators and thermostat

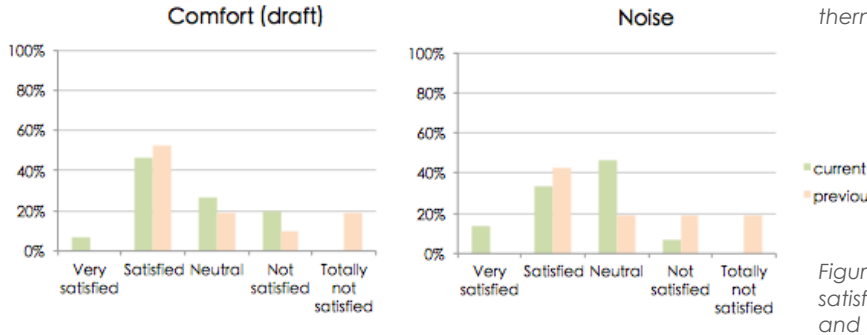


Figure 85: satisfaction previous and current study draft and noise

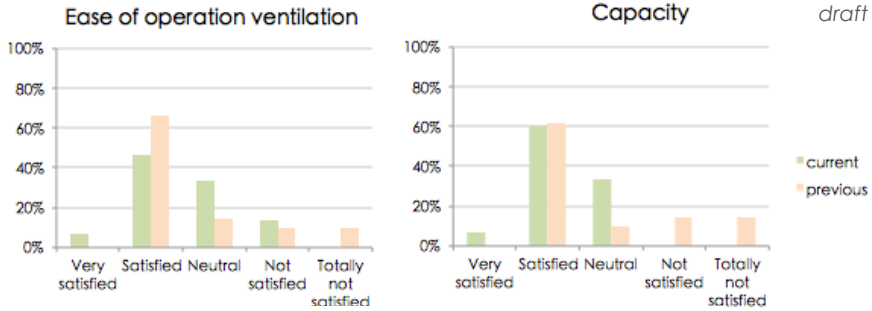


Figure 86: satisfaction previous and current study operation of ventilation and capacity

5.5.2 Thermal comfort

Second subject that is compared with the previous study of Cauberg-Huygen is the experienced thermal comfort during summer and winter.
Figure 87 present the results of the thermal comfort during summer. The graphs show that the overall thermal experience is valued slightly warmer for every room of the house in this current study compared to the previous results.
This shift can have different causes. First of all it can depend on the outdoor weather conditions during the survey period. It is possible that the occupants experienced warmer summers after the first survey, and for that reason value the rooms warmer than in the previous study.
A second explanation can be that the response group of the current survey ventilate more during hot summer days than the previous response group. Opening the windows during hot days means that warm air enters the building, which makes it more difficult to cool the house.
During winter (Figure 88), the living room and kitchen are experienced colder than during the previous study,
This phenomenon can be caused by the fact that the occupants need to ventilate more naturally to exhaust polluted air in these areas, because it is the main living area, also during cold days.
On the contrary, the bedroom and bathroom are experienced as warmer. An explanation can be that the occupants are now more accustomed to the way they need to heat the first floor level, by keeping the windows closed and keeping the bathroom door open to heat the bedrooms.
Also in winter, the outdoor weather conditions can still be a possible explanation for the difference in thermal experience during the previous and current study.



Figure 87: Summer thermal comfort previous and current study

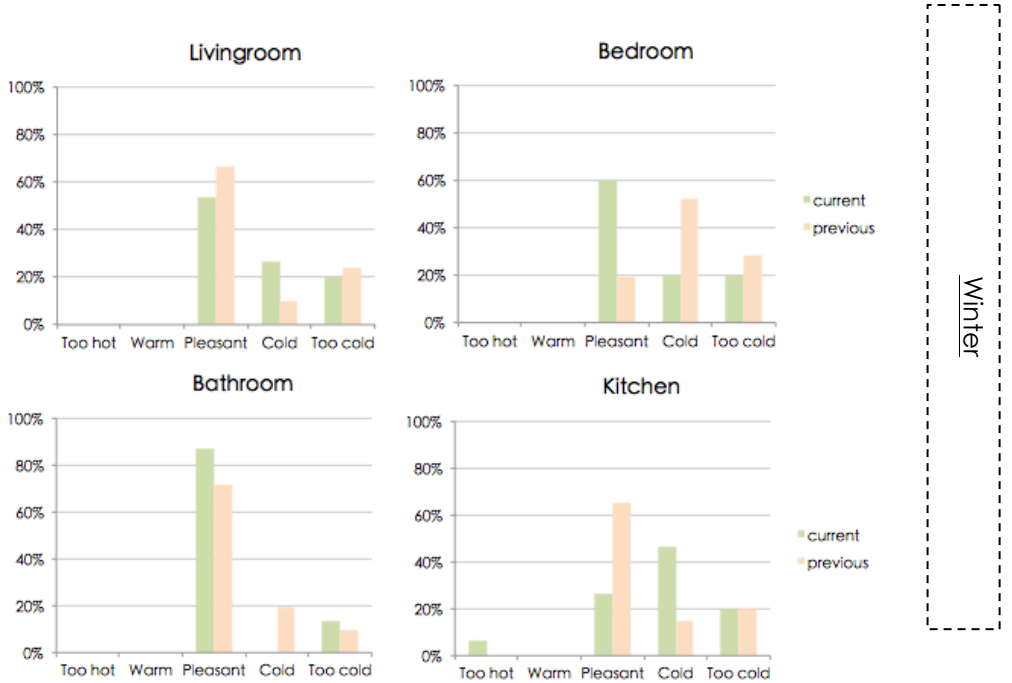


Figure 88: Winter thermal comfort previous and current study

5.5.3 Ventilation comfort

The last subject that will be compared with the previous study is the experience of the mechanical ventilation air.
The results of this comparison show that in both cases, for winter and summer the mechanical ventilation air is generally experienced warmer in all the rooms (Figure 89 and Figure 90).
This specifically focuses on the experience of the mechanical ventilation air and not of the natural ventilation air.
A possible answer for this is that the mechanical ventilation system has slightly degenerated in this period of time, and that the maintenance of the system is not executed properly by the housing corporation. It is possible that the system needs adjusting in the programming after some time after installation. I could not check whether or not this has been done by the corporation.
It is also possible that the occupants have difficulty with distinguishing the thermal comfort of the mechanical ventilation air and the natural ventilation air. The reliability of this question is for that reason not very high.

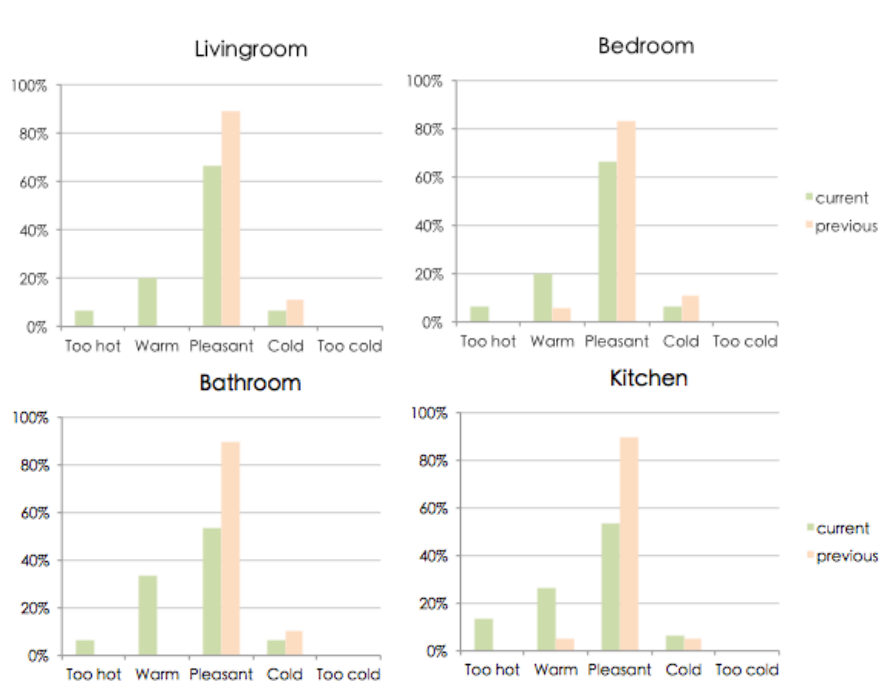


Figure 89: Thermal comfort mechanical ventilation air previous and current study

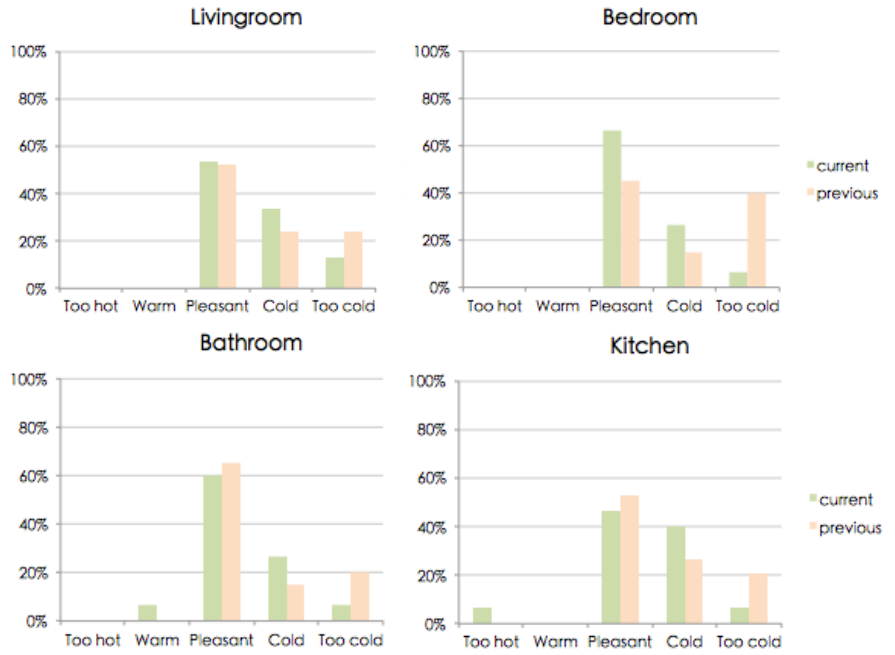


Figure 90: Thermal comfort mechanical ventilation air previous and current study

5.6 Conclusions

As mentioned in the introduction of this chapter, the first results that are presented in the previous section are not useable for making any final conclusions about the separate categories in relation to the energy usages. In this particular study, the influence of the different household characteristics is also not directly showing any significant relation with the energy usage, which has been proven by previous studies. Only the variable household size seems to show a relation with energy use.
Because of the relatively small sample size, it is even more difficult to filter the most interesting variables for further analysis, and which variables have a mutual relation.
As for the behavioural variables motivation, awareness and attitude, the results show there is an indication that the relation with energy use is positively related instead of negatively. This means that higher energy use is visible when occupants have a higher motivation, awareness or attitude. The statistical analysis that will follow in Chapter 6 will go into further detail to see if there can be any conclusions drawn about this phenomenon. Till now it seems that the results of this study match the homeostasis theory and the previous results from the study by VROM (2010), and are in contradiction with other literature written about these behavioural variables that postulates that increased motivation, attitude or awareness should lead to a decrease in energy use (section 2.5).

The comparison of the results of this study with the previous study from Cauberg-Huygen showed that in general the occupants show a more positive satisfaction about the building services than two years ago. This indicates there is an opportunity to transform habits and opinions from occupants with appropriate interventions (like information strategies), or that habits can naturally change over time.

6. STATISTICAL ANALYSIS

6.1 Statistical analysis method

Before the presentation of the results of the statistical analysis, this paragraph will first explain the used methods and the theoretical background of those methods to get a better understanding of the results.

The retrieved data from the user survey will be analysed with correlation analysis and not with regression analysis. This choice is based on the nature of correlation and regression.
Correlation makes no a priori assumption as to whether one variable is dependent on the other(s) and is not concerned with the causality between variables; instead it gives an estimate as to the degree of association between the variables. In fact, correlation analysis tests for interdependence of the variables.
Regression attempts to describe the dependence of a variable on one (or more) explanatory variables; it implicitly assumes that there is a one-way causal effect from the explanatory variable(s) to the dependent variable, regardless of whether the path of effect is direct or indirect. There are advanced regression methods that allow a non-dependence based relationship to be described (eg. Principal Components Analysis or PCA) (Read, 1998).

The small sample size of this study and the large amount of underlying psychological effects that all influence occupant behaviour, don't make it possible to apply regression analysis to the data. The output data in my study mostly has an ordinal scale, which is the most important reason for not using regression, because this method can only be applied on data with an ratio or interval scale. The complex framework of interdependency of the separate variables as described in paragraph 2.5 indicates that there is not a one-way causal effect from the explanatory variable(s) to the response variable. In other words, one variable is not directly and linearly related to one other variable, instead they have an interrelated character between several other variables.
It is more interesting to find out if the relationship between the separate variables as stated in Figure 3 can be confirmed by this research, and if there is an association between these variables with electricity-, heat- and total energy use.

6.1.1 Scale type of data

In statistics there are several types of data. Determining the type of data you are dealing with during your research is important for choosing the appropriate statistical tests. The following distinctions are made:

Nominal	A variable can be treated as nominal when its values represent categories with no intrinsic ranking
Ordinal	A variable can be treated as ordinal when its values represent categories with some intrinsic ranking
Interval	Like ordinal except we can say the intervals between each value are equally split
Ratio	Ratio data is interval data with a natural zero point.

The output data of my user survey mostly has an ordinal scale, because the data has a clear ranking scale. In some cases, as with age or energy use for instance, the data has a ratio scale.
This is another reason for not using regression, because regression can only be executed based on interval or ratio data.

6.2 Correlation

Correlation quantifies the degree to which two variables are related. Correlation does not fit a line through the data points. You simply are computing a correlation coefficient (r) that tells you how much one variable tends to change when the other one does. When r is 0.0, there is no relationship. When r is positive, there is a trend that if one variable increases the other one does so too. When r is negative, there is a trend that if one variable increases the other one decreases.

The two most popular correlation coefficients are: Spearman's correlation coefficient rho and Pearson's product-moment correlation coefficient. Figure 91 gives an overview of the procedure how to choose for the correct correlation coefficient. In this study I mostly use ordinal data, as a result of which Spearman's correlation coefficient is used.

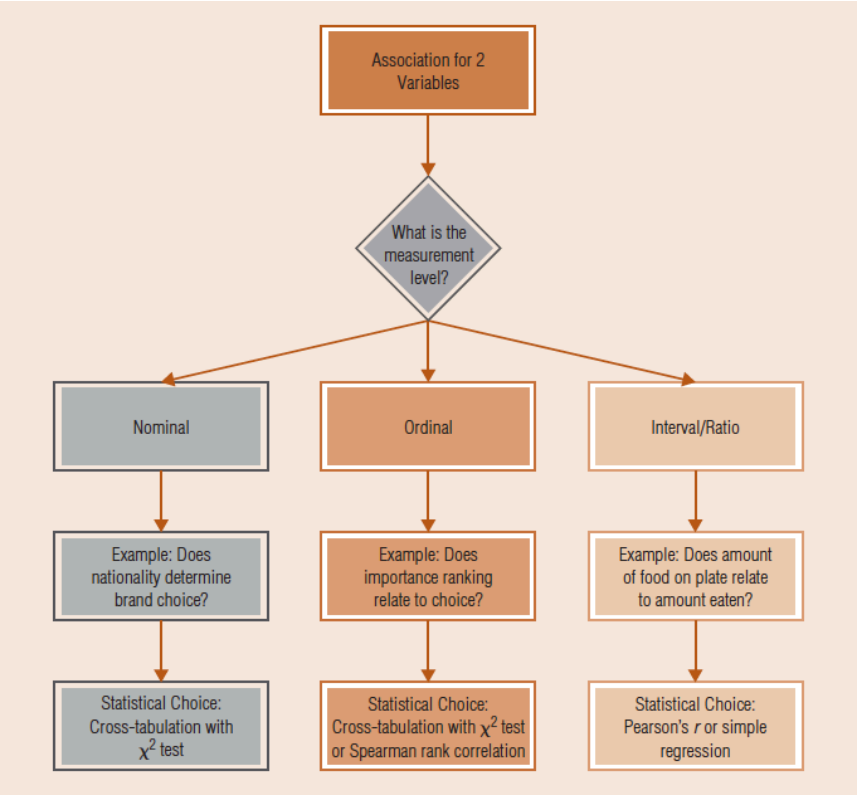


Figure 91: Common procedures for testing Association. http://www.cengage.com/marketing/book_content/1439080674_zikmund/book/ch23.pdf

Bivariate correlation
Bivariate means examining the association between two variables.

Partial correlation
Is a type of correlation that can be done that allows to look at the relationship between two variables when the effect of a third variable is held constant. A partial correlation means that the correlation between two variables is being controlled for the effects of a third variable. Specifically, the effect that the third variable has on both variables in the correlation is controlled (Field, 2013).

6.2.1 Spearman's correlation coefficient (r_s)

The Spearman's correlation coefficient is a non-parametric statistic based on ranked data (ordinal variables). Spearman's test works by first ranking the data, and then applying Pearson's equation (6.1) to those ranks (Field, 2013).

(6.1) $$r = \frac{cov_{xy}}{s_x s_y} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(N-1)s_x s_y}$$

The correlation coefficient is presented by r_s. In order to make conclusions based on this outcome, the r_s needs to be interpreted the appropriate way. A rule of thumb, typically used in the social science, that makes it possible to value the outcome is (Grotenhuis & Weegen, 2011):

>0 to 0,1	very weak
0,1 to 0,25	weak
0,25 to 0.35	moderate
0,35 to 0,45	strong
0,45 and higher	very strong

Using this scale it will be able to determine if the correlation between the separate behavioural categories and energy usage is weak or strong.

6.2.2 Coefficient of determination R^2

Although it is not possible to make direct conclusions about causality from a correlation, it is possible to go a step further by squaring the correlation coefficient. The squared correlation coefficient R^2 (coefficient of determination) is a measure of the amount of variability in one variable that is shared by the other.
This value can also be seen as a percentage instead of a proportion if we multiply the output by 100. In other words, if the outcome is 0%, it means the two variables don't share any variability, and if it is 100%, it means that the two variables share all their variability.
However, although R^2 is an extremely useful measure of the substantive importance of an effect, it cannot be used to infer causal relationships (Field, 2013).

6.2.3 One- and two tailed tests

Hypotheses can be directional or non-directional. A directional hypothesis already gives the direction of the outcome, for example that certain behaviour increases energy use. A non-directional hypothesis gives no indication of the direction of the output. It is unknown if the behaviour increases or decreases the energy use.
For this study the hypotheses are non-directional. The main research question is focussed on the effect of occupant behaviour on energy use, and does not state anything about an increasing or decreasing effect.
This distinction is important for applying the correct statistical test. For directional hypotheses one-tailed tests are used, whereas for non-directional hypotheses two-tailed test need to be used. Thus, for this study a two-tailed Spearman's bivariate correlation will be used.

6.2.4 Significance

When a statistic is significant, it means that the statistic is reliable.
Before performing a statistical test, a hypothesis (H, or alternative hypothesis) about the result is formulated, for example; A is true. By doing this, there is automatically an opposite hypothesis (H_0, or null hypothesis) formulated; A is not true. When running a statistical test with a significant result, it means that the chance for the null hypothesis (H_0) to be true is smaller than the set significance level (for example 0.05). This means that the null hypothesis can be rejected and that the chance is big that the hypothesis (H) is true.
This doesn't automatically mean that a non-significant result means the null hypothesis is true. A significant test statistic is based on probabilistic reasoning, which limits what we can conclude. A non-significant result only tells us that the effect is not big enough to be found, but it doesn't tell us that the effect is zero. Moreover because there is always a small chance for the null hypothesis to be true, otherwise the significance level would be 0. (Field, 2013).
Commonly used significance levels are 0.1, 0.05 and 0.01 (Grotenhuis & Weegen, 2011). Most commonly used significance level in statistical research is 0,05. For this study the level of 0.1 will be used, because of the small sample size.
The *p*-value doesn't give any further information about the value of the outcome. To interpret the output r_s and R^2 need to be used to formulate conclusions.

Because this study has a small sample size (N=13), the sampling distribution is not normal but has a *t*-distribution. This means that it has a probability distribution that changes its shape as the sample size gets bigger (when the sample is very big, it has the shape of a normal distribution).
This p-value is strongly influenced by the sample size. A bigger sample size will result in normally distributed data, which in turn makes the statistical analysis more reliable, and thus more significant. With smaller sample sizes like in this study, the effect of outliers or other disturbing data on the *p*-value is much bigger than with a large sample size.
To minimize the effect of disturbing values SPSS has a bootstrap option. Bootstrapping gets around this problem by estimating the properties of the sampling distribution from the sample data. Using this option in SPSS results in bootstrapped confidence intervals for the correlation coefficient. The confidence interval is the boundary between which the population value falls (in for instance 95% of the samples). If this interval crosses zero it means that the population value could be a negative number or a positive one. In other words, we can't be sure if the true relationship goes in one direction or the complete opposite.
Thus, for interpreting the statistical results derived from the user survey, not only the *p*-value needs to be taken into account, but also the upper and lower boundaries of the confidence interval (Field, 2013).

6.3 Bivariate analyses

The following paragraph will present the bivariate correlation results of the household characteristics and behavioural factors with electricity-, heat and total energy use.

6.3.1 Household characteristics

Table 12 shows the results of the bivariate correlation analyses of the 4 household characteristics in relation to the different types of energy use. As explained in the previous paragraph, the used method is a two-tailed bootstrapped test for Spearman's correlation coefficient. The first column of values shows the correlation coefficient, the second the coefficient of determination R^2 and the third the significance.

Households		Correlation coefficient	coefficient of determination (R2)	*p*-value
Household size	*electricity*	0.772	0.60	0.002*
	heat	0.324	0.10	0.28
	energy	0.655	0.43	0.015*
Education	*electricity*	-0.131	0.02	0.669
	heat	0.014	0.00	0.963
	energy	-0.125	0.02	0.683
Age	*electricity*	0.041	0.00	0.893
	heat	-0.373	0.14	0.209
	energy	-0.168	0.03	0.583
Presence	*electricity*	-0.094	0.01	0.761
	heat	-0.261	0.07	0.389
	energy	-0.208	0.04	0.496

Table 12: Bivariate correlation household characteristics

The analysis reveals the significance of the relation between household size and electricity use (r_s = 0.772; p = 0.002), and the relation between household size and the total energy use (r_s = 0.655; p = 0.015) (electricity use + heat use in MJ).
The relation between household size and heat use however is not significant.
Using the rule of thumb for the valuation of the correlation coefficient, we can say that there is a very strong correlation between household size and electricity- and total energy use (resp. p = 0.772 and p = and 0.655).
Table 13 also shows the corresponding lower and upper boundaries for the confidence interval. It shows that for both variables (electricity and total energy use) the boundaries are above 0, which indicates a positive correlation between the variables. In other words, a bigger household uses more electricity and total energy than a smaller household.
This study didn't reveal correlations between energy use and the other household characteristics.

			Household_size	Electricity usage	Total energy usage
Correlation Coefficient			1.000	.772**	.655*
Sig. (2-tailed)			.	.002	.015
N			13	13	13
Bootstrap[c]	Bias		.000	-.021	-.019
	Std. Error		.000	.160	.218
	95% Confidence Interval	Lower	1.000	.316	.068
		Upper	1.000	.962	.907

Table 13: Bivariate correlation household size and electricity- and total energy use

6.3.2 Behaviour

Table 14 shows the same results as described for the household characteristics, but specified for the behavioural factors. The differently coloured marks represent different significance levels.
- *Orange* is significant at level 0.05
- *Green* is significant at level 0.1
- *Yellow* (> 0.1 and < 0.2) is not significant, but may result in significance if the sample size were larger.

This table shows that Awareness, Attitude and influence of previous building type show a significant correlation (based on a significance level of 0,05) between electricity, and total energy use. The following correlations are found:

Awareness	electricity use	(r_s = 0.55; p = 0.05)
Attitude	total energy use	(r_s = 0.634; p= 0.02)
Previous building	electricity	(r_s = 0.707; p= 0.007)
	total energy use	(r_s = 0.673; p= 0.012)

Based on a significance level of 0.1, more are found:

Motivation	electricity use	(r_s = 0.481; p= 0.096)
Awareness	Total energy use	(r_s = 0.493; p= 0.087)
Attitude	heat use	(r_s = 0.508; p= 0.076)

Specific knowledge shows no significant test results, but the *p*-value approaches the 0,1 significance level for electricity and energy use (r_s = 0.423; p= 0.15 and r_s = 0.447; p=0.126)

The other behavioural factors are not found to be significant (high *p*-values), as a result of which I have not included them in further research on their influence on energy use.
The rest of the analysis will focus on the behaviour categories that showed significant test results. They will be further analysed in the following sub sections.

Behaviour		Correlation coefficient	coefficient of determination (R2)	*p*-value
General knowledge	*electricity*	-0.147	0.02	0.601
	heat	-0.12	0.01	0.696
	energy	0.09	0.01	0.769
Specific knowledge	*electricity*	0.423	0.18	0.15
	heat	0.128	0.02	0.677
	energy	0.447	0.20	0.126
Motivation	*electricity*	0.481	0.23	0.096*
	heat	0.249	0.06	0.413
	energy	0.397	0.16	0.18
Awareness	*electricity*	0.55	0.30	0.05*
	heat	0.304	0.09	0.313
	energy	0.493	0.24	0.087*
Attitude	*electricity*	0.38	0.14	0.2
	heat	0.508	0.26	0.076*
	energy	0.634	0.40	0.02*
Current energy saving behaviour	*electricity*	-0.069	0.00	0.823
	heat	0.131	0.02	0.671
	energy	0.031	0.00	0.919
Influence previous building type	*electricity*	0.707	0.50	0.007*
	heat	0.303	0.09	0.314
	energy	0.673	0.45	0.012*
Thermal comfort winter	*electricity*	0.278	0.08	0.358
	heat	-0.179	0.03	0.559
	energy	0.063	0.00	0.838
Natural ventilation behaviour winter	*electricity*	-0.185	0.03	0.545
	heat	0.006	0.00	0.985
	energy	-0.125	0.02	0.684

Table 14: Bivariate correlation behaviour

6.3.2.1 *Awareness*

Table 15 presents the details that result from the correlation test.
The r_s coefficients for awareness and electricity use and total energy use are resp. 0.55 and 0.493. This can be valued as a very strong correlation between these variables. Taking a closer look at the boundaries of the confidence interval reveals some uncertainties. For both the variables electricity use and total energy use the interval crosses zero. This means that the direction of the correlation can be positive or negative. In this case however, the lower boundary is very close to zero in both cases. This indicates that it is highly likely that the direction of the correlation is positive.
This would mean that a larger awareness results in a higher electricity use and total energy use.
Looking back at the first excel results in paragraph 5.4.8 this trend was already noticeable. Thinking logically, it is an unexpected phenomenon that a larger awareness results in a higher energy use. One should expect the opposite; larger awareness results in lower energy use.
Previous studies have shown that most of the occupants of low energy houses do realise they live in a low energy house, but a lot of people tend to create a perception that their behaviour is not relevant anymore for the energy usage of the house (VROM, 2010). This phenomenon could indicate homeostasis, which means that people adapt their behaviour to changes in the environmental context (Wilde, 1998).

			Awareness	Electricity usage	Total energy usage
Correlation Coefficient			1.000	.550	.493
Sig. (2-tailed)			.	.052	.087
N			13	13	13
Bootstrap[c]	Bias		.000	-.024	-.021
	Std. Error		.000	.246	.243
	95% Confidence Interval	Lower	1.000	-.078	-.087
		Upper	1.000	.877	.839

Table 15: Bivariate correlation Awareness and electricity and total energy use

6.3.2.2 *Attitude*

Next behavioural factor that showed significant test results is attitude. The output of the analysis can be found in Table 16. The variable attitude is the only one of the variables that reveals a correlation with heat usage. The r_s is 0.508, which indicates that there is a very strong correlation between these variables. However, the upper and lower boundaries of the confidence interval contain zero. The direction of the correlation is not clear, which makes it difficult to make a conclusion for this correlation. The correlation between awareness and total energy use shows a r_s of 0.634 and a confidence interval always above zero. The correlation between these two variables can be assumed very strongly positive.

This illustrates the same phenomenon as found for awareness, the homeostasis effect. A positive attitude towards energy saving measures results in a higher total energy use.

			Attitude	Heat usage	Total energy usage
Correlation Coefficient			1.000	.508	.634*
Sig. (2-tailed)			.	.076	.020
N			13	13	13
Bootstrap[c]	Bias		.000[d]	-.016[d]	-.017[d]
	Std. Error		.000[d]	.266[d]	.222[d]
	95% Confidence Interval	Lower	1.000[d]	-.148[d]	.090[d]
		Upper	1.000[d]	.872[d]	.878[d]

Table 16: Bivariate correlation Attitude and heat use and total energy use

6.3.2.3 Influence previous building type

The variable influence of the previous building type showed to be correlated with electricity use and total energy use. Table 17 presents the results showing that the variables have a r_s of resp. 0.707 and 0.673, which means there is a very strong correlation. The entire confidence interval is also above zero in both cases, so the influence of the previous building type is positively correlated with electricity and total energy use.

The influence of the previous building type category describes the previous houses of the occupants ranked from very energy friendly houses to very energy unfriendly houses. Looking at the results it can be assumed that the occupants who previously lived in an energy friendly house use less energy than occupants that lived in an energy unfriendly house. This is a very interesting point, because it illustrates the fact that occupants create habitual behaviours in their houses that they also execute after they move into a new house.
Even though this study only made a global specification for this category, this result emphasizes the relevance for further detailed research into this topic of habitual behaviour and the time it takes for occupants to adjust this behaviour in new surroundings.

			Previous building influence	Electricity usage	Total energy usage
Correlation Coefficient			1.000	.707**	.673*
Sig. (2-tailed)			.	.007	.012
N			13	13	13
Bootstrap[c]	Bias		.000	-.045	-.036
	Std. Error		.000	.152	.187
	95% Confidence Interval	Lower	1.000	.309	.153
		Upper	1.000	.872	.920

Table 17: Bivariate correlation Previous building type and electricity use and total energy use

6.3.2.4 Motivation

Table 18 presents the output for the correlation test for motivation and electricity usage. The correlation coefficient between these two variables is r_s = 0.481, which can also be valued as very strong. The confidence interval however crosses zero. In this case the lower boundary is very close to zero. The direction of the correlation cannot be determined but it is likely that this correlation is positive.
This would mean that a higher motivation results in a higher electricity use. Again, homeostasis may be acting here.
Looking back at the results of the other behavioural factors, there is a positive correlation for awareness, attitude and motivation with energy use. This information is very important to take into consideration when wanting to manipulate occupant behaviour. These results suggest that increasing awareness, attitudes and motivation would have a negative effect on the target of saving energy. This sounds very unnatural and not logical when thinking of intervention strategies, and is in contradiction with literature on these topics (section 2.5) except for the study by VROM (2010). Taking the results of this study literally, it means that one should decrease the awareness, attitude and motivation of an occupant in order to decrease energy use. My view on this phenomenon is that it is not a question of increasing or decreasing ones behavioural factors, but the important task is to bring the perception of the occupant and reality in agreement.

			Motivation	Electricity usage
Correlation Coefficient			1.000	.481
Sig. (2-tailed)			.	.096
N			13	13
Bootstrap[c]	Bias		.000	-.008
	Std. Error		.000	.230
	95% Confidence Interval	Lower	1.000	-.046
		Upper	1.000	.840

Table 18: Bivariate correlation Motation and electricity use

6.3.2.5. Specific knowledge

Although the results of the correlation test cannot be considered significant (*p*-value > 0.1), the results will still be discussed using the output presented in Table 19. Because the sample size is very small it is important to take a closer look at the output and not only look at the *p*-value. Based on the correlation coefficient it could be said there is very strong correlation between the two variables, but the zero crossing confidence interval doesn't make it possible to determine the direction of the correlation. Table 19 shows that the lower boundary of the confidence interval for total energy use and specific knowledge is closer to zero (-0.137) than the lower boundary for electricity and specific knowledge (-0.265). Compared to the disregarded behavioural factors that had very high *p*-values with low correlations, the results for specific knowledge are showing relatively good results. It is probable that with a larger sample, this category will show a significant relationship with a positive correlation between specific knowledge and electricity and energy use.

			Specific knowledge	Electricity usage	Total energy usage
Correlation Coefficient			1.000	.423	.447
Sig. (2-tailed)			.	.150	.126
N			13	13	13
Bootstrap[c]	Bias		.000	-.014	-.020
	Std. Error		.000	.301	.235
	95% Confidence Interval	Lower	1.000	-.265	-.137
		Upper	1.000	.886	.810

Table 19: Bivariate correlation specific knowledge and electricity use and total energy use

6.3.3 Mutual bivariate correlations behaviour

After having a better understanding which behavioural factors have correlate with energy use, next step is to investigate the mutual correlation between the separate behavioural factors.
As explained in section 2.5, the framework of psychological factors that influence behaviour is a complex framework. The separate factors don't always have a singular or direct relation with energy use, but are influenced (positively or negatively) by other behavioural factors. For this reason, a bivariate correlation is executed on the separate factors, to indicate which factors share a large amount of variability with each other. Table 20 gives an overview of the *p*-values for the correlation between the individual factors. It shows that there are some factors that influence each other:

- motivation - awareness (on a α is 0.1 level)
- awareness - attitude (on a α is 0.05 level)
- motivation - previous building type (on a α is 0.1 level)

First step is to criticize if these correlations are logical and if they correspond with found relationships from literature.

As for the relations between motivation – awareness and awareness – attitude, it can be assumed that this is a plausible relation. Figure 92 shows the scheme of the stated relations between the behavioural factors as first presented after the literature study into behaviour. The red dotted circle marks the relation in this framework that has been confirmed with the statistical analyses. The red arrow indicated that there is also a relationship found between attitude and awareness, so these factors do not influence knowledge and motivations separately, but also influence each other. In addition to this figure and in contrary with the literature, the statistical analysis did not prove a relation between attitude – motivation, knowledge – motivation and knowledge and attitude.
As for the relation that shows a significant correlation between motivation and the influence of the previous building, it cannot be stated that these two variables have a valid relation. These two factors have no logical relationship so this correlation will be disregarded for further analysis.

p-value	specific knowledge	motivation	awareness	attitude	previous building
specific knowledge	-	0.581	0.854	0.49	0.348
motivation	0.581	-	0.061	0.32	0.064
awareness	0.854	0.061	-	0.005	0.339
attitude	0.49	0.32	0.005	-	0.248
previous building	0.348	0.064	0.339	0.248	-

Table 20: p-values correlation test for separate behavioural factors.

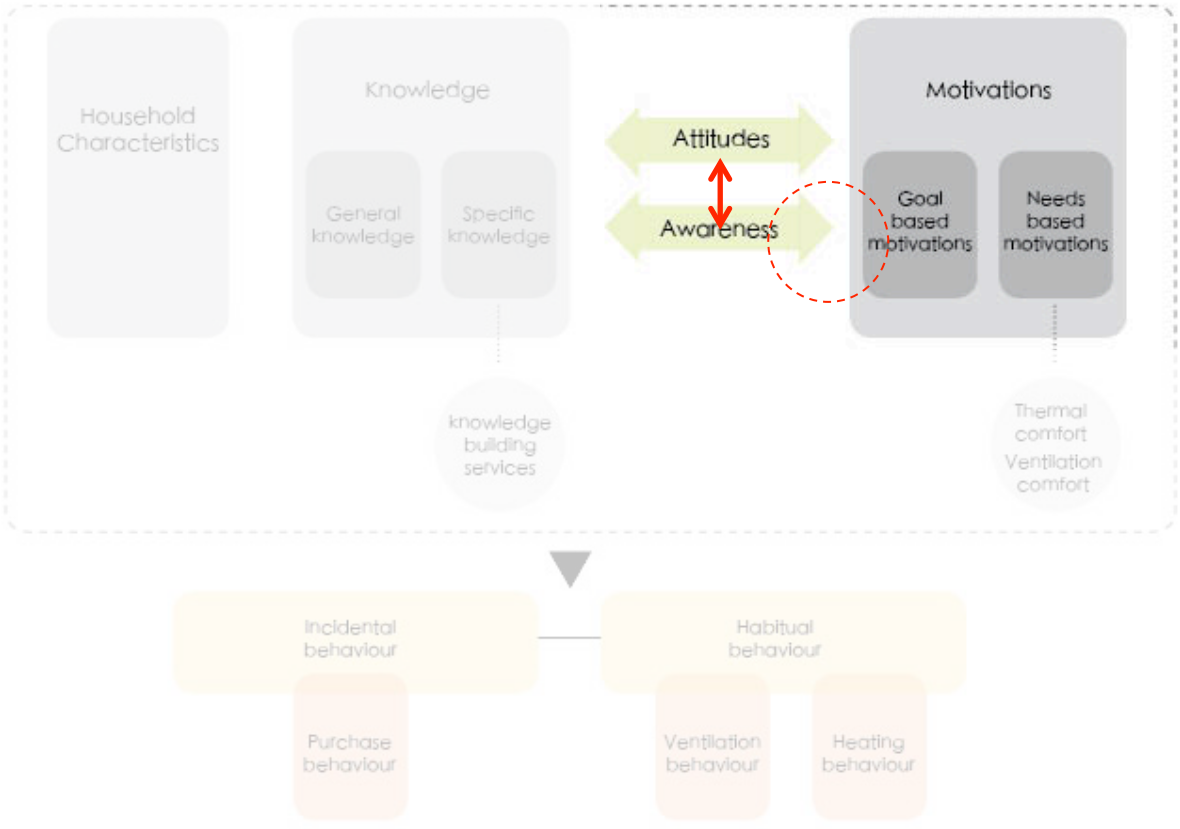


Figure 92: relation scheme influences on occupant behaviour

Figure 93 shows that awareness and attitude have a very strong positive correlation. Thus, increasing attitudes also increases awareness and/or the other way around.
Figure 94 shows that the confidence interval for the correlation between awareness and motivation crossed zero, but that the lower boundary is very close to zero. It is likely that this correlation, with a very strong correlation coefficient of 0.494 also has a positive direction.
This means that increased motivation leads to increased awareness and/or the other way around.

			Awareness	Attitude
Correlation Coefficient			1.000	.707**
Sig. (2-tailed)			.	.005
N			14	14
Bootstrap[c]	Bias		.000	-.009
	Std. Error		.000	.120
	95% Confidence Interval	Lower	1.000	.449
		Upper	1.000	.935

Figure 93: Bivariate correlation awareness and attitude

			Awareness	Motivation
Correlation Coefficient			1.000	.494
Sig. (2-tailed)			.	.061
N			15	15
Bootstrap[c]	Bias		.000	.011
	Std. Error		.000	.258
	95% Confidence Interval	Lower	1.000	-.093
		Upper	1.000	.871

Figure 94: Bivariate correlation awareness and motivation

6.4 Partial correlations

Resulting from the output of the previous bivariate correlations and the consideration that the separate behavioural factors influence each other, it is more accurate to also execute partial correlations in order to control the correlation of two variables with a third dependent variable.
The amount of possible influences that can be analysed in partial correlation is endless. To stay focused on the main research question the partial correlation will only be executed for the behaviour variables that showed a correlation with energy or electricity use and a mutual correlation (section 6.3.3). Filtering the variables that meet this requirement resulting from the bivariate correlation, leaves the following combinations presented in Table 21.
As we can see, the correlation between motivation – electricity and awareness – electricity is not showing a significant result anymore if controlled for awareness respectively attitude.

behaviour controlled for behaviour				
variabels	control for	*p*-value	correlation	coefficient of determination (R2)
electricity motivation	awareness	0.341	0.301	0.09
electricity Awareness	attitude	0.304	0.324	0.10

Table 21: Partial correlations for behavioural variables

A comparison of the partial correlation results with the previous bivariate correlation results (Table 22) illustrates this more clearly. Whereas the correlation coefficient is very strong with a reliable test result for the bivariate correlation tests, the correlation coefficient decreases after the partial correlations with no longer significant test results.
Thus, after partial correlation it is not possible to make conclusions about the influence of the two behavioural factors anymore. Although this is not a satisfying result, it is more accurate than making conclusions only based on the results from the bivariate correlations, because they represent a very simplified reproduction of the reality.

	variabels	control for	*p*-value	correlation	coefficient of determination (R2)
Partial	electricity	awareness	0.341	0.301	0.09
	motivation				
	electricity	attitude	0.304	0.324	0.10
	Awareness				
Bivariate	Motivation	electricity	0.096*	0.481	0.23
	Awareness	electricity	0.05*	0.55	0.30

Table 22: Comparison partial and bivariate correlation

6.5 Thermal experience and preference

The last variables that will be analysed for the correlation with energy use are the thermal comfort and preference of the occupants. Section 6.3.2 already showed the correlation for thermal comfort in winter and energy use, which didn't show significant test results.
The reason for further research into this variable (despite the non-significant test results) is to find an answer on why the occupants ventilate naturally in their residences. During the period of this study, the occupants did not yet use their heating, so the only actual behaviour that can have an influence on the energy use is the natural ventilation behaviour (see Figure 3). It is important to be able to say more about this behaviour for the development of the design solutions.
Figure 71 and Figure 78 presented the frequency of natural ventilation behaviour during summer and winter. During summer it was obvious that most of the occupants ventilate much to very much. It is interesting to know more specifically for what reason the occupants ventilate a lot during summer. The fact that they do ventilate a lot is not a positive thing for the energy concept of the house, because the highly insulated building skin is supposed to keep the warm air outside. When opening the window, the insulation layer is interrupted, with the consequence that the warm outside air is entering the building. This can cause dissatisfaction for the indoor thermal comfort. We want to know if the occupants open the windows because they experience an uncomfortable indoor climate, or that they prefer a different indoor climate. If this is not the case, other reasons are decisive for this behaviour. The same underlying idea applies to the winter situation. Figure 78 showed that the majority of the occupants ventilate naturally on a regular basis, with two outliers that never ventilate and always ventilate. Especially during winter, the opening of the windows can have a big influence on the heat demand.

Table 24 shows the results of the correlation test on the different thermal comfort variables and heat use. Because it is only useful to compare the variables to heat use, the electricity and total energy use are left aside.
None of the correlations show significant test results. The ventilation behaviour during winter appears to have no relationship at all with the heat use. In terms of the energy performance of the building this is a good result, because it implies that opening the windows during winter is not related to a higher heat use. This leads into the direction that occupants ventilate naturally resulting from preferences or other (unknown) reasons.
If we compare the results with each other, we can see that the correlation between thermal preference winter and the heat use shows the lowest *p*-value. Even though we cannot conclude anything from this correlation coefficient, it is likely that in the same test with a larger sample size the correlation would become significant with a positive direction. This would support the hypothesis that the heat use increases if the occupants prefer a warmer indoor climate, which is a logical relation.
Next step is to look at the correlation between the natural ventilation behaviour and the thermal preferences during the seasons. Table 23 presents the *p*-values of this correlation test. No significant test results have been found, which means that it cannot be concluded that the natural ventilation behaviour is correlated to the thermal preference or experience during the seasons. The lowest *p*-value is for the correlation between the thermal experience in summer and the natural ventilation during summer (r_s = 0.371; p = 0.174).

Thermal comfort		*p*-value	correlation	coefficient of determination (R2)
thermal experience winter	*electricity*	0.358	0.278	0.08
	heat	0.559	-0.179	0.03
	energy	0.838	0.063	0.00
thermal preference winter	*electricity*	0.154	-0.42	0.18
	heat	0.209	0.373	0.14
	energy	0.93	0.027	0.00
thermal experience summer	*electricity*	0.581	-0.169	0.03
	heat	0.487	-0.212	0.04
	energy	0.2	-0.38	0.14
thermal preference summer	*electricity*	0.023	-0.624	0.39
	heat	0.419	0.246	0.06
	energy	0.772	-0.089	0.01
ventilation behaviour winter	*heat*	0.985	0.006	0.00

Table 24: correlation thermal comfort and heat use

Thermal comfort	preference winter	experience winter	preference summer	experience summer
natural ventilation behaviour winter	0.737	0.715		
natural ventilation behaviour sumer			0.609	0.174

Table 23: Correlation natural ventilation and thermal comfort: p-values

			Natural ventilation behaviour summer	Thermal comfort experience summer
Correlation Coefficient			1.000	.371
Sig. (2-tailed)			.	.174
N			15	15
Bootstrap[c]	Bias		.000	-.021[d]
	Std. Error		.000	.257[d]
	95% Confidence Interval	Lower	1.000	-.236[d]
		Upper	1.000	.791[d]

Table 25: Bivariate correlation summer thermal experience and natural ventilation summer

Looking at the correlation coefficient and boundaries of the confidence interval in Table 25, it appears that the natural ventilation frequency is positively correlated with the thermal indoor experience during summer. Because correlation doesn't say anything about causality, we cannot say which variable is a result from the other. In other words, it is possible that the occupants open the windows and ventilation panels because they find the indoor temperature too warm, or that they find the indoor temperature too warm because they open the windows and panels more frequently. The relation between the two variables can go both directions.

Thus, this study did not find a reason, based on the retrieved user survey data, for the natural ventilation behaviour of the occupants. This may sound like an unsatisfying conclusion, but the opposite is true. Knowing that the natural ventilation behaviour is not dependent on the thermal experience or preference of the occupants means that the reasons for this behaviour must be searched for elsewhere. One of these reasons could be that the opening of the windows is related to the preference to experience fresh air inside the house (Itard, et al., 2009; Santin & Itard, 2010; Soldaat, 2007). Even though these passive houses are equipped with a mechanical ventilation system with heat-recovery, that theoretically should provide a healthy air quality when all the windows stay closed, people still open their windows to manipulate their indoor air experience.

Integrating this knowledge in design solutions for low energy houses, means that as a designer one must take as a given that occupants open their windows 'randomly' for varying reasons. This makes the nature of the natural ventilation behaviour of occupants of a dynamic character.

As explained in paragraph 3.4.1, the studied houses in Columbuskwartier are design with an energy concept where the natural ventilation behaviour of the occupants has certain restrictions in order to let the house perform optimally in terms of energy performance. This is not a design perspective where the dynamic behaviour of the occupants is taken into account.

Because of the fact that occupant behaviour has a bigger influence on the energy performance of low energy houses than technical factors, the design challenge of the future is to design a low energy house where the dynamic occupant behaviour has no (or a very small) influence on the energy performance. The less influence the occupant has on the energy performance, the more robust a design becomes.

6.6 Conclusions

The previous chapter 5 and chapter 6 presented the results of the analysis part of this research based on the user survey data. The first step in this process (chapter 5) was to get more insight in the separate behavioural factors in relation to electricity, heat and total energy use. It showed that it is difficult to make conclusions based on this information, mainly because of the small scale of the review group (small sample size).
The second part (chapter 6) gave a more detailed view on the correlations between the variables. This analysis method made it possible to make conclusions and assumptions about the relation between the behavioural factors and energy use. It also proved that there indeed is a mutual correlation between some behavioural factors, which partly confirms the relation scheme that was derived from the literature study.
Another thing that askes for an answer is the reason why the behavioural factors mostly showed a correlation with electricity use and not with heat use. This could be explained by the fact that electricity usage is more tangible than heat usage. This tangibility can be interpreted from two different perspectives. First it is important to ascertain that in general in the media more attention is paid to sustainable solutions and renewable energy sources for electricity provision.
Second explanation may lay in the fact that electricity usage is determined by more direct actions from the occupants like the operation of devices. Heat usage on the contrary, has a more indirect controllable character. A third important aspect that may explain the correlations is that heat usage is more related to comfort and preferences than electricity use, which are dominant and difficult to adjust for occupants.
Summarizing the results of the correlation tests, the following variables showed to correlate with (or are likely to have a relation with) with energy use:

- Specific knowledge
- Motivation
- Awareness
- Attitude
- Influence previous building type

Looking at the sub question:

What is the share of user behaviour in the difference of the predicted and actual energy use?

The results of the statistical analyses neither give an answer to the actual share of the user behaviour in the difference in the predicted and actual energy use nor in the extent to which they explain the variance in energy use among identical passive houses. To be able to give an answer to the share of a variable in the difference between the predicted and actual energy use, it is first necessary to determine what the share is of the variable in the individual actual energy use. Because of the fact that this study was not able to give a conclusive answer on this, mainly because of the small sample size, it is not possible to say anything about the share of the behaviour in the difference between the predicted and actual energy use.

Another conclusion is that this study did not find a relation between the executed natural ventilation behaviour by the occupants and their thermal experience or preference. Although the natural ventilation behaviour did not show a relation with energy use, this variable does explain the encountered dissatisfactions about the indoor climate as presented in Figure 53 to Figure 56. Design solutions should not only focus on the theoretical (predicted) energy performance, but should also take into account the dynamic

character of the occupant, in order to minimize deviating energy uses and dissatisfaction of the occupants Integrating sustainable solutions that meet the dynamic character of the occupant will provide more robust houses, which are necessary in order to meet the on-going strengthening of energy demand regulations for houses (like the EPC policy).

7. MONITORING

The last step in the process of collecting data that takes a more detailed look at specific occupant behaviour on a smaller scale is the monitoring of 2 houses. As described in the method at the beginning of this report, the 2 houses that are monitored have to meet certain requirements in order to get the best insight into the occupant behaviour. This chapter will first pay attention to the selection process, followed by the description of the context of the houses and the used measuring methods. After that the results of the monitoring will be presented, which are subdivided into electricity use and heat use where the two houses will be compared. The chapter will end with a conclusion about the influence of occupant behaviour on energy use.

7.1 Selection criteria monitoring objects

To get results that give the best possible insight into the difference in occupant behaviour and the related energy use, it is important to exclude as many other factors that can be of influence on the energy use as possible. This means that the houses need to be identical, with the same technical performance. This specific selection process was part of the beginning of this study, and also decisive in the choice for the studied objects in Columbuskwartier. After the collection of the user survey data, it is possible to make a further filter on household and behaviour characteristics to select the two houses (Figure 95).

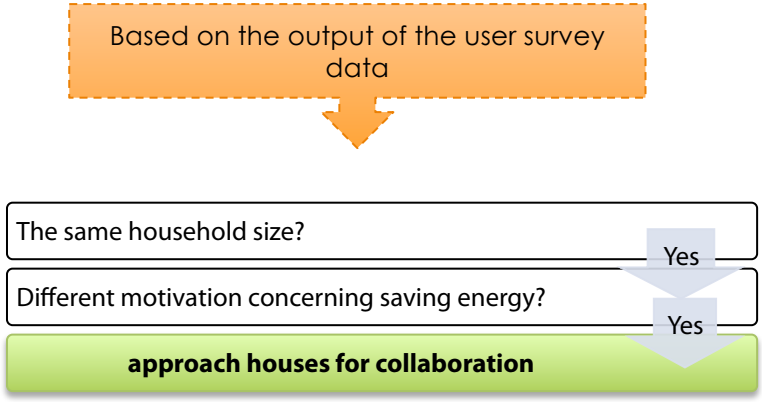


Figure 95: selection process monitored houses

To exclude the influence of the household size on the monitoring results, household size must be the same. As proven with the bivariate correlation analysis, this is the only household characteristic that shows a relation with energy use. The last step is selecting two houses with occupants that have a different degree of motivation, attitude or awareness, to see if this difference is of influence on their energy use.

7.1.1 Household types

Most of the respondents appeared to have a household size of 3 persons (Figure 96). For this reason the choice is made to select 2 houses with a household size of 3 persons, in order to have a larger variation in occupant behaviour factor.

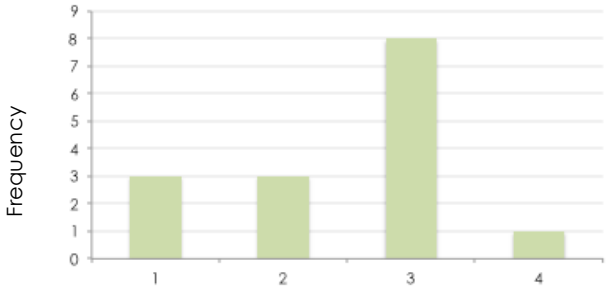


Figure 96: Household sizes

7.1.2 Occupant behaviour profiles

After filtering the household sizes of 3 persons, Table 26 is used to see the different scores on the behavioural factors. It appears that motivation has the largest variance in scores, with a highest score of 4 (very motivated) to a lowest score of 2 (a little motivated).
These 4 households with highest and lowest scores on motivation have been approached for collaboration, and after some difficulties with finding occupants that wanted to collaborate, houses E and H were selected (Table 27).

	G. Knowledge	S. Knowledge	Motivation	Awareness	Attitude
A	1	2	2	2	3
E	3	1	4	3	3
F	3	3	3	2	2
G	2	2	3	3	3
H	3	2	2	2	3
I	2	3	2	2	2
J	0	2	3	2	-
K	4	2	3	2	2

Table 26: behaviour variables occupants

	G. Knowledge	S. Knowledge	Motivation	Awareness	Attitude
E	3	1	4	3	3
H	3	2	2	2	3

Table 27: Selected houses

	E	H
G.knowledge	Knowledge	Knowledge
S. Knowledge	No knowledge	Little knowledge
Motivation	Very motivated	A little Motivated
Awareness	Aware	A little aware
Attitude	Positive	Positive

Table 28: Behaviour profiles

Table 28 shows that the occupants have the same general knowledge and attitude, but that house E has a higher motivation and awareness than house H, but that house H has a slightly higher specific knowledge than house E.

7.2 Context selected objects

After the applied selection criteria it appeared that the 2 selected objects had another advantage for excluding other external factors that could be of influence on the energy use. Figure 97 marks the houses with red circles. It appeared that the houses were located in the same street with the same orientation. This is a positive circumstance for excluding the different external factors, like the influence of wind direction and insolation, especially because the monitoring period is executed simultaneously so the results are collected under the same weather conditions.

7.3 Measuring methods

Due to the identical floor plans of the houses, the installing of the measurement equipment has been done on the same location in both houses (Figure 98). To monitor the temperature and relative humidity, data loggers have been used (Escort loggers (Figure 100) and Pluwise Sense (Figure 101) section 7.3.1).
Besides this, the presence was logged using IT-200 InteliTime pro logger presence detectors (section 7.3.1; Figure 99).
The electricity use was measured on appliance level using the monitoring system of Plugwise Home Basic (Section 7.3.1; Figure 102).
This system contains 9 plugs that are installed between the socket en the plug of the appliances that are measured. These plugs work like a network and send their retrieved data to one plug which send the total data of the separate appliances to a usb receiver that displays the data in the included software (more information about this system can be found on www.plugwise.com).



Figure 97: location monitored houses

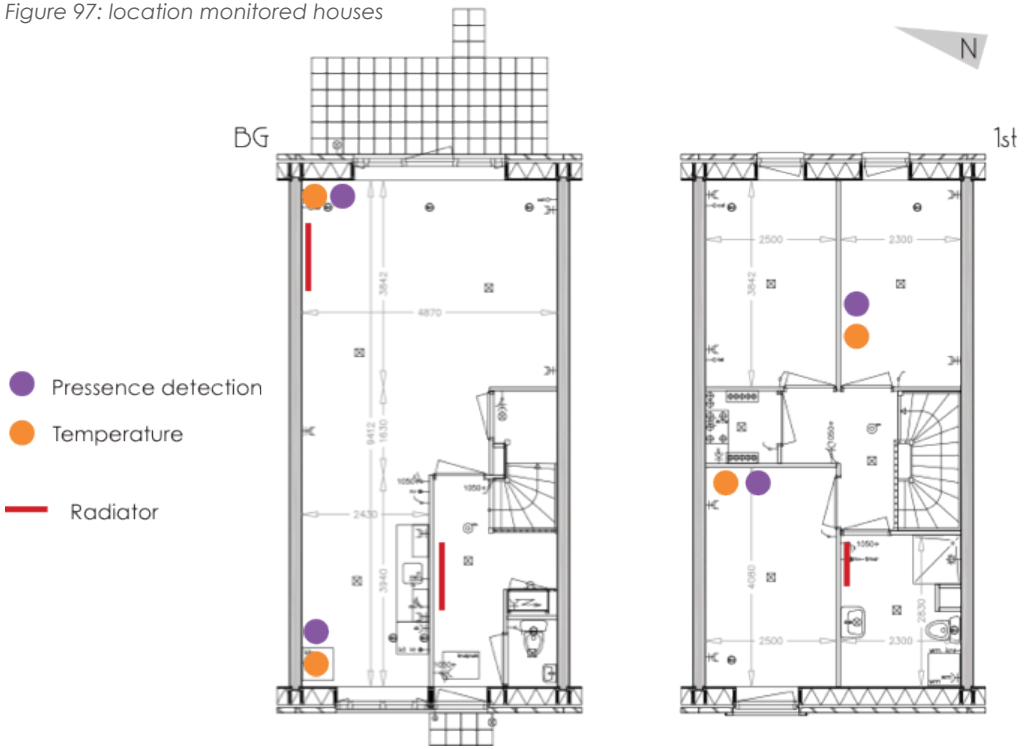


Figure 98: Location measurements

7.3.1 Technical specifications

IT-200 InteliTime pro logger

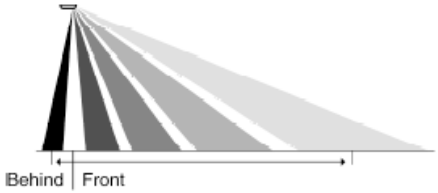
The IT-200 monitors an area of up to 13.9 m^2.
The unit should be placed near the light source with the light pipe aimed at the light and the lens facing the occupant's area.



Figure 99: IT-200 InteliTime pro logger source: www.wattstopper.com

Distance Coverage

Mounting height (m)	Behind	Front
2.4	-0.3	4.6
3.0	-0.5	5.8
3.7	-0.6	7.0
4.6	-0.8	8.8



Escort junior Temperature & Humidity data logger



Figure 100: Escort junior data logger source: www.escort-intruments.ch

- 1 Temperature and 1 Humidity sensor

Measurement Range:
- Internal Sensor -20°C / +60°C
- Internal Sensor Accuracy +/- 0.3°C
- Humidity Sensor 0 - 100% RH
- Humidity Sensor Accuracy +/- 3%

Plugwise Sense & Home Basic



Figure 101: Plugwise Sense. source: www.plugwise.com

- 1 Temperature and1 Humidity sensors

Measurement Range:
- Temperature Sensor 0°C / +60°C
- Temp. Sensor Accuracy +/- 0.3°C
- Humidity Sensor 5 - 95% RH
- Humidity Sensor Accuracy +/- 3.2%



Figure 102: Plugwise Home Basic. source: www.plugwise.com

- 1 Circle+, 8 Circles, 1 USB, Software (source software)
- Supply Voltage 230 – 240 VAC
- Frequency 50/60 Hz
- Accuracy (current) 5% ± 0.5 W
- Accuracy (cumulative) 1% ± 0.2 W

7.3.2 Daily log

Besides the monitoring hardware, the occupants filled in a specifically composed daily log during 7 days (the same 7 days for both houses). The used daily log can be found in Appendix I Figure I-1.
The occupants had to register for every hour the following subjects:

- The use of shower and/or bath
- Presence at home
- The use radiator valves
- Cooking behaviour
- Opening of the windows per room
- Heating behaviour per room

These questions were chosen to be collected through a daily log because there were no available measurement tools to register these behavioural data.

7.4 Results

Because of the large amount of retrieved data, the results will be presented in subparagraphs for electricity and heat. After that the comparison will be made resulting in conclusions.
The monitoring period started 14-09-2013 and ended on 8-11-2013. The focus of the analysis of the results will be on the period when the occupants both filled in the longitudinal questionnaire, which has been done in the period from 5-10-2013 till 11-10-2013. The main reason is that this period gives the most information about the actual behaviour of the occupants in relation to their energy use. The remaining data collected during the monitoring period can be found in Appendix J.
An important fact is that both of the houses did not use their radiators during this period, which makes it impossible to conclude anything about their heating behaviour. The results do, however, give a good insight in the natural ventilation behaviour of the occupants and the effects of this on the indoor air temperature.

7.4.1 Electricity

The collected data about the electricity use of the occupants has been retrieved from monitoring on appliances level. Unfortunately it was not possible to meter all the big installations of the houses like the mechanical ventilation unit and the electrical cooking device, because they are equipped with other plugs that did not fit the Plugwise plugs.
It was also not possible to measure the artificial light use. These three factors have a big share in the total electricity use.
Based on the electricity use of the appliances that were measured (Appendix K) and on the longitudinal questionnaire, the electricity use of the remaining appliances that were not measured is derived (Figure 104).
Figure 103 presents the graphs of the measured electricity use during the monitoring period. It shows that house E has a higher constant level of electricity use than house E (indicated by the orange dotted line).
The aim of the monitoring is to investigate if it is possible to find an explanation for these differences in usage.
Looking back at the results of the statistical analyses I found that there are (possible) significant correlations between electricity use and the following variables:

- Motivation
- Awareness
- Previous building type

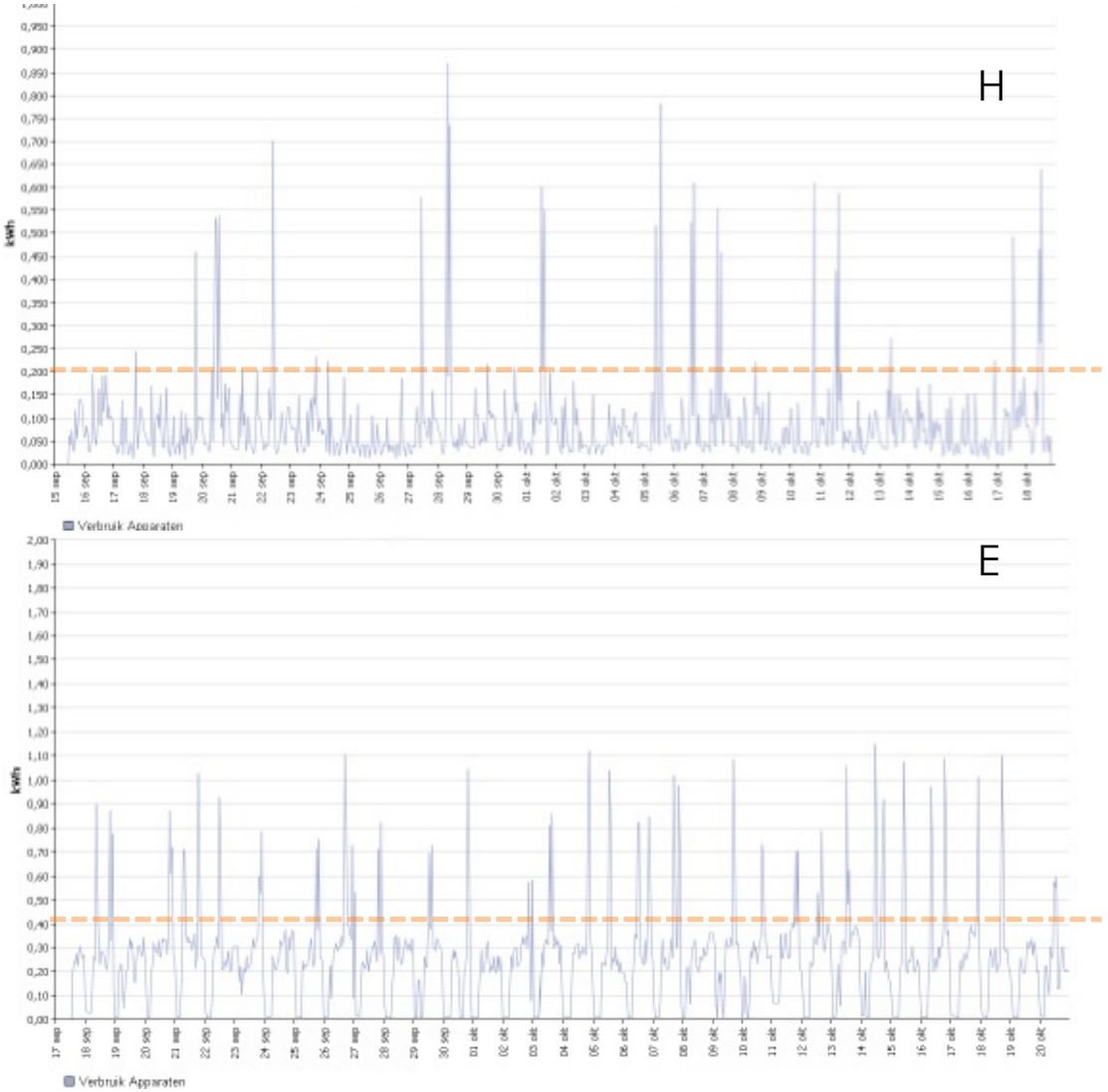
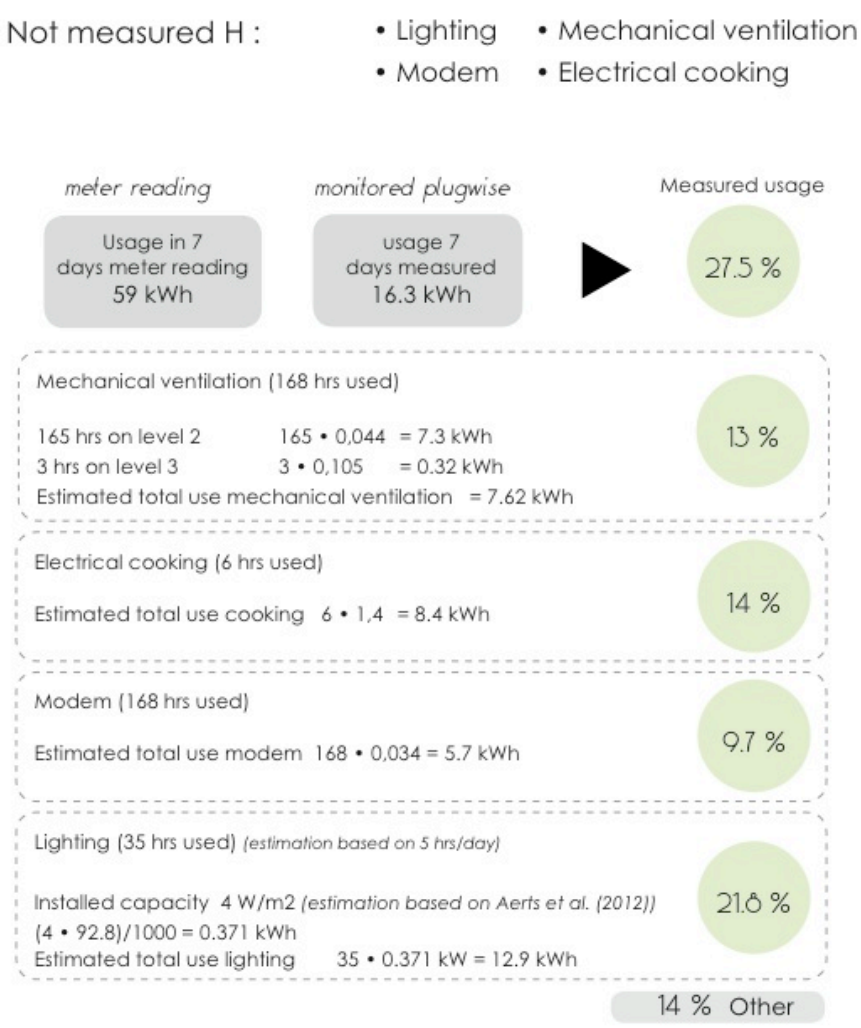


Figure 103: Measured electricity use in the whole house



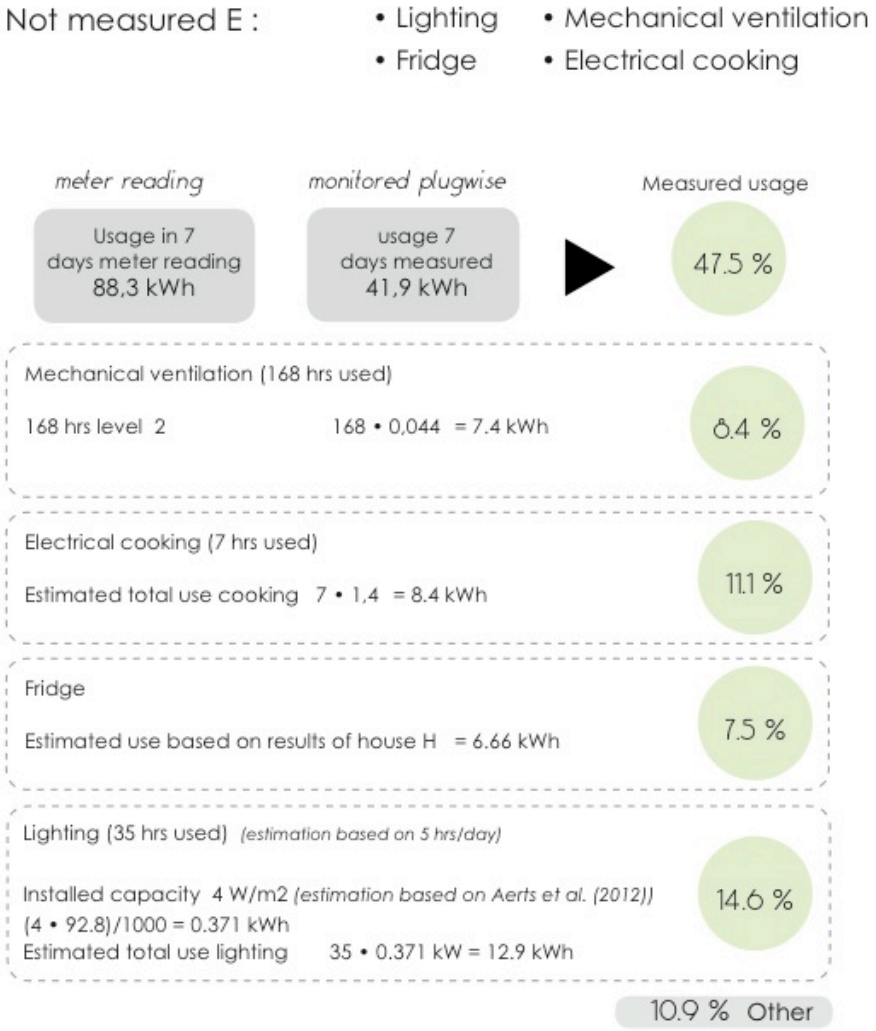


Figure 104: Electricity distribution house H and E

Before taking a closer look at these behavioural factors, an important household characteristic will be analysed. Although the household size is the same, so this variable can be excluded from the possible causes, there is still the household characteristic presence left that can have a direct and big influence on electricity use. Figure 105 shows that the presence during the period of the longitudinal questionnaire was the same 2.2 (average persons per hour) (Appendix J Table J-5). It can be concluded from this result that the household characteristic presence is not an explanatory factor for the difference in electricity use. This means that only the behavioural factors can explain the difference in the electricity use.
Figure 106 Shows the electricity use (black dotted line) compared with the scores of the two houses on the different behavioural variables. This figure confirms the findings that resulted from the bivariate correlations. The occupants in E, that uses more electricity, is also showing a higher motivation and awareness than in house H. This again points at the homeostasis effect that may occur within the residences. The occupants do realise they live in a low energy house, but they tend to create a perception that their behaviour is not relevant anymore for the energy usage of the house.
It also shows that the occupants of house E previously lived in a house that was less energy efficient than the previous house of the occupants from house H. This also confirms the findings resulting from the bivariate correlation analysis. The blue diagram represents current energy saving behaviour indicated by the occupants. The occupants in house E say they do a lot concerning saving energy, while this is not shown in their actual electricity use. This illustrates that the perceptions of occupants are not always in accordance with the reality.

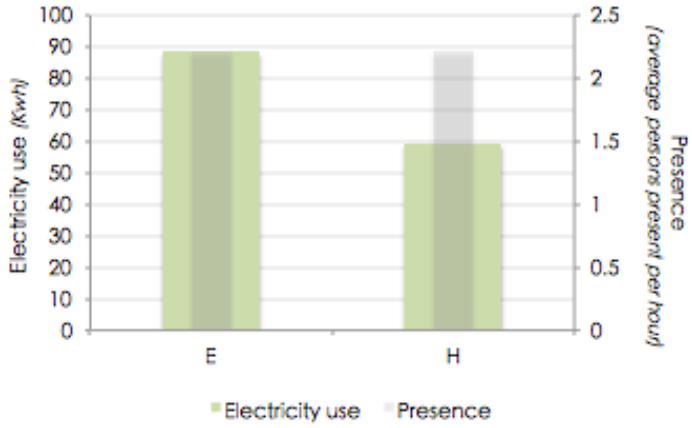


Figure 105: Presence vs. electricity use

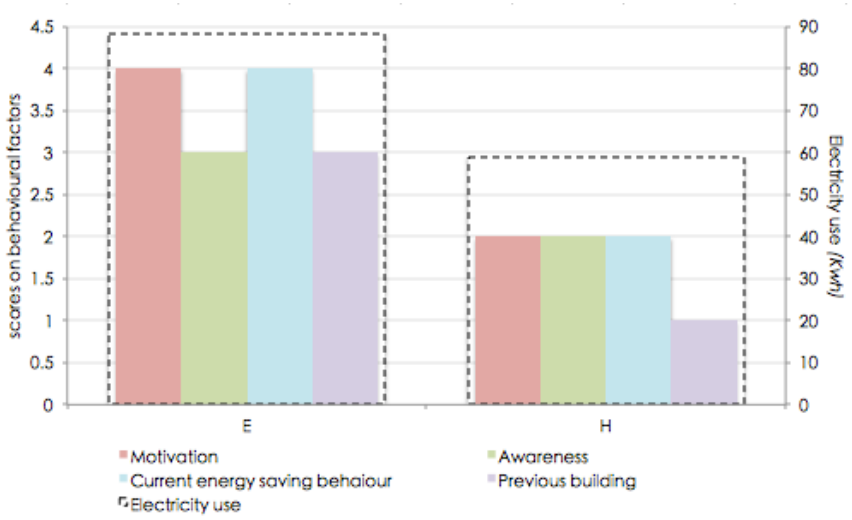


Figure 106: behavioural factors vs. electricity use

7.4.2 Heat

As for heat, the monitoring has been less satisfying, due to the fact that the occupants did not use the radiators during the monitoring period. The heat usage during this period has thus only been for the hot tap water demand. Investigating the effects of the behavioural factors on the heat usage for space heating cannot be executed with this study.
Despite this, we still can get insight into the impact of the difference in hot tap water demand on the difference between the heat usages of the two houses.
Other important information that will be revealed with the temperature monitoring is the influence of the natural ventilation behaviour on the indoor temperature and the relation with possible dissatisfaction.

First thing to analyse is the influence of presence on heat use. It has already been concluded that the average presence of persons is the same for both houses. Figure 107 shows that the measured heat use (retrieved from meter readings) during the longitudinal questionnaire is 0,09 GJ for house E, and 0,225 GJ for house H. Due to the comparable presence, this influence will be disregarded.
As expected, Figure 108 proves that the difference in heat usage is caused by the difference in amount of shower time.
Considering the measured heat usage is only caused by tap water heating, it is only possible to make an annual prediction of the hot tap water demand. For house E this will be 4,69 GJ and for house H 11,7 GJ. According to the EPN calculation, the average annual heat usage for tap water heating would be 8,3 GJ (section 4.1). Using this predicted use for tap water heating, it means that the heat use of house E is a lot lower than predicted, while the heat use of house H is above predicted.

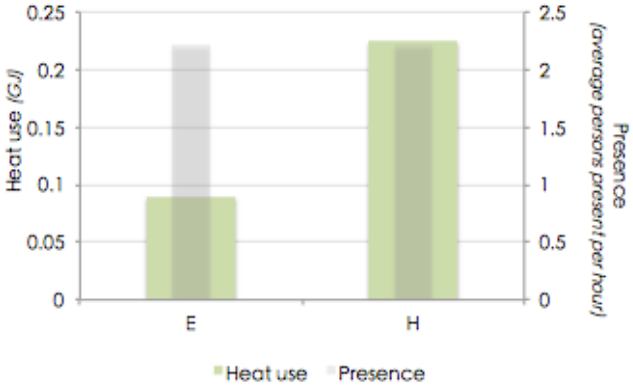


Figure 107: Heat use vs presence

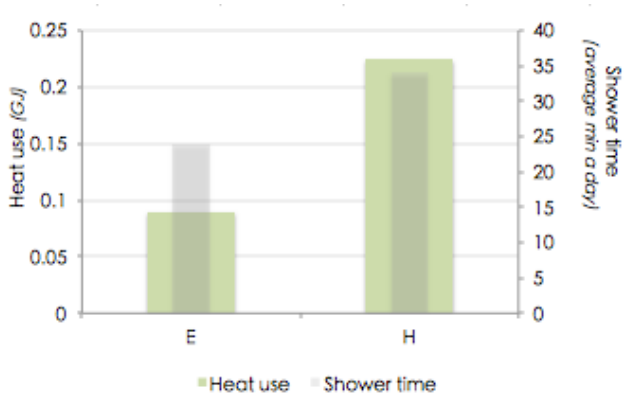


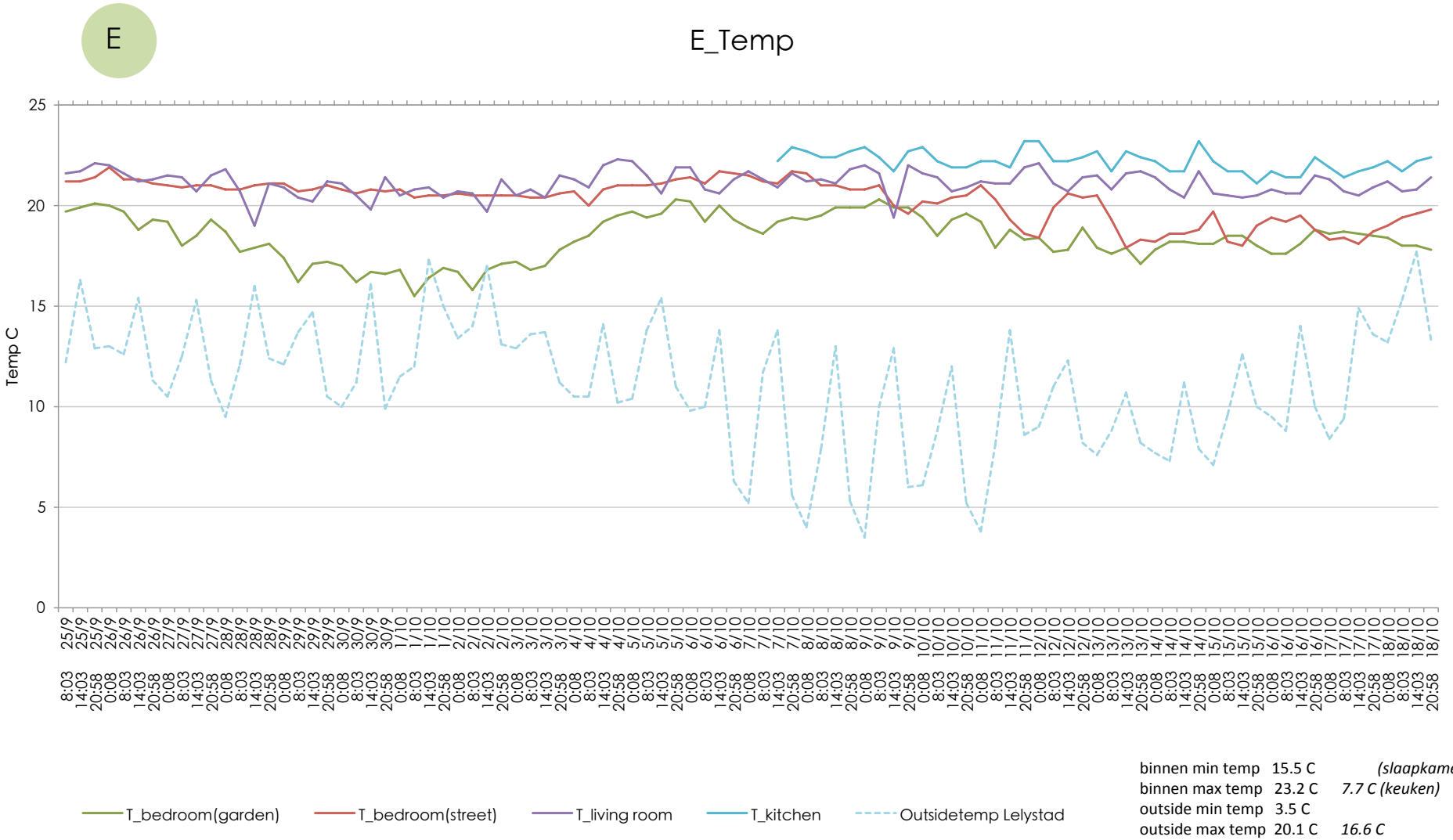
Figure 108: Heat use vs shower time

The bivariate correlation analysis revealed that only the behavioural factor attitude shows a relationship with heat use. Because of the fact that these two houses have the same positive attitude (Table 27), this variable can also be disregarded as a potential variable of influence.

Figure 109 and Figure 110 present the measured indoor air temperatures of the different spaces, for house E and house H, compared to the outside air temperature of the weather station Lelystad.
The first obvious notable thing is that the indoor temperatures of H are more constant than in house E.
Overall, it can be concluded that the inside temperatures show a constant result compared to the fluctuating outside temperature. Because of the fact that the thermographic pictures also didn't show any leakages in the building skin and that the buildings are technically identical, the difference in constancy between the houses is caused by another factor. To get insight in the effect of presence and the amount of natural ventilation on indoor air temperature, first the indoor air temperatures of the separate rooms are compared between houses E and H (Figure 111) for the period that the occupants filled in the longitudinal questionnaire (5-10-2013 till 11-10-2013). The green lines represent the measurements of house H and the orange lines represent the measurements of house E.
These graphs show that the indoor temperature of house E is a little bit lower in every room and fluctuates more, with an exception for the kitchen, where the temperatures are almost the same.
Based on the longitudinal questionnaire, the amount of natural ventilation and the presence can be compared to the air temperatures for the separate rooms. Figure 112 to Figure 115 show the temperatures for the separate spaces of both houses, compared to the amount of natural ventilation (opened windows and ventilation panels) and the presence of the occupants. The grey bars indicate if the windows are open or that the occupants are present. Again, these graphs show that the presence of the occupants is comparable for the different spaces. The biggest difference that can be derived from the graphs is that house E applies a lot more natural ventilation than house H. In the bedrooms of house E, the windows are almost always open, even when the occupants are not present. The amount of natural ventilation in the living room can be valued as medium for house E and low for house H.

The statistical analysis was not able to find an underlying reason for the amount of natural ventilation (section 6.5) that occurs in the houses. This has specifically been analysed for the variables thermal experience and preference. The detailed retrieved data from the monitoring is useful to control this previous result, to see if the same conclusion is applicable for these two houses.

E



binnen min temp	15.5 C	*(slaapkamer tuin, oost)*
binnen max temp	23.2 C	*7.7 C (keuken)*
outside min temp	3.5 C	
outside max temp	20.1 C	*16.6 C*

Figure 109: Temperature measurements house E compared to outside temperature Lelystad

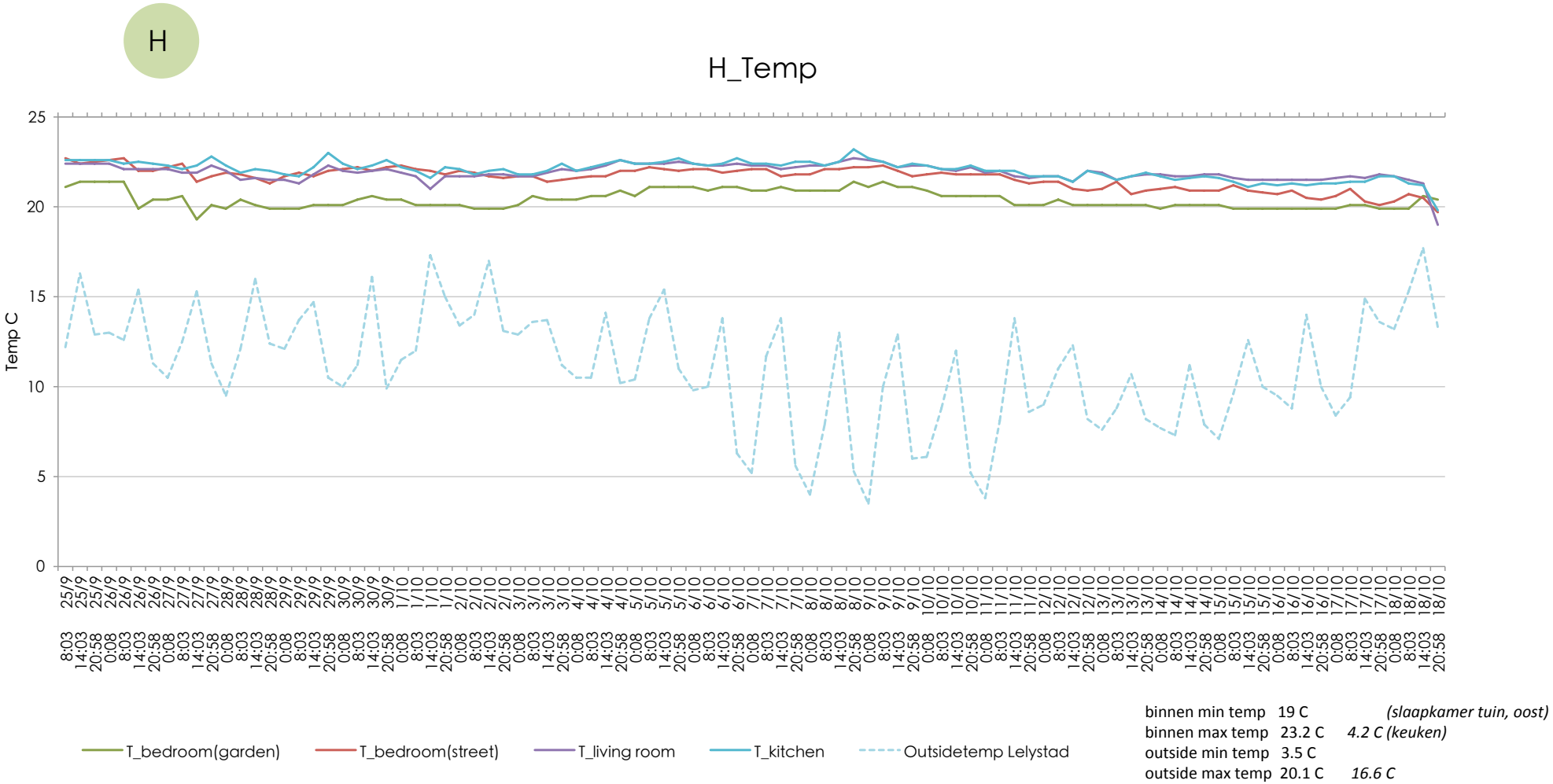


Figure 110: Measured temperatures house H compared to outside temperature Lelystad

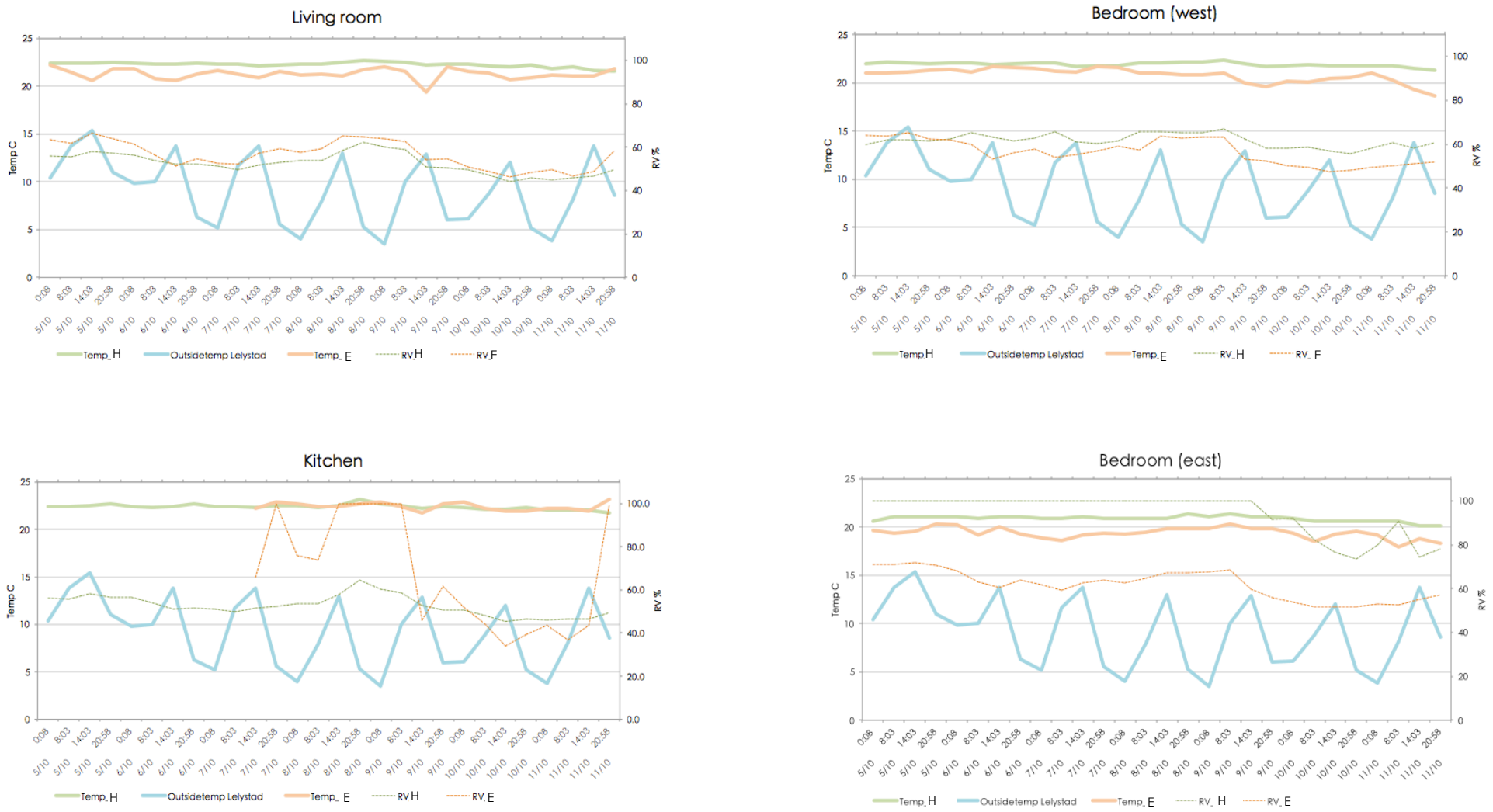


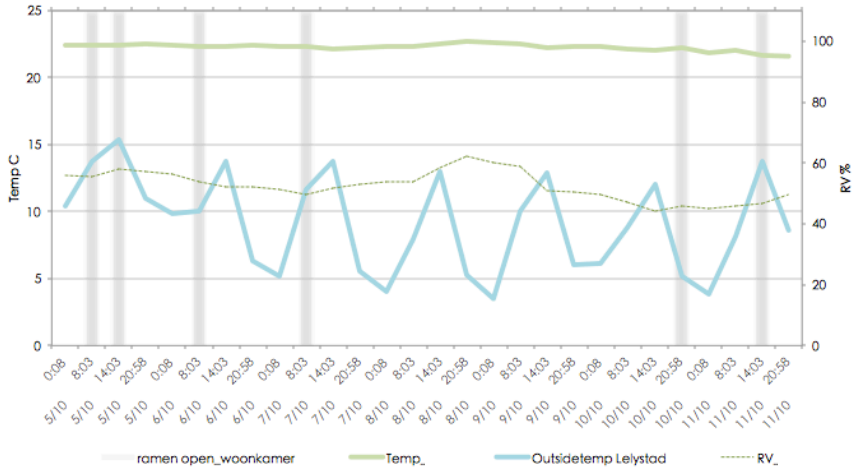
Figure 111: Compared indoor temperatures per room

Living room

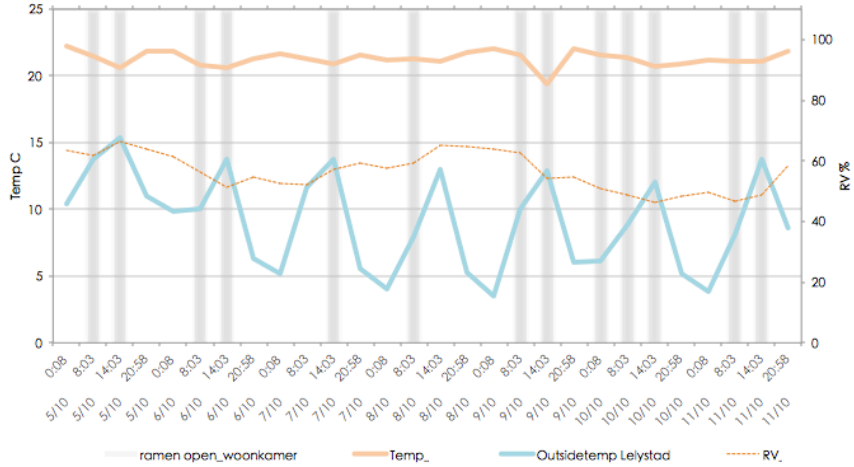
Natural ventilation

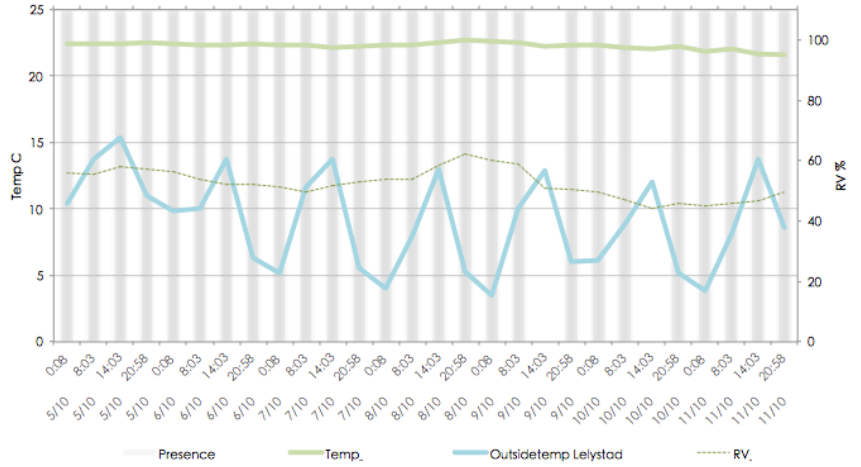
Presence

H



E





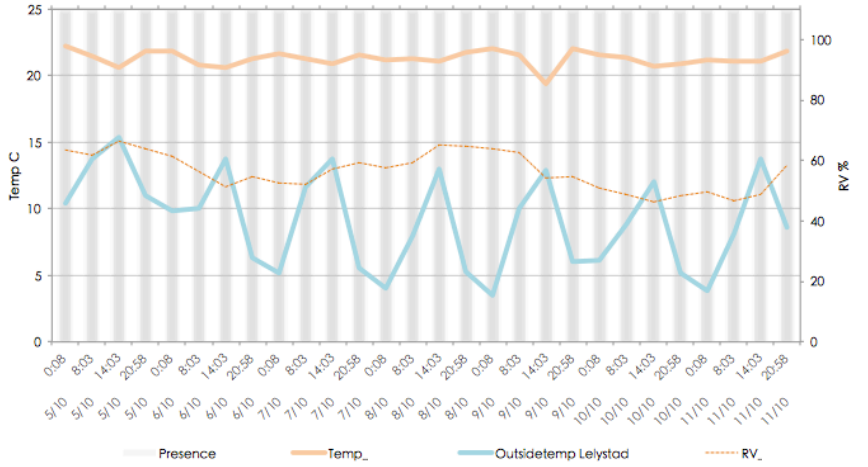


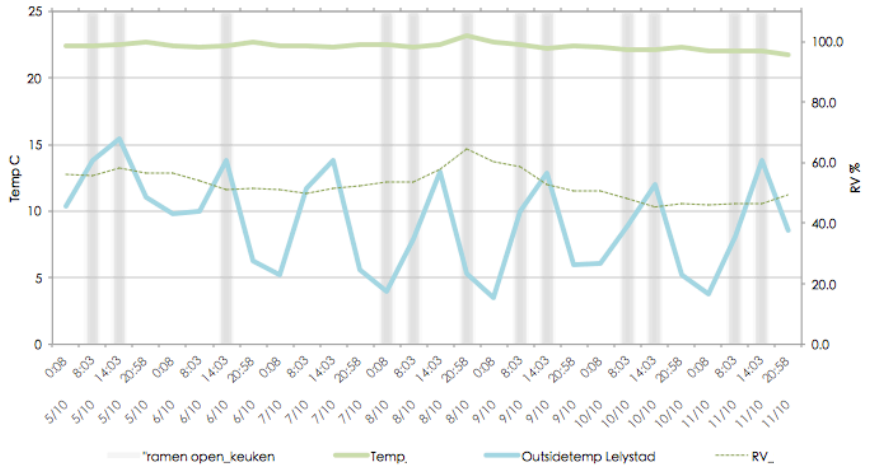
Figure 112: Natural ventilation and presence compared with temperatures livingroom, house H and E

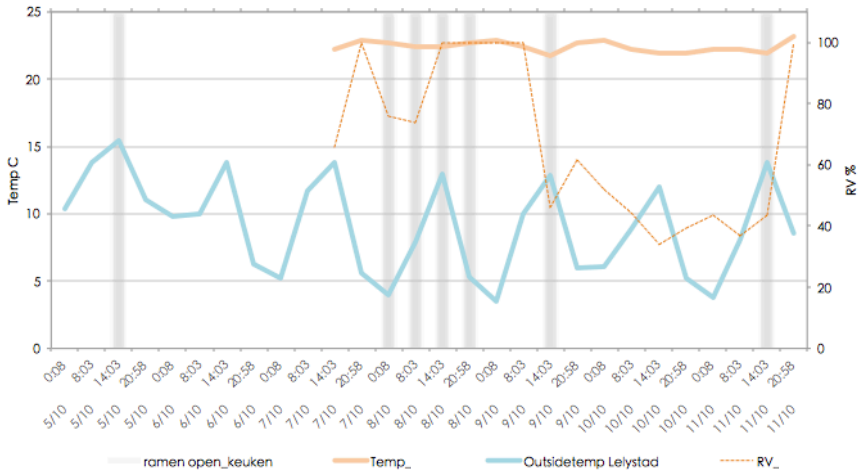
Kitchen

H

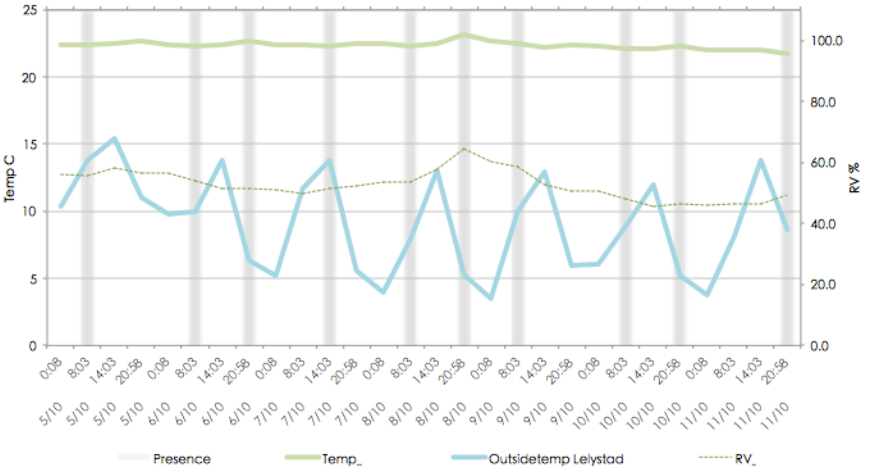
E

Natural ventilation





Presence



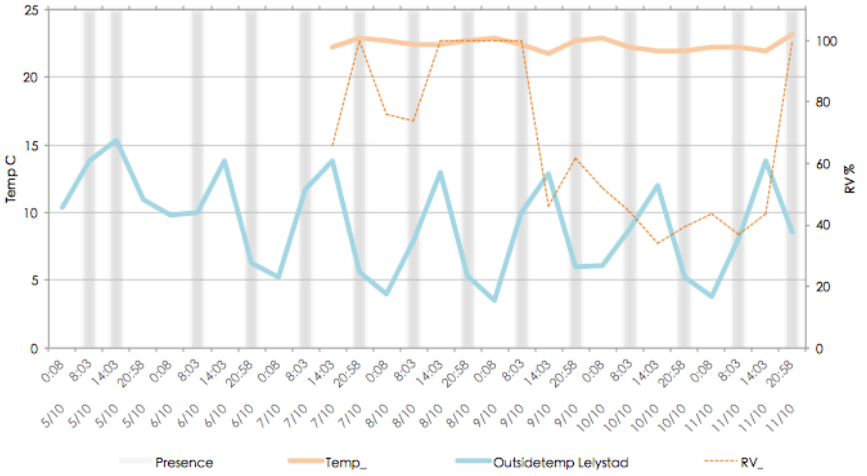


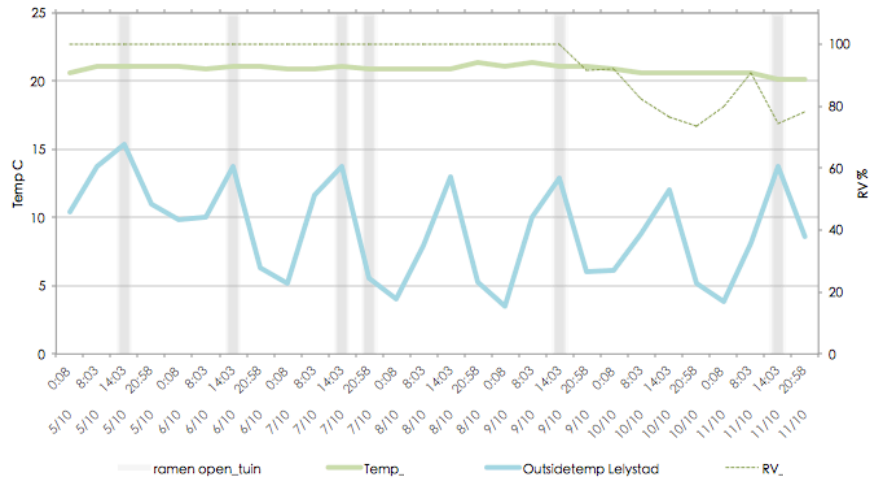
Figure 113: Natural ventilation and presence compared with temperatures Kitchen house H and E

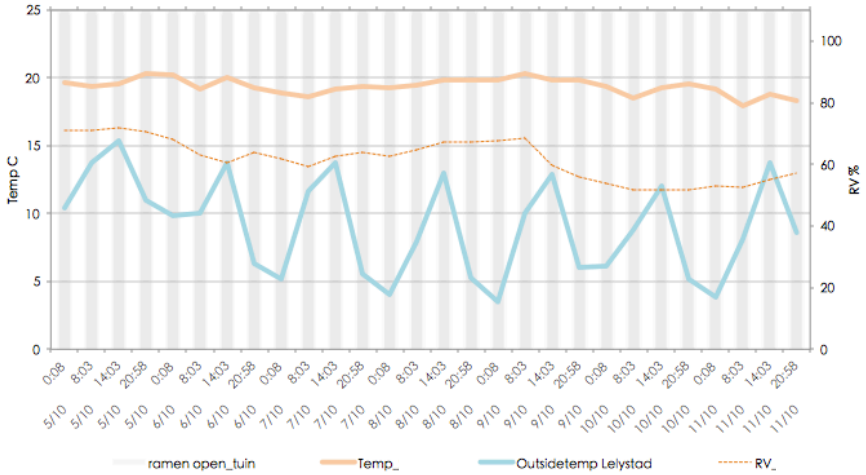
Bedroom (east)

H

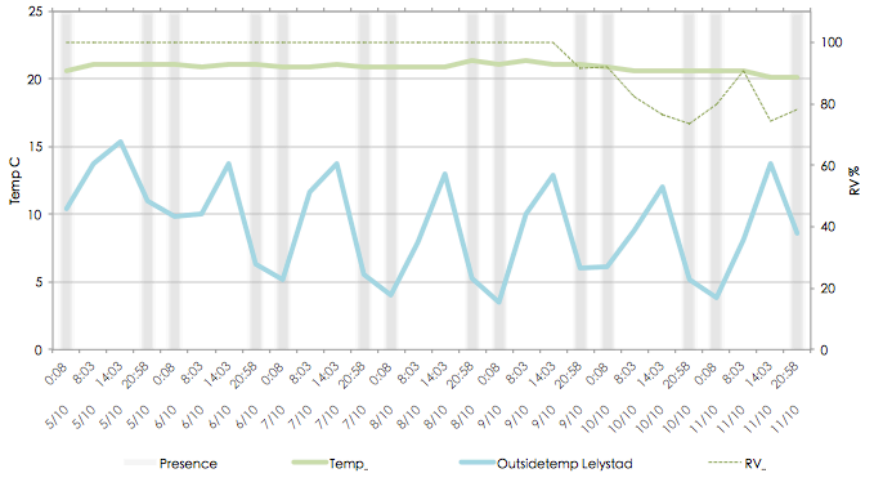
E

Natural ventilation





Presence



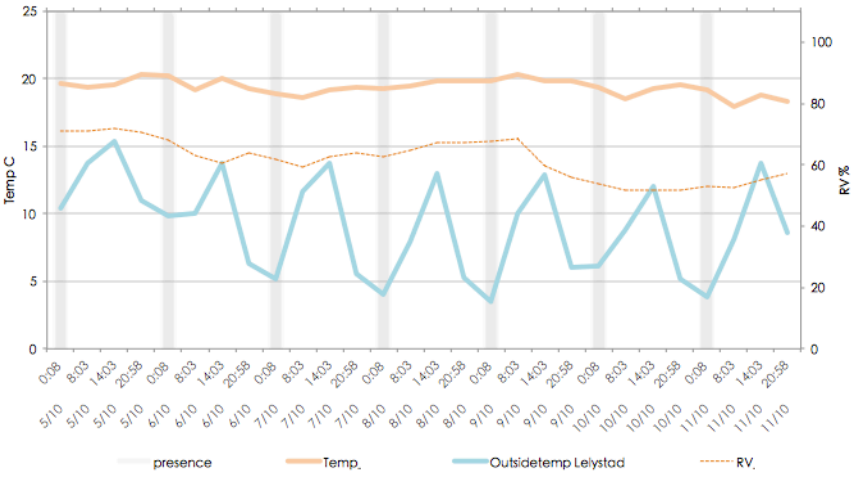


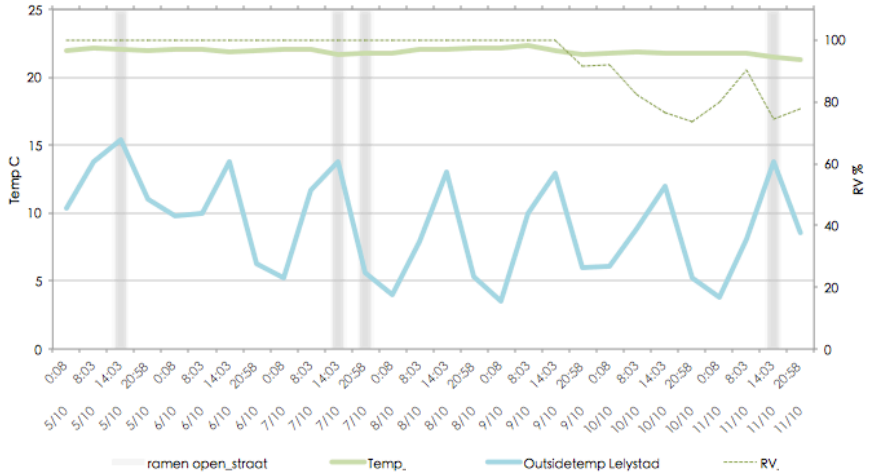
Figure 114: Natural ventilation and presence compared to temperature Bedroom(east), House H and E

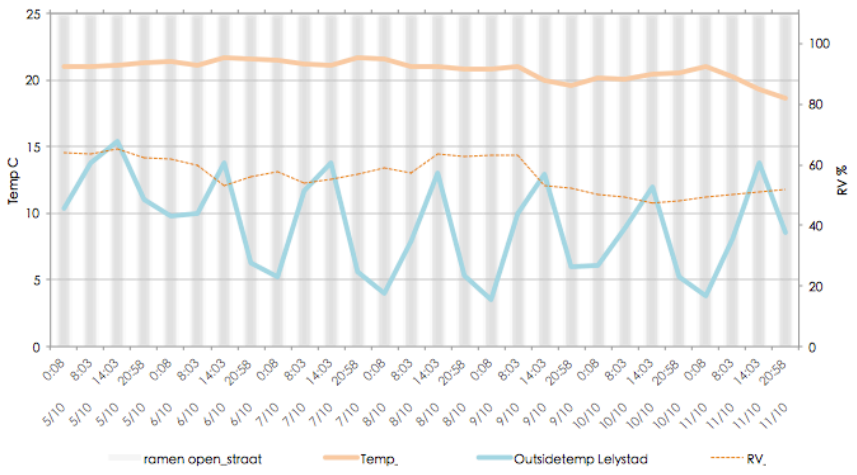
Bedroom (west)

H

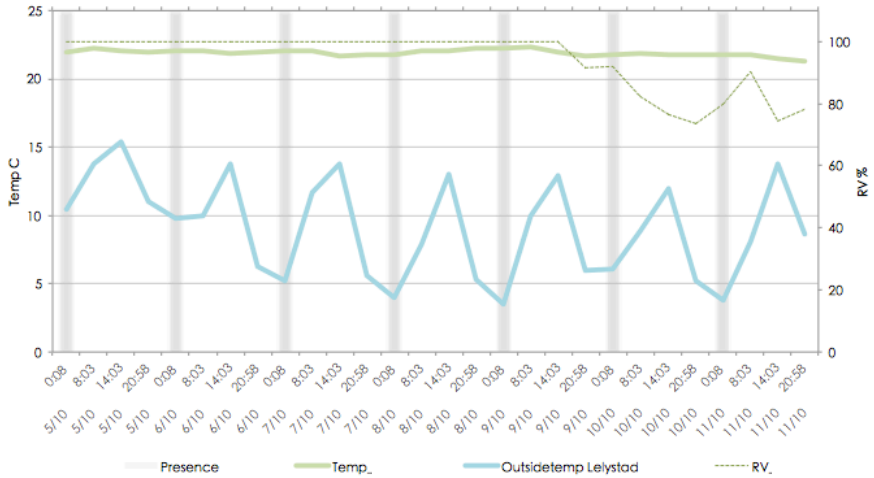
E

Natural ventilation





Presence



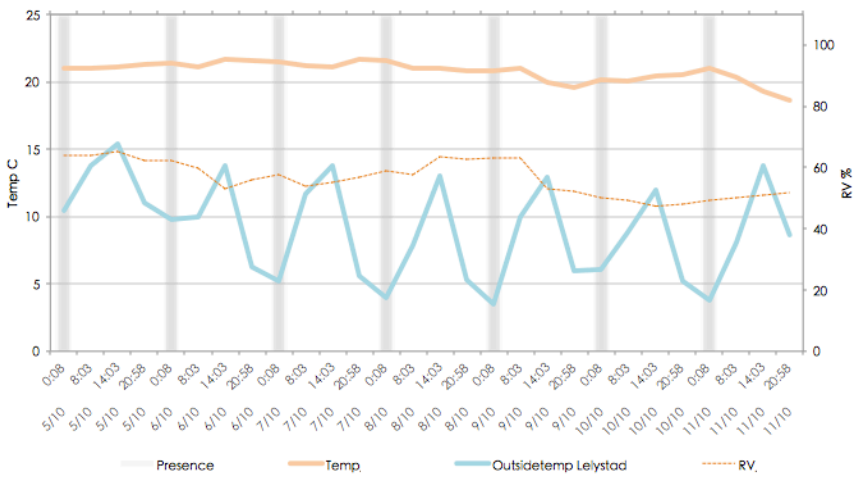


Figure 115: Natural ventilation and presence compared to temperature Bedroom (west), House H and E

As seen in the previous graphs, house E has a high natural ventilation level, while house H has a low natural ventilation level. To be able to formulate suitable design solution to improve the energy performance and the occupant satisfaction, it is important to take the thermal experience and preference into account. Last step of the monitoring analysis is to see if the natural ventilation behaviour levels are dependent on the thermal experience and preferences of the houses.

Figure 116 presents the thermal experience and preference of house E and H for the living room and bedroom during winter, together with the target temperature settings for the rooms that the occupants have indicated in the user survey.

First thing to see is that the target temperature settings for house E are lower than house H. This indicates that the occupants of house E prefer a lower indoor air temperature than house H. Controlling this for their indicated experience and preference, we can see that the bedroom temperature is experienced as pleasant and they do not prefer a change. As for the higher temperature setting for house H, it shows that they find the bedrooms cold during winter and prefer a little bit warmer temperature during winter. Although house E has a low air temperature setting they find the bedroom too cold during winter and would prefer a little bit warmer temperature. The same goes for house H.

Most important thing to conclude from this graph is that the preference corresponds with the indicated experience.

The summer situation (Figure 117) shows a more confusing pattern between experience and preference.

It shows that even though the occupants experience hot or cold, their corresponding preference is not supporting this experience. Relating this to their natural ventilation behaviour, it confirms the findings that resulted from the statistical analyses, that there is no relation noticeable between thermal preference and natural ventilation behaviour, especially during summer.

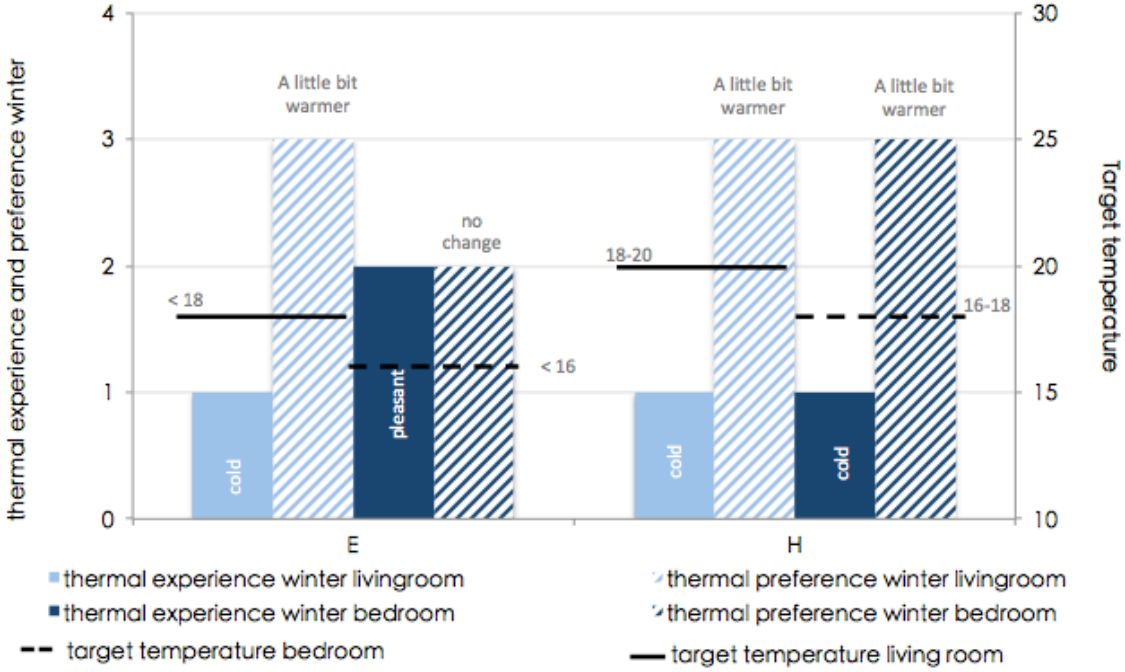


Figure 116: thermal experience and preference winter livingroom and bedroom

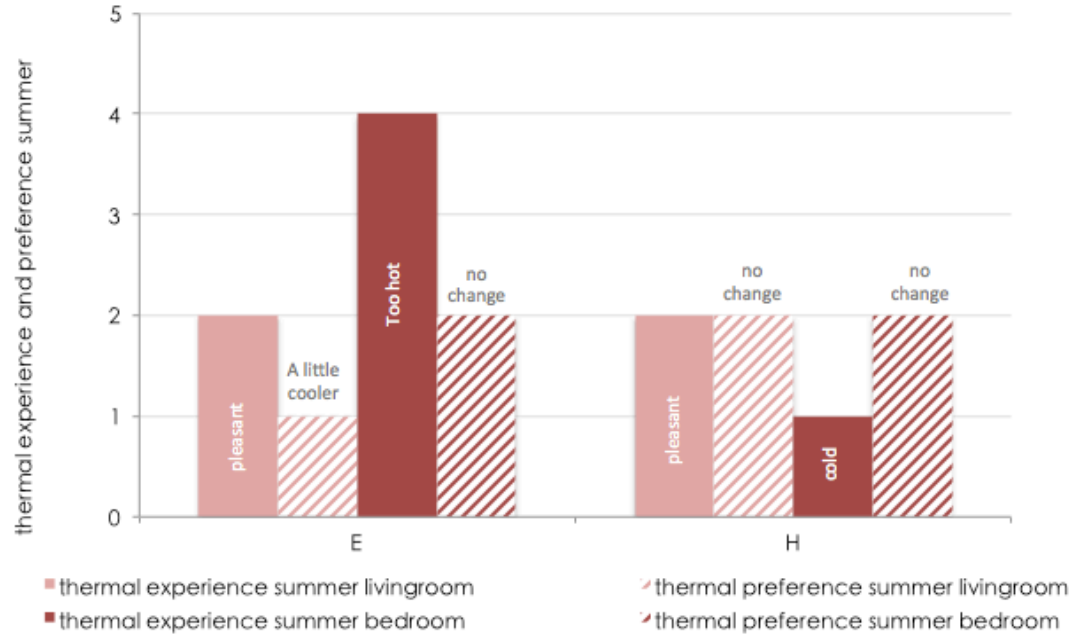


Figure 117: thermal experience and preference summer livingroom and bedroom

7.5 Conclusion

The presentation of the analysis of the monitoring results brings an end to this research. A lot of data has been collected, and a lot of data has been analysed. Summarizing the results of the monitoring brings the following conclusions;
Overall it can be stated that the monitoring results are in accordance with the conclusions drawn from the statistical analyses. Concerning the electricity use the monitoring gave a more detailed view on the electricity use distribution in the houses. The previous found relations between behavioural factors and electricity use have been confirmed.
Concerning heat use, the results have been a little less satisfying due to the lack of radiator use in the monitoring period. The results did give insight into the indoor thermal conditions of the separate rooms, which are compared with the natural ventilation behaviour and presence of the occupants. It proved that the natural ventilation behaviour has an impact on the indoor conditions. The highly insulating and airtight building skin (together with internal and solar heat gains) proved to provide a constant indoor air temperature.
Besides, a lot of natural ventilation causes a lower temperature with more fluctuations.
The monitoring results also didn't find a relation between the thermal preference of the occupants and the amount of natural ventilation. The assumption remains that occupants execute this behaviour for different reasons than from a thermal perspective. This specifically means that as a designer it is not possible to control or manipulate this behaviour, but it should be taken as given, in order to work with this knowledge and not work around it.

8. DESIGN SOLUTIONS

8.1 Aim of solutions

This chapter will present design solutions for low energy houses based on the found results in the previous chapters. The focus of this study has been on the influence of behavioural factors on energy use. The study has found that in low energy houses the habitual behaviours of ventilation behaviour and heating behaviour are the two actual behaviours that can be of influence on the energy use. These behaviours arise from several psychological factors (awareness, motivation, attitude, specific knowledge, thermal comfort).
The aim of the solutions is to give conceptual solutions for designers, which enable them to improve the energy performance of low energy houses, by incorporating the found information about dissatisfactions and the nature of occupant behaviour.
To limit the design scope, this study will focus on solutions for typical Dutch social housing building types, like the houses of Columbuskwartier, which are a good representation for this building type. The reason for this choice lays in the fact that Columbuskwartier is the first social housing project that is realised on this big scale with and EPC of 0.31. This project should be used as a demonstration project to learn from, so that future new developed social housing projects will perform like they are designed.
The solutions that will be given will maybe not have a 'spectacular ' character, because they are intended as improvements for the already known (and applied) passive house concepts. Achieving an EPC of 0.31 (like Columbuskwartier) is already a very good and promising achievement, but the future restrictions will only become stricter. By integrating solutions that will reduce the difference between the individual energy uses of identical houses, the chance becomes smaller that the actual energy use will be higher than the predicted energy use, when the average actual use is the same or smaller than the predicted use.

8.2 Detected problems

This paragraph will summarize the detected problems that will form the foundation for the conceptual solutions.

First thing that needs to be pointed out is that the technical analysis showed to have no influence on the difference between the predicted and actual energy use, and the variance in energy use between the individual occupants. The construction method of the house and the building skin form a good principle for achieving a low EPC. In Holland we like to use concrete to build our houses. The tunnel-forming method in combination with a thick insulation package, like applied in Columbuskwartier, ensures a highly insulated and airtight building.
Thus, this method is recommendable for future projects and fits with our current way of building (Figure 118).

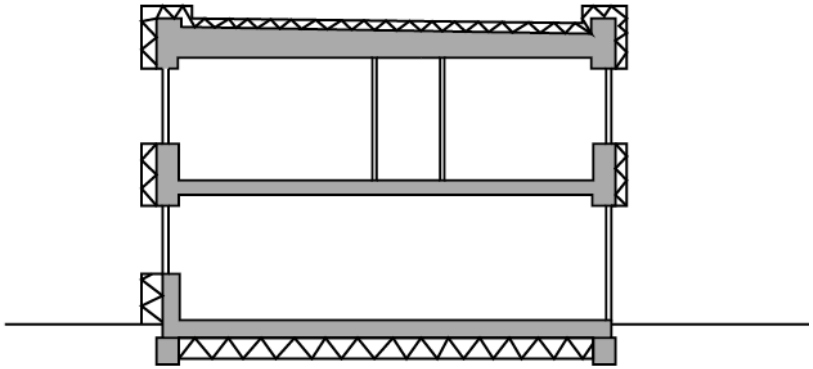


Figure 118: Suitable construction methog, concrete, insulation

The problems that are revealed in this study relate to the occupants. Dissatisfactions and behavioural aspects showed to be an explanation for the difference in the individual energy use.

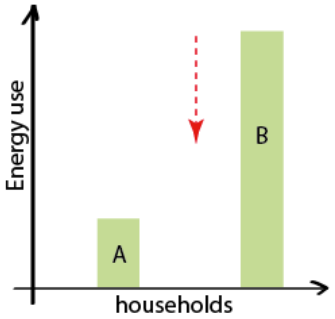


Figure 119: Reduction difference individual energy use

8.2.1 Dissatisfactions

The user survey showed (together with the previous survey of Cauberg-Huygen) that there are occupants that are dissatisfied with the thermal indoor conditions of the houses. Especially the bedrooms on the first floor showed to be a weak spot. The detected dissatisfactions are:

- Bedrooms too warm during summer
- Bedrooms too cold during winter
- Living room too warm during summer
- Living room too cold during winter

Although the majority of the occupants value the thermal indoor conditions as pleasant, it is still interesting to find solutions that minimize this dissatisfaction.

The underlying problem of the present dissatisfaction is that it takes too much time to warm up the spaces in winter and too much time too cool the space in summer according to the occupants (Table 11).
Their demands have a dynamic character, which asks for solutions that can adapt fast to meet the dynamic demands in order to prevent dissatisfaction.
The passive building methodology is based on insulating a building as good as possible to keep warm or cold air outside (Figure 120). The concrete core of the construction forms a high amount of thermal mass that accumulates heat. This implies that the adaption time of a standard passive house (like the Columbuskwartier) is very slow, with or without climate installations considered. It is clear that these two principles are not complementary.

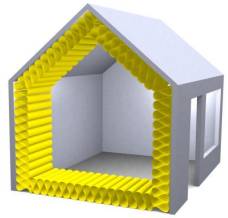


Figure 120: passive house, airtight skin. Source: http://www.luchtdichtbouwen.nl/passiefhuis

The problem of dissatisfaction becomes more complex if we take the natural ventilation into account. This study showed that occupants ventilate naturally for varying reasons, which have shown not to be related to the thermal preference of the occupants. Predicting the amount of natural ventilation is thus not possible because the underlying motives are not yet completely known.
In contrast to this fact, the energy concept of the houses in the Columbuskwartier assumes the natural ventilation to be a part of the energy concept in order to let the building function optimally

(paragraph 3.4.1). This requires a lot of specific knowledge and awareness of the occupants, which cannot be assumed as a given fact in the design stage.

8.2.2 Behavioural aspects

This study also gave more insight into the underlying psychological factors of occupant behaviour. After the literature study and the statistical analysis of the user survey data it showed that the following behavioural factors are of influence on energy use:

- Awareness
- Attitude
- Influence previous building type
- Specific knowledge
- Motivation

With this knowledge it is possible to think of design solutions that are able to manipulate these behavioural factors. It is clear that not all these behavioural factors can be manipulated or adjusted with design solutions. The two factors that can be manipulated however are awareness and specific knowledge. By increasing the awareness of the consequences of the behaviour of the occupants together with increasing the specific knowledge, the actual behaviour can be manipulated in a more desirable direction.
Important for achieving this is that the information of their consequences should be easily accessible and inevitable.

8.2.3 Robustness

The design solutions together should ensure a reduction of the difference in individual energy use among the occupants. This means that the solutions have to be able to adopt different levels of behaviour without resulting in a big difference in energy use ((SEV & EnergieSprong, 2011). In other words, the solutions must be aimed at making a house robust, so that the occupant has as little as possible effect on energy use.
The biggest challenge in this context is to overcome the contradiction of slow adapting houses based on good insulation, high thermal mass and low temperature sustainable heat sources, and the fast and dynamic demand and behaviour of its occupants.

8.3 Interventions current design

Before presenting the concept solutions, this paragraph will first give recommendations for the current houses in the Columbuskwartier. Without major (structural) interventions it is possible to resolve some problems that are being encountered in these houses. Main problems are found in the bedrooms where no radiators have been installed. Resolving this problem can be done from two perspectives:

- Take all the doors away, so the heat from the radiators downstairs and the batroom can be distributed without obstacles.
- Provide the bedroom with radiators, so that the occupants don't have to heat these spaces up on an indirect way.

The first option is not a desirable one, because doors have a privacy function for the occupants, and they want to have control whether the doors are open or closed.
That leaves only the second option suitable for resolving the bedroom problems (Figure 121).

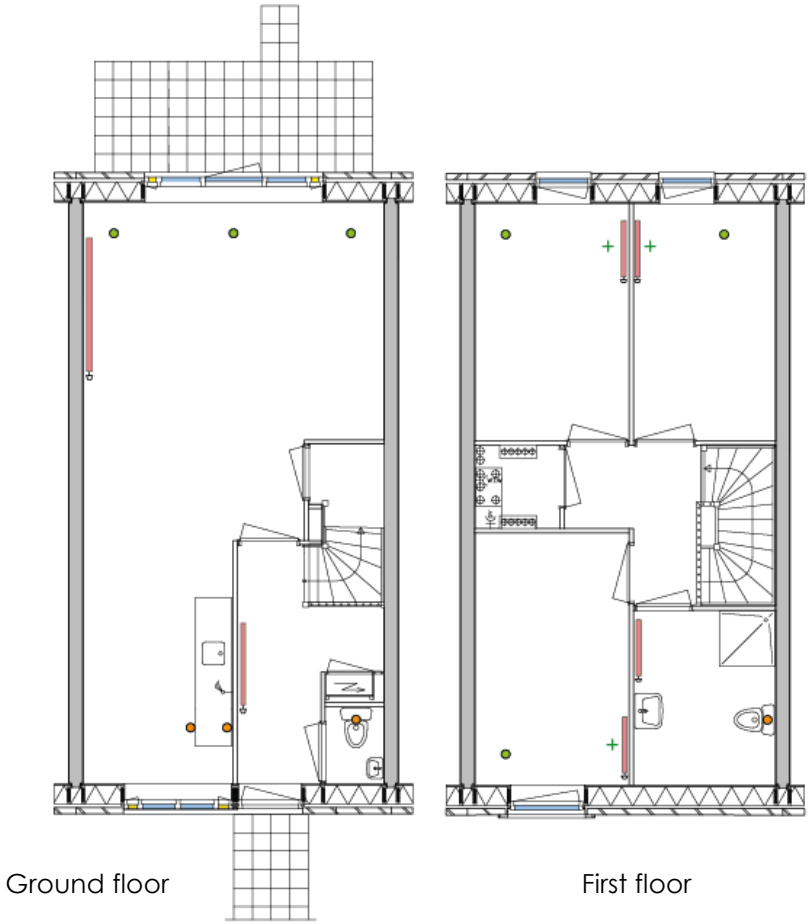


Figure 121: Interventies huidige ontwerp

8.4 Concept solutions

The design solutions will be subdivided in the different categories mass, ventilation, heat sources, heat delivery systems and user information systems. The solutions are meant as concept for designers to work with and don't give architectural solutions in terms of sophisticated integration of these concepts. The application of these concepts can have a lot of different visual embodiments.

8.4.1 Mass

As explained before, the principle of adding thermal insulation to a house is to provide for a maximum resistance to heat transfer. This is intended to prevent unwanted warm outside air entering the building during summer. In winter it works the other way around, the thick building skin prevents the warm indoor air to leave the building, so that the wanted warm air stays inside. The concrete construction acts as thermal mass for heat accumulation, which minimizes indoor temperature fluctuations. During winter this ensures a lower heat demand (Figure 122).

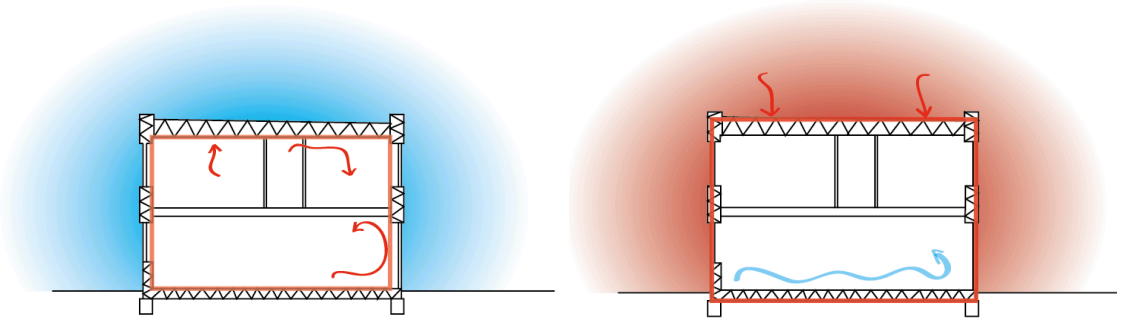


Figure 122: principle of insulation rep, winter and summer

However, problems arise when the insulation properties of the building skin get interrupted by opening windows.
The occupants in this study showed to also open their windows on cold and warm days. In winter this results in cold air entering the building, which on its own is not a bad thing if it results from a preference of an occupant, but the negative consequence is that, because of the high thermal mass, it takes a longer time to warm up the building again when the occupants desire a warm comfortable indoor climate (Figure 123). On the other hand, it also takes a longer time for the building to cool down, which is a positive effect.
The only problem that mass entails, is that the process is slow. Focussing on winter when energy is needed for space heating, occupants desire a fast response time for warming the spaces, which is in contrast with the characteristic of mass.
Overcoming this problem asks for the integration of efficient heat delivery systems, which will be given in paragraph 8.4.4.

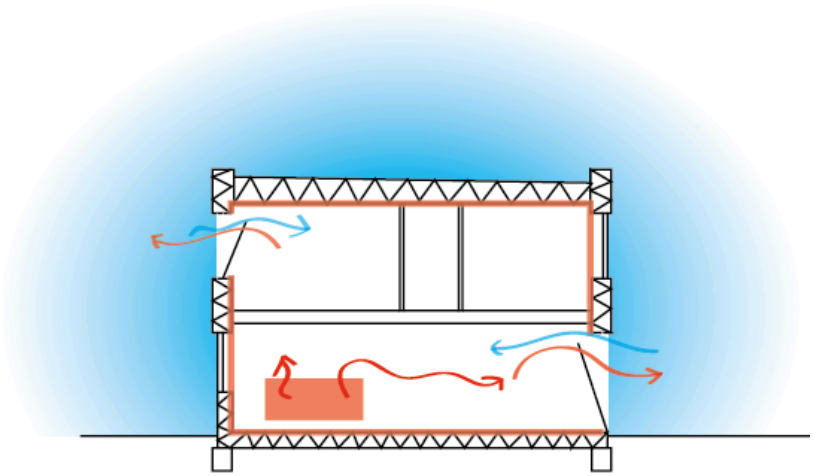


Figure 123: Negative influence opening windows winter

During summer however, mass is needed to accumulate heat and reduce peak temperatures. Opening windows on a warm day when the outdoor air temperature is higher than the indoor air temperature, means bringing warm air inside. Again this is not a bad thing coming forth from a preference of the occupant, but the negative consequence is that it is difficult to cool the building again without an active cooling systems (Figure 124).

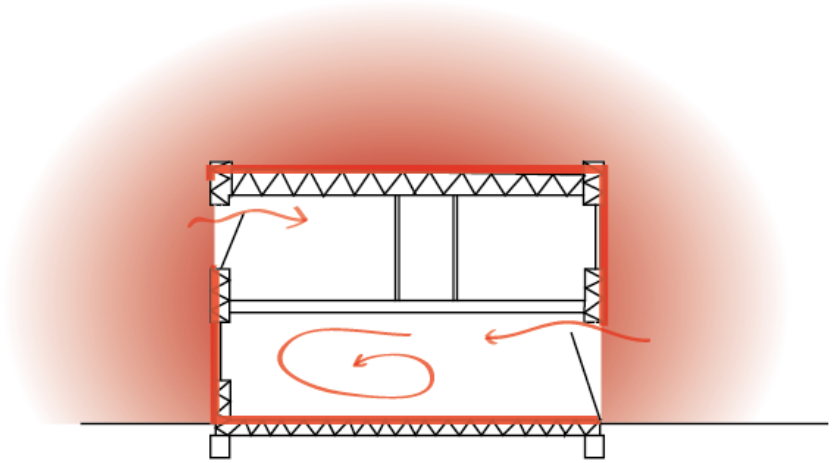


Figure 124: Negative influence opening windows summer

A solution that is not based on an active cooling system (which is not a sustainable option) in **addition** to a good insulated building skin can be found in using Phase Change Materials (PCM).
PCM's are materials that utilize the power of phase change melting and refreezing to actively absorb and release heat (Figure 126). It works like thermal mass, but with the advantage that it works faster due to the fact that they have a high amount of energy required to

melt one kg, so they can absorb a lot of energy during melting or solidifying.
Applying it in houses in addition to a construction with high mass like concrete, means that if occupants open their windows on a warm day, the PCM's can absorb this additional unwanted warm heat during the day (by changing it's phase), and discharge this heat again during night (Figure 125).

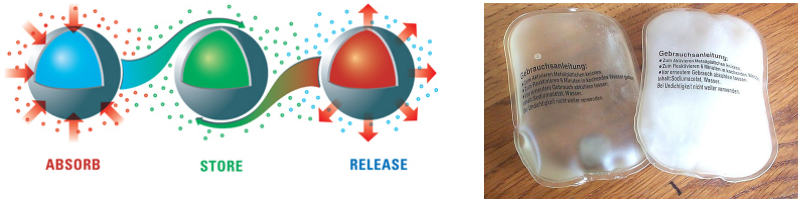


Figure 126: Principle of PCM source: http://technotheek.utwente.nl and http://www.goodhousekeeping.com/product-reviews/research-institute/cool-news-about-temperature-re

PCM is a good option to use as additional mass to reduce the effect of the warm air on the indoor climate caused by the unpredictable behaviour of the occupants regarding the opening and closing of their windows. When the windows stay closed during hot days, the building skin will function as the primary barrier, keeping the warm air outside, but when the windows are opened on hot days the PCM's take up the heat. This system does not need to be operated by the occupants, thus the knowledge and awareness level of an occupant can be disregarded. This principle is consistent with designing robust buildings, because PCM's can adapt to occupants with different natural ventilation habits.
To be clear about the application of this material, it must be used as additional mass to reduce the unwanted temperature fluctuations caused by natural ventilation. PCM's do not replace the function of concrete as primary mass.
The advantage of this new smart material for application in houses is now getting acknowledged, but the development is still in a premature stage. Several companies have developed plating products that contain PCM's that can be placed on walls or

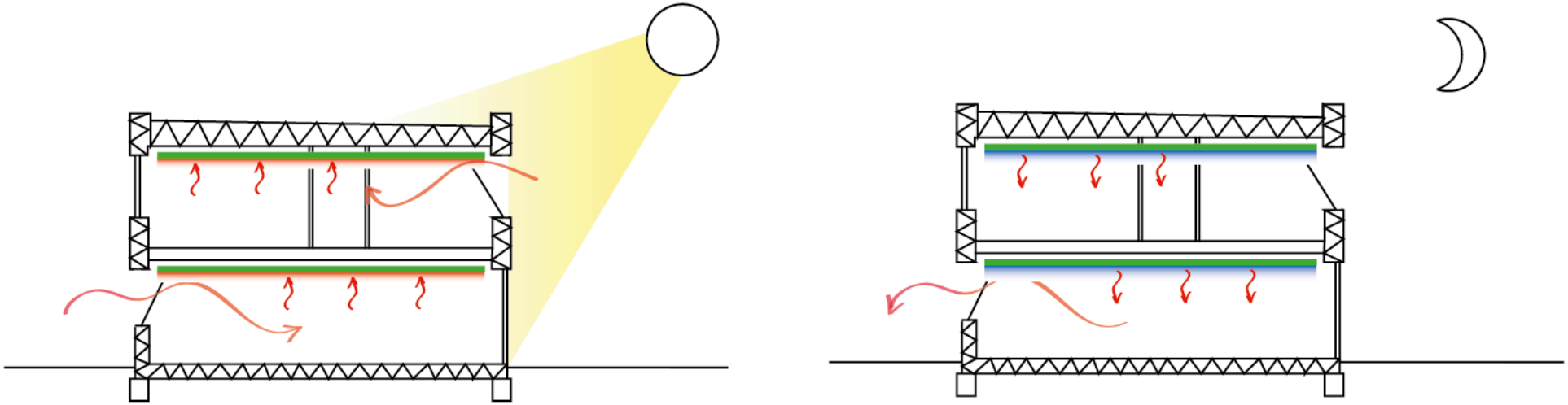


Figure 125: Principle PCM's during daytime and nighttime

ceilings. Placing these plates on walls in houses is not desirable, because people like to put things on walls as decoration. Drilling holes in the material has a negative effect on its properties. The only place where these materials can be installed is on the ceiling. This has two main reasons:

- The chance for drilling holes in the material is being minimized.
- Putting the material in the ceiling instead of the floor prevents the heating system (like floor heating) and the accumulating effect of the PCM's to counteract.

When placing the material in the floor, the problem that arises is that during winter when the heating system is used, the energy that is released by the heating system will (probably) first be taken up by the PCM's before entering the space. This will mean that the energy for heating is not being used efficiently for heating up the space, and that it will take a larger amount of energy to warm up the space directly.
Thus, for this reason it is recommendable to install the PCM's plating at the ceiling, where it can function when it is needed, and that is during summer periods. Another benefit is that warm air rises, so the air temperature at ceiling height is warmer than at floor height.
Till now it is known that the properties of PCM's are most efficient and useful in thermally light-constructed buildings to increase the accumulating effect. The effects of PCM in thermally heavy constructed buildings are very low. This concept solution of using PCM as additional mass for reducing the effects of natural ventilation in buildings that are already well-insulated, needs to be further investigated to discover the effectiveness and the actual amount of heat absorption. Future study needs to prove how and in what amount PCM's can accumulate heat in a passive house. The described application of PCM's in this study can therefore only been seen as a possible solution besides the already known and used design solutions. Research into the application of PCM's in passive houses needs to be tested and monitored over a longer period, and finding an answer to this question was not possible during this research.

8.4.2 Ventilation

An important principle for the ventilation concept of a low energy house that results from this study is that the occupants use the natural ventilation as the main ventilation for their spaces and not the installed mechanical ventilation system. A reason for this can be the fact that the effect of opening windows has a faster and more direct result on the fresh air inside the spaces than the mechanical ventilation provides.
Integrating a ventilation concept in a design which is based on the

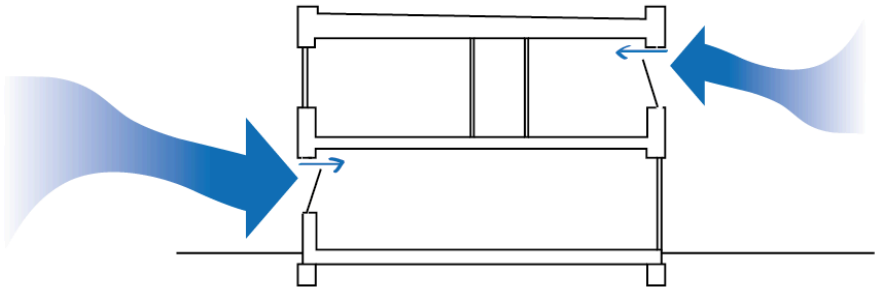


Figure 127: reduce airflow

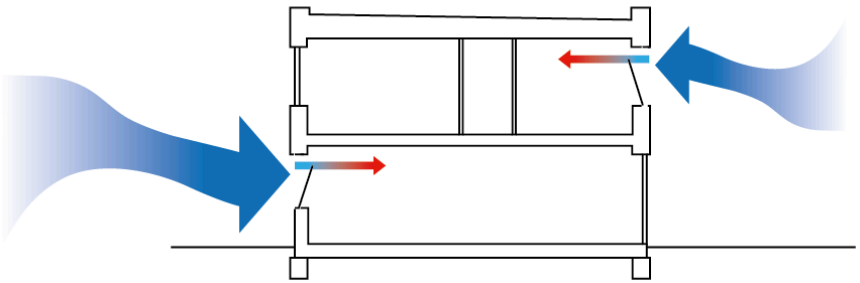


Figure 128: Preheat airflow

given fact that occupants like to open their windows on a randomly basis with as little as possible effect on the energy use can be addressed from two perspective:

- Minimizing the incoming airflow when windows are being opened (Figure 127).
- Preheating the entering air when windows are opened. (Figure 128).

With the on going innovations concerning ventilation systems, one can state that the used mechanical ventilation system in the Columbuskwartier is already out-dated and perhaps superfluous.
Because the Dutch building regulations describe certain requirements for the indoor air quality of houses, a secondary ventilation system is required besides the natural ventilation, in case all the windows are closed.

The requirements for this additional ventilation system according this study are:

- Self-regulating device
- Heat-recovery properties
- Installable in separate spaces

A new system that meets these requirements is the Breathing window (Figure 129). This system is based on a self-regulation ventilation panel that ventilates the air straight through the building skin (Figure 130).
The device is equipped with a heat exchanger with a high efficiency. Besides, the devices can also include integrated Co2-sensors and relative humidity- and temperature sensors. With all these sensors, the device is able to adjust its settings to interact with the changing indoor conditions without the need of occupant control.

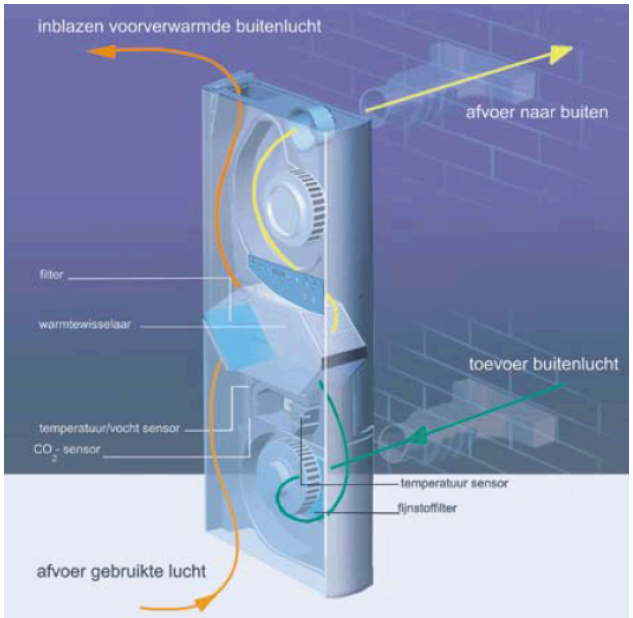


Figure 129: Breathing window. Source: http://www.econvice.nl/index.php?page=nieuwsitem&item=133

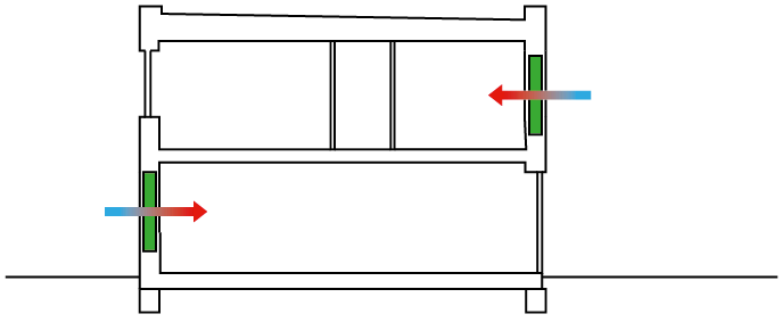


Figure 130: Principle Breathing window

Using a breathing window as secondary ventilation system contributes to the robustness of a building. Because of the self-regulating system that interacts and moves along with the indoor climate conditions, the knowledge and awareness of the occupants can be disregarded.
Thus, using natural ventilation as the primary ventilation system (because occupants do this anyway) with a breathing window as a supporting ventilation system to ensure a healthy indoor climate when the windows are closed, almost provides a total ventilation concept for houses. It is also a very promising new innovation because EPC reductions of 0.2 can be achieved (AgentschapNL, 2009)
The last step to complete the ventilation concept is the fact that the kitchen and bathroom still ask for local mechanical ventilation when used. A concept that can complete the ventilation concept is a demand-controlled mechanical exhaust system. With an exhaust ventilation unit that is able to separately control kitchen and bathroom, which can be achieved by installing Co2 and humidity sensors in these spaces that are connected with the exhaust ventilation system. The mechanical exhaust only takes place when needed (Figure 131). Because of the sensors, occupants do not have to put the exhaust manually on a higher level, the system can control itself. Exhausting the air locally and only when needed reduces the ventilation losses with the related energy losses to a minimum.

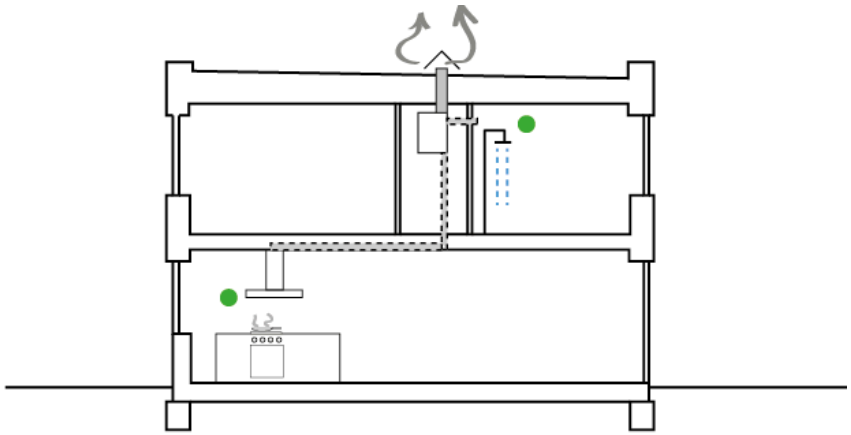


Figure 131: Co2 sensors

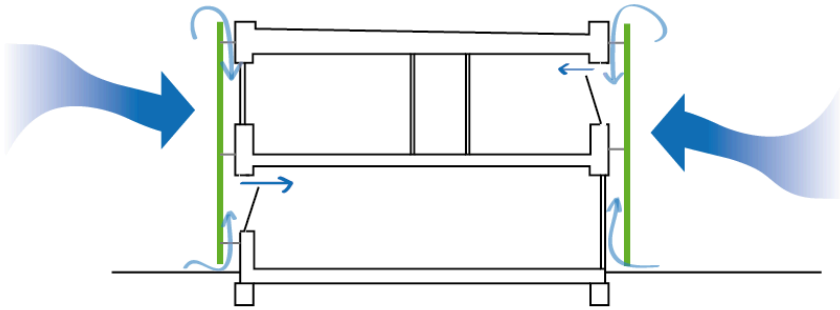


Figure 132: dubble facade to reduce airflow

A design solution that is based on the principle of reducing the incoming airflow is adding a second façade to the building skin, also known as a double façade (Figure 132). This second façade can have different appearances and can be transparent as well. Openings at the bottom and top of the façade ensure a highly ventilated cavity, so when the occupants open the windows, they will still experience fresh (outdoor) air entering the rooms, but with a reduced airflow.

Another solution could be a combination of reducing and preheating incoming air. Locally placed double façades in front of the windows with integrated PCM-filtering systems can reduce and preheat incoming air at the same time. The filters can be made of PCM's that only preheat the air when needed, that is during winter. This way the occupants still have the freedom to open their windows whenever they want without creating negative effects for the heat demand. The PCM are also able to cool the incoming air during summer when choosing the proper transition temperature of the PCM.
A critical note is that it needs to be investigated if opening the windows with such a system is comparable with the experience of opening a 'normal' window. Theoretically and energetically, this double façade principle has a lot of benefits, but when occupants

don't experience this the same as opening a window for letting fresh air inside, the system will still not be a success.

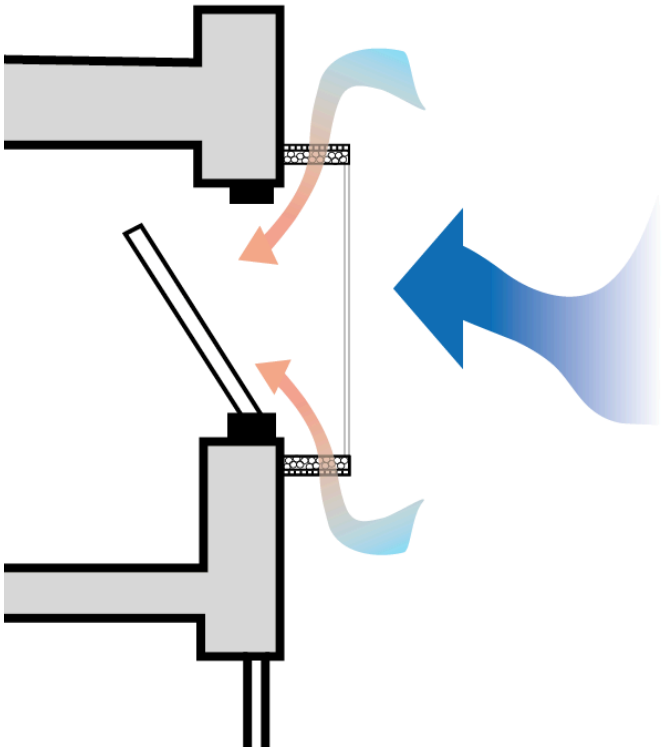


Figure 133: Combination of reducing and preheating airflow

8.4.3 Heat sources

Another important part of a sustainable concept is the choice for a heat source that makes it possible to warm up the spaces during winter when the building skin as a protection is not sufficient. The current houses in Columbuskwartier are connected to the district heating system of the local energy distributor NUON. This district heating system does not belong to a sustainable solution because its works with high water temperature running through the underground pipes. The capacity of this system is too high for residential houses like this, which is exergetically not efficient.
A more sustainable solution is using an earth-water or water-water heat pump (Figure 134) on block level. A heat pump is a device that upgrades ambient heat from a low temperature to a higher temperature so it can be used for space heating and tap water heating.
It is important to take into account when applying this system, that the supply temperatures are relatively low, which makes the nature of this system to have a slow heating character. For that reason it is very important to find a suitable indoor heat delivery system that transfers this heat as efficiently as possible to the adjacent spaces.

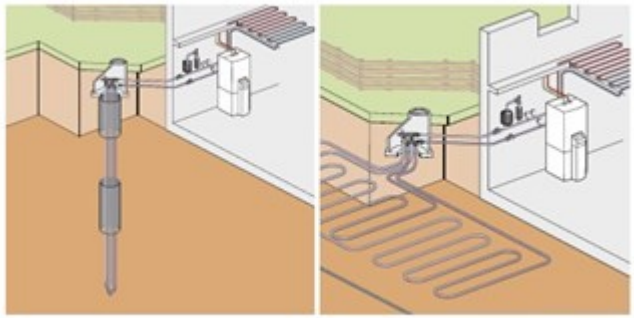


Figure 134: earth heat pump. Source: http://habitos.be.msn.com/nl/bouwen/verwarming/warmtepomp/

8.4.4 Heat delivery systems

Like introduced in the previous paragraph, working with sustainable heat sources, means that the supply temperatures are lower, which limits the choices for suitable indoor heat delivery systems.
As concluded in this study, occupants prefer a heating system that responds fast on their heat demand and that is operable locally. If they want to heat up the space, they don't want to wait 24 hours till the space has the preferable temperature, but they want it directly. Fulfilling this demand is only possible on two different ways:

- High supply temperature from heat source
- Larger heat delivery surfaces

The first option is not applicable when designing a low energy house. That leaves only one option that is suitable in combination with low supply temperatures, and that is creating as big as possible heat delivery surface. The most obvious choice is using a floor heating system. (Figure 135).
Traditional floor heating systems that are currently being applied have some disadvantages that do not reflect the occupant demands. Meeting the occupant's demands requires the following properties for the heating system to have:

- Locally operable (thermostats per room)
- Fast reaction time

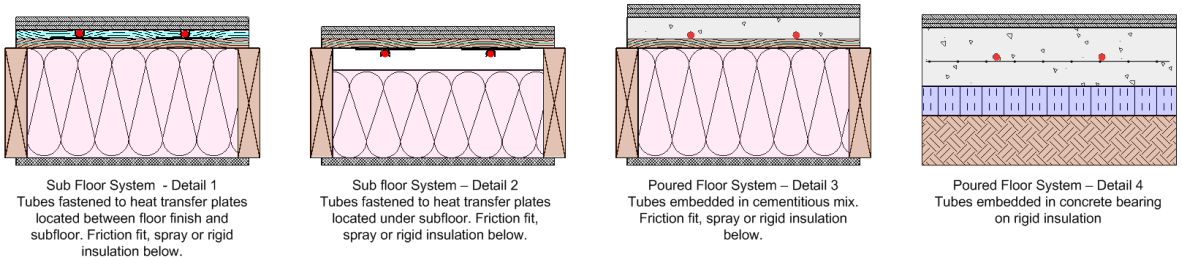


Figure 135: Floorheating system. Source: http://en.wikipedia.org/wiki/File:Under_floor_heating_assemblies_typical.gif

Floor heating systems are not known (yet) for their fast heating time. To reduce the slow warming-up time, the mass between the water pipes of the system and the adjacent space should be as small as possible, so that less time will be spent on accumulating the heat in the construction mass of the floor. An example of a floor heating system that is designed to reach a fast reaction time is from the company Bioclina (2014). They invented a floor heating system that operates with a reaction time of 15 minutes to 1 hour. Common floor heating systems have a reaction time of 4 to 6 hours (Bioclina, 2014).
Second important design consideration, is that the floor heating system must be operable per room, so that the heat is used where wanted (Figure 136). The current floor heating systems in residences are not (standard) equipped with a thermostat in every room to locally control the heating system. Reducing heat losses means heating on the places where the demand is.

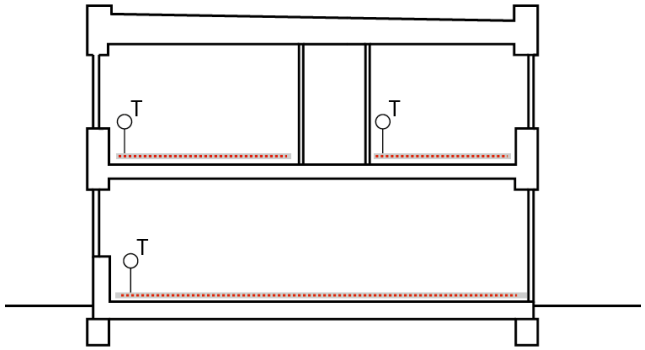


Figure 136: Local operable floorheating

8.4.5 user information systems

The last step to integrate all the findings of this study in order to provide a complete energy concept for houses is to manipulate the user behaviour in a positive way (VROM, 2010).
The behavioural aspects that can be influenced with design solutions, is to increase the specific knowledge and awareness of the occupants. This idea is now entering the market in the form of occupant information systems that give real-time insight in the indoor conditions and the effects of the occupant on the energy use and costs. This concept is still in the first stages of development and is not being implemented as a standard part of the energy installation of houses. The good thing is that the importance and impact of these systems is getting acknowledged by the companies and other parties (like the energy companies) that are specialized in designing energy concepts.
An example of such a development is the user information system 'Toon' that is developed by the Dutch energy company Eneco (Figure 137). This device shows the indoor air temperatures, outdoor air temperatures and functions as a thermostat at the same time. It is

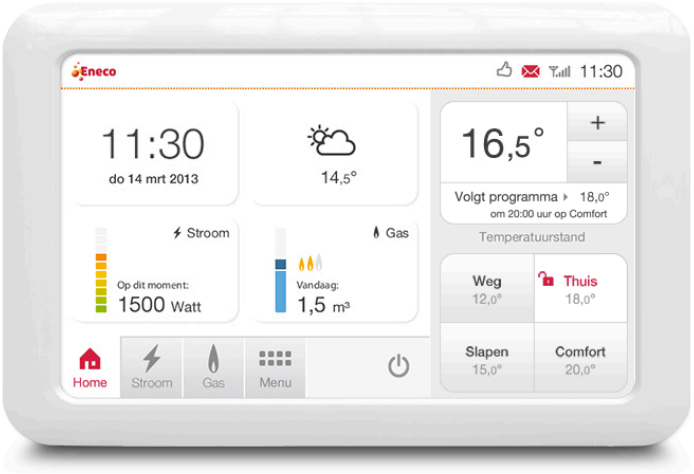


Figure 137: User information system Toon by Eneco. Source: www.eneco.nl

connected to the heating system, which makes it possible to get real-time insight in the used energy for space heating and hot tap water. Occupants don't have to take special and complicated actions to get this information, they are being confronted with it every time they use the thermostat. A simple visual representation of the consequences of their behaviour on the energy use, and especially the costs will make the occupants more aware and will make the perceptions of the occupant correspond better with the actual consequences.
They will see that even though they live in a passive house, their behaviour is still of importance to reduce energy use, so the possible homeostasis phenomenon that has been indicated in this study will be reduced.
Secondly, it is important that this detailed information is available in every room of the house and not only in the living room, which is currently a common thing. Connecting these information systems to the separate operable floor heating systems in every room combines the information system and the local heating demands of the occupants. Doing this will reduce heat use because the heat is used only where wanted.

To get more information about the individual effects of the appliances on the electricity use, smart plugs that work as a network (for example the principle of Plugwise hardware) can send their information to the same devices that display the heat use.

9. CONCLUSIONS

The main research question of this study is *what the share of user behaviour in the difference between the predicted and actual energy use in low energy residences with an EPC<0,4 is, and which behaviour is decisive. And how the difference in energy use in identical residences can be explained.*

Research Method

For this study the methods user survey and monitoring have been used to collect data for the statistical analyses. The methods proved to be adequate for this in-depth study, but the sample size of N=15 made it difficult to draw conclusions from the statistical analysis.
The results of the user survey have been used to select two appropriate houses for monitoring and for the statistical analyses. The monitoring is executed in September and October 2013 for the period of one month. During this month, the occupants also filled in a daily log from 5-10-2013 till 11-10-2013. The collected monitoring data together with the daily log data are used to compare the two households and their behavioural factors in relation to their energy use. The results of this study are used to formulate conceptual design solution that can be used as a guideline for architects for realising low energy houses.

Predicted vs actual energy usage

Considering the sub question to find out *what the difference is in the predicted and actual energy use*, this research revealed that the predicted and actual energy use are not corresponding. Considering the predicted heat use through the EPN and PHPP method as an average heat use, the actual average measured heat usage does not differ that much from the predicted.
Comparing the actual energy use with the predicted energy use by the EPN method, the actual energy use is 9% higher. For the PHPP, the actual energy use is 52% higher than predicted.
More interesting is the fact that the results show a large difference between the lowest and highest actual heat usage, with a standard deviation of 6.3 GJ from the average measured heat usage 0f 13.8 GJ, which answers the sub question *how large the variance in energy usage is in identical residences.*

Factors of influence

Resulting from previous study results and literature, four main parameters are of influence on the difference in predicted and actual energy use:

1. Technical factors (construction, installations)
2. Household characteristics
3. Occupant behaviour
4. Weather conditions

With regards to the sub question *if there are any technical explanatory factors for the difference in predicted and actual energy usage*, this research did not reveal any technical factors that could explain this difference. Because of the fact that there were no explanatory technical factors found, this study did also not found technical factors of influence for the variance between individual energy use.
Even though it was not possible to conduct detailed investigation into all the technical factors that can be of influence on the energy performance, it can be concluded that there are no indications of technical errors that can explain the difference.
This emphasized the direction of the study into further research on the influence of occupant behaviour and household

characteristics.
After bivariate and partial correlation analyses of the survey output, the results did show a significant relation between the household size and electricity usage. It proved that larger households use more electricity.
Previous study results however did show more relations between the household characteristics and energy usage. Due to the small scale of this research, it must be taken into account that when repeating this study on a larger review group more relations between household characteristics and the energy use may be found.
Thus, considering the sub question *what the share is of the household characteristics in the actual energy usage*, which is supporting the main question of how the variance in energy use can be explained, this study only found a relation between household size and energy usage. This result is not sufficient to give a complete and quantitative answer to the sub question, concerning the determination of the share of the total household characteristics on energy usage

Occupant behaviour and energy usage

A large part of this research is dedicated to defining occupant behaviour and the underlying psychological factors, and the relation to residential energy usage. Based on literature, two main sorts of behaviour can be distinguished:

1. Incidental behaviour
2. Habitual behaviour

This study has only been focused on habitual behaviour, because incidental behaviour is not applicable in this specific study. The main answer on the sub question of *what kind of behaviour can be found in residences* is given by this distinction. For this specific study, habitual behaviour includes the following behaviours:

1. Opening windows and ventilation panels (level of natural ventilation)
2. Use of the radiator valves for heating (space heating)
3. Use of hot domestic tap water.

Due to the fact that during the monitoring period the occupants did not use the radiators, only the natural ventilation behaviour and hot water usage were relevant behavioural factors.
Giving a more detailed answer on the sub question, this study defined the underlying principles that influence habitual behaviour, based on literature from the field of psychology, and forms a complex network of interrelated parameters. Based on this literature and the results from this field study it can be concluded that the following parameters have an influence on energy use:

1. General knowledge
2. Specific knowledge
3. Motivation
4. Awareness
5. Attitude
6. Current energy saving behaviour
7. Type of energy efficiency of previous residence

Based on the collected data during this study, a few significant relations were found between the separate parameters and energy usage after bivariate and partial correlation analysis with SPSS. The behavioural factors that showed a significant correlation with energy are:

Awareness	–	electricity usage	*(positive)*
Attitude	-	total energy usage	*(positive)*
Influence previous building type	-	electricity usage	*(positive)*

Three other factors showed to have an almost significant correlation with energy usage:

Specific knowledge	-	electricity usage	*(positive)*

Motivation	-	electricity usage	*(positive)*
Attitude	-	heat usage	*(positive)*

A conclusion that follows from these results is that the behavioural factors show more relation with electricity usage that with heat usage.
This could be explained by the fact that electricity usage is more tangible than heat usage. This tangibility can be interpreted from three different perspectives. First it is important to ascertain that in the media more attention is paid to sustainable solutions and renewable energy sources for electricity provision.
Second, electricity usage is determined by more direct actions from the occupants like the operation of devices. Heat usage on the contrary, has a more indirect controllable character. Third, heat usage is more related to comfort and preferences, which are dominant and difficult to adjust for occupants.
Even though the statistical analysis did prove some significant correlations, it is not possible to give a quantitative answer to the sub question *what share the occupant behaviour has in the difference between the predicted and the actual energy usage*.
The bivariate correlations did emphasize the complex relation between the behavioural parameters, which indicates interesting directions for further research.
Based on the results from this field study we can conclude that the following behavioural factors are decisive to explain the variance in individual actual energy use:

- Awareness
- Attitude
- Influence previous building type
- Specific knowledge
- Motivation

This forms the answer to the second part of the main research question hoe the variance in energy use in identical residences can be explained.
Besides this, the results of the monitoring and longitudinal survey proved that the difference in indoor climate conditions is mainly caused by the natural ventilation behaviour of the occupants. We can conclude that the occupant behaviour has an influence on the indoor temperatures in these low energy houses, which in turn can have a great influence on the space heating demand and behaviour in colder seasons.

Indoor climate problems

Besides the resulted significant relations between the occupant behaviour, household characteristics and energy use, the study also revealed dissatisfaction of the occupants regarding their indoor climate. The information retrieved from the survey showed that the main and most important climate problems are related to:

- Bedrooms too cold during winter and too hot during summer
- Long time to heat up the first floor
- Not enough specific knowledge about the energy concept of the house.

The most important cause for these problems is the lack of radiators on the first floors. The concept of indirect heating of the first floor requires specific knowledge about the energy concept and longer heating time. In order to warm up the building, the occupants need to put the downstairs radiators on as high as possible and for a longer period for the fastest results. This results in an inefficient heat demand on colder days.

Design solutions and Recommendations

Focussing on design solutions for this typical Dutch terraced housing case study, there are a few design principles that need to be taken into account when integrating the results from this study. The given solutions will give residences a more robust character, meaning that

the dynamic character of the building occupant has less effect on the energy usage.

First of all it is important to understand the dynamic behaviour of occupants and see this as a given fact, instead of designing for a 'typical' and standardized occupant. This change of mind set is of importance if we keep using EPC or PHPP energy predictions as an indication tool for reducing the national residential energy demand. These prediction methods will develop over the years and probably become more accurate, but will always express an average energy usage for the designed houses.
Reducing the effect of the dynamic character of the occupants on the energy use can be achieved by applying the following steps:

- Reduce the amount of installations that need to be operated by occupants
    - Natural ventilation as basis during summer
    - Passive house concept (highly insulated and airtight envelope)

- Decentralised additional ventilation
    - Breathing window for pre heating supply air during winter and providing a healthy indoor air quality when windows can't be opened during cold days.
    - Co2 controlled balanced ventilation units in façade

- Increasing insight of occupants into energy use, and increasing the awareness of effect of appliances on the energy use
    - Real-time and local insight in energy use specified for different appliances and space heating installations
    - More insight in energy use compared to the energy use of the community (neighbourhood, district)

- Indoor heat delivery systems
    - Local heating instead of central or indirect heating
    - Fast heat delivery systems for low temperature supply
        - Local floor heating systems
        - Low temperature radiators with bigger surface
- Thermal mass
    - Phase Change Materials (for faster accumulation of heat when windows are opened during warmer outside temperatures)

Besides the above explained design solutions that directly follow from the results of this study, there are also design solutions that need to be taken into account in order to reduce energy use:

- Use of sustainable heat sources
    - Heat pump (earth-water, water-water), district or individual
    - Solar collector
    - Heat recovery of used hot tap water

- Use of sustainable electricity sources
    - PV-cells
    - Wind energy

10. DISCUSSION

Defining behaviour in relation to energy usage

A critical note needs to be made at defining the parameters that influence behaviour in relation to energy usage. Combining the psychological scientific field with the technical scientific field in relation to energy use has not been conducted on a large scale yet. The different scientific fields that describe these parameters all have different definitions and interrelations.
The definitions of the parameters in this context are subject for discussion, because there are no previous research results that consider awareness, motivation and attitude all together in relation to energy usage in low energy houses, so it is not possible to directly compare results.
The not significant outcome of the analyses emphasizes the discussion concerning these parameters. Future study on larger scale must prove if the formulated definitions and relations are correct or not.

Additional research

This research resulted in a lot of interesting topics for future research. Most obvious is the execution of this study on larger scale. The big variation found in energy usage residences that are less sensitive for different occupant behaviour concerning the energy usage. In architectural terms we can define this as robustness of residences. Giving architects more tools and concepts for designing robust residences should help in reducing the national energy usage. When executing this research on larger scale, it is also of great importance to monitor over a longer period, including the coldest season where space heating behaviour can be investigated in relation to natural ventilation behaviour and heat usage.
Another interesting topic is more behaviour related. This study showed that there may potentially be an important relation between the level of energy efficiency of the previous residence and the energy usage in a new residence. Studying the habits occupants develop in different types of residences, and how long it takes before occupants adopt new habits in a new residence, gives more insight in the appropriate tools that can be used to efficiently manipulate occupant behaviour in a positive way concerning energy usage.
Besides these studies it is also useful to do more research into the difference between the PHPP and EPC calculation methods and which of these two is more applicable and realistic for the Dutch housing stock. Research could show that there are more realistic and dynamic methods for predicting energy usage of residences, which make the EPC and PHPP superfluous.
in identical houses with no technical explanatory factors, asks for designing

Analyses method

For analysing the obtained data from the field study, excel and SPSS have been used. The first step in the analysis process was filtering and combining variables in excel. The first graph and trends were used as the beginning point for the SPSS analysis. Finding a suitable analysis method for finding answers on these research questions has proved to be difficult, due to the complex interrelations between the parameters that influence human behaviour.
In order to get insight into the influence of the behaviour on the energy usage, multiple parameters need to be correlated with the energy usage in one calculation. This study remained limited to partial correlation analysis using SPSS. Future studies could obtain

more information from the data when using more complex multiple regression methods.

11. REFLECTION

Project and wider social context

The target of this study was to get insight in the actual energy performance of residences with an EPC of 0.4 or lower with the focus on the influence of the building occupants on the energy usage. This study confirmed that the actual energy usage of these low energy residences deviates from the predicted energy usage, which is calculated during the final design stage. However, in identical residences there is a significant variation in energy usage, which is caused by a complex set of parameters, including household characteristics and behaviour.
If we want to reduce the energy use in residences, we must take the dynamic characteristics of human behaviour into account and integrate this in the early stages of the design process. Considering the future targets getting stricter, it is important for designers and project developers to apply this knowledge instead of ignoring it.

Planning and research question

Despite the framed main research question, it was not possible to find a specified quantitative answer on what the actual share of the occupant behaviour is on the difference between the predicted and actual energy usage. Because of the complex and psychological nature of human behaviour, the tools and time for this study were not sufficient to find significant indications on this question. Especially the sample size proved to be too small for analytical research.
Considering the planning, not all steps have been executed within the previously set up time frame. This was all caused by the fact that all the needed data needed to be obtained by field study.

Problems and challenges during field study

One of the biggest challenges during this study was to obtain the data needed to answer the research questions. At the beginning of this study it soon became clear that the housing stock with residences with an EPC of 0.4 or lower was not very big in the Netherlands. It started with finding identical residences with a low EPC in the surrounding area. After finding a suitable case study, different parties needed to be contacted in order to find out what the possibilities were for research. Because this project is marked as unique in the building sector, different parties started studies, but the outcomes were difficult to obtain because of the different interests of the parties.
Getting a green light sign from the housing corporation made it possible to start the research, but didn't mean the end of the challenges. One of the biggest challenges was to find as much as possible occupants who wanted to fill in the extensive survey. After retrieving less useful surveys as hoped in advance, two houses needed to give their co-operation for indoor monitoring for one month including filling in a longitudinal survey for a week.
With all the theoretically most ideal parameters set beforehand, it was very difficult to find two houses that did meet these parameters. I'm very grateful for the two houses that cooperated, and that these two houses did meet a lot of these parameters.
Being dependent of people for this study, especially not motivated people, requires a flexible approach and improvisation when time is limited. Even though this was taken into account at the beginning of the research, the impact was underestimated.

Conclusions and uncertainties

The sample size of this study has proven to be too small in order to formulate hard conclusions for several research questions. According to the literature and outcomes of previous studies, there is still enough to learn on this topic. The method used and the formulated definitions can be used in research on a larger scale with more resources. Scaling up the research will definitely lead to significant correlations.
The used analysis method of bivariate and partial correlations is a labour intensive method, because the behavioural parameters have a complex non-linear relationship. The output of this study can be used as a filter for future research into these behavioural parameters and the influence on energy usage.
Besides the not significant relations after the analyses, it is also important to take into account the uncertainties that result from general survey research. Formulating questions and answering questions is always subject to interpretation. Especially for this study it is important to take this into account because of the small review group. The larger this group becomes, the smaller these uncertainties become.

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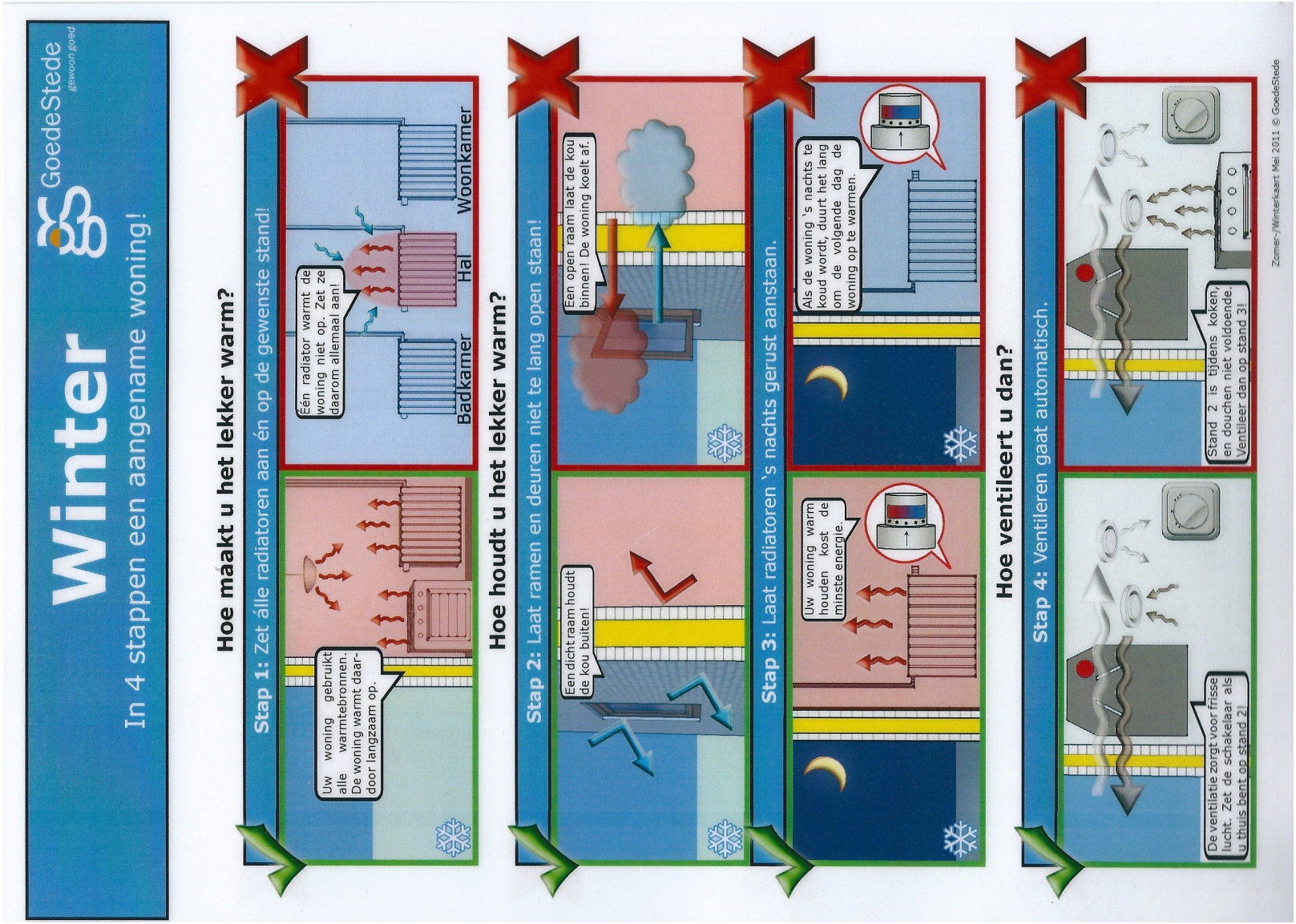
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APPENDIX A Summer and winter instructions by Goedestede



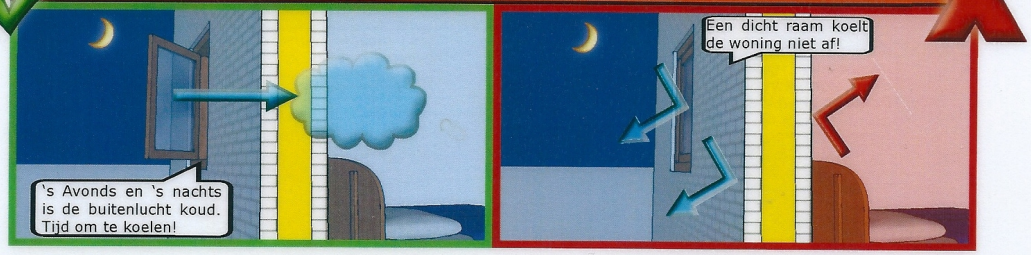
Zomer

GoedeStede
gewoon goed

In 4 stappen een aangename woning!

Hoe maakt u het lekker koel?

Stap 1: Zet 's avonds en 's nachts ramen open.



Hoe houdt u het lekker koel?

Stap 2: Laat ramen en deuren overdag niet te lang open staan!



Stap 3: Zet 's avonds en 's nachts ramen open.



Hoe ventileert u dan?

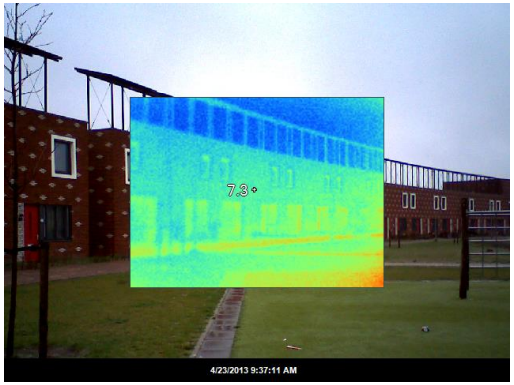
Stap 4: Ventileren gaat automatisch.

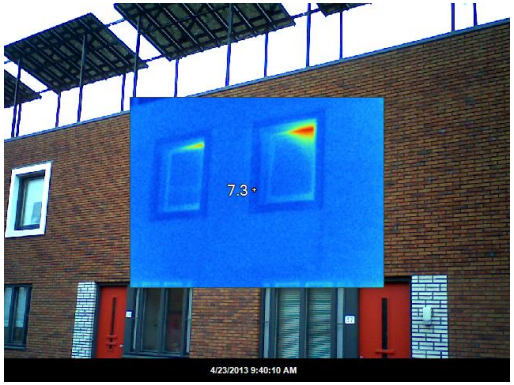


Zomer-/Winterkaart Mei 2011 © GoedeStede

APPENDIX B Thermographic pictures



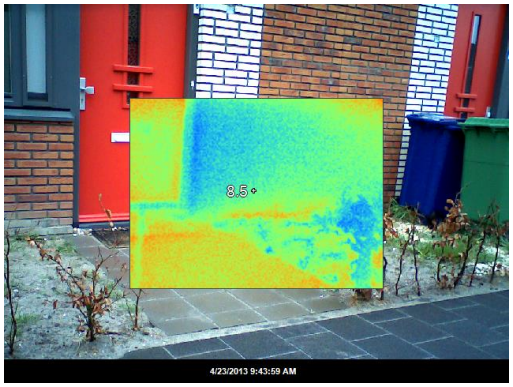


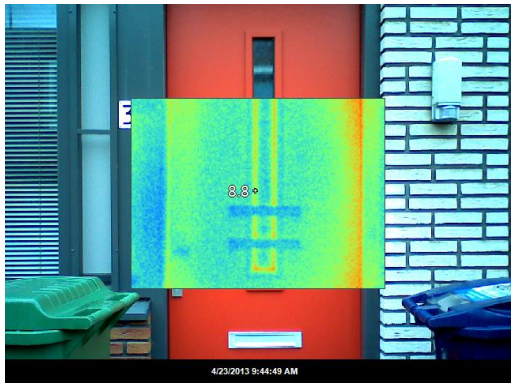


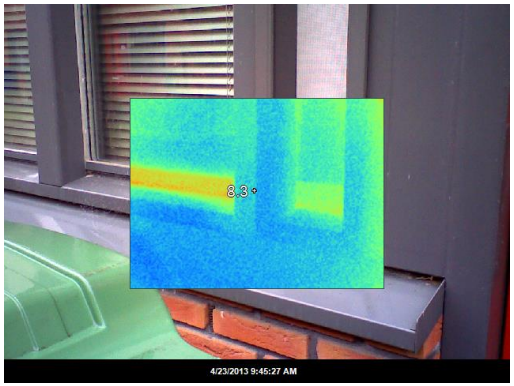


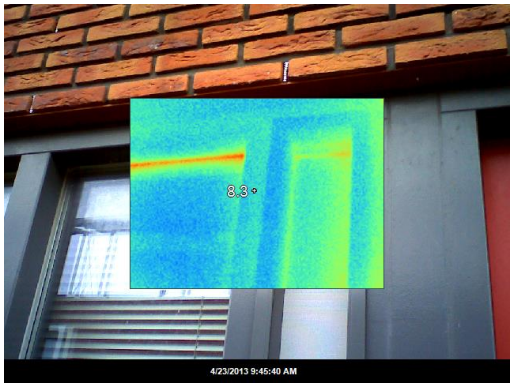








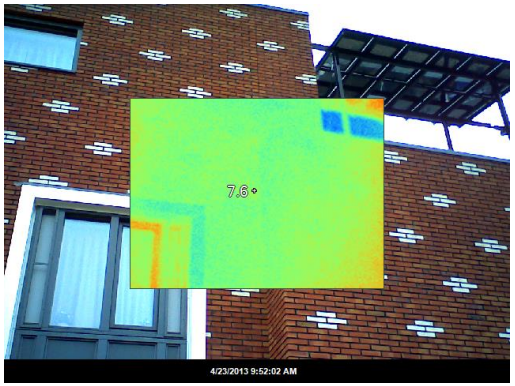


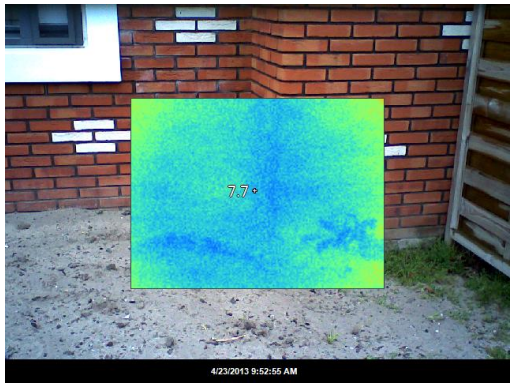






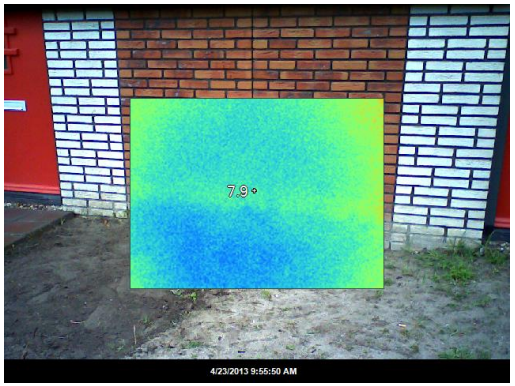

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4/23/2013 9:51:14 AM

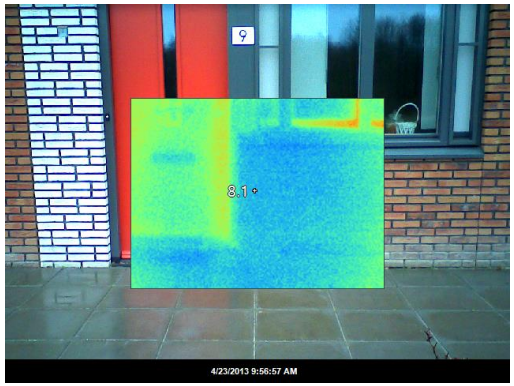

7.6 •
4/23/2013 9:52:02 AM

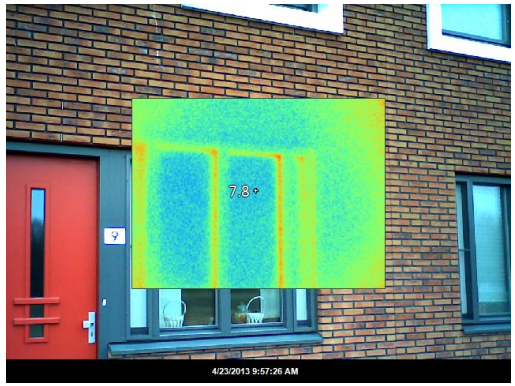

7.7 •
4/23/2013 9:52:55 AM

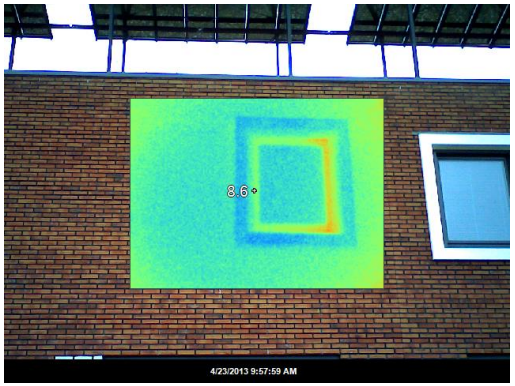

8.1 •
4/23/2013 9:54:18 AM

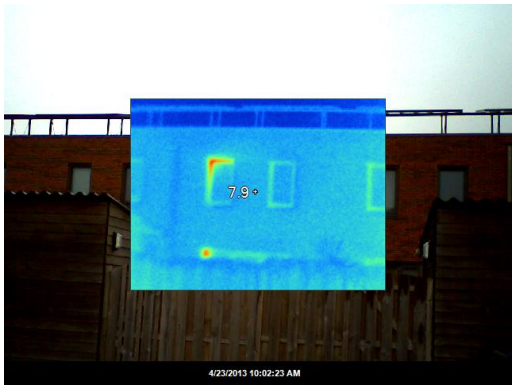

9.5 •
4/23/2013 9:55:07 AM


7.9 •
4/23/2013 9:55:50 AM


8.1 •
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7.8 •
4/23/2013 9:57:26 AM


8.6 •
4/23/2013 9:57:59 AM


7.9 •
4/23/2013 10:02:23 AM


8.7 •
4/23/2013 10:03:05 AM


8.7 •
4/23/2013 10:03:52 AM

APPENDIX C1 Occupant energy use survey data Cauberg-Huygen

In de volgende grafiek is het elektriciteitsverbruik te zien vanaf het moment van bewoning (circa augustus 2010) tot halverwege september 2012. De rode lijn geeft aan wat het gemiddelde elektriciteitsverbruik is in uw buurt over de afgelopen twee jaar. Dit is 7638 kWh elektriciteit. Het landelijk gemiddelde elektraverbruik van een gezin is op jaarbasis 3500 kWh. Per twee jaar is dit 7000 kWh. Het elektraverbruik in de passiefhuizen in Almere ligt dus iets boven het landelijk gemiddelde.

Met uw unieke bewonersnummer kunt u zien wat uw elektriciteitsverbruik is ten opzichte van de andere bewoners.

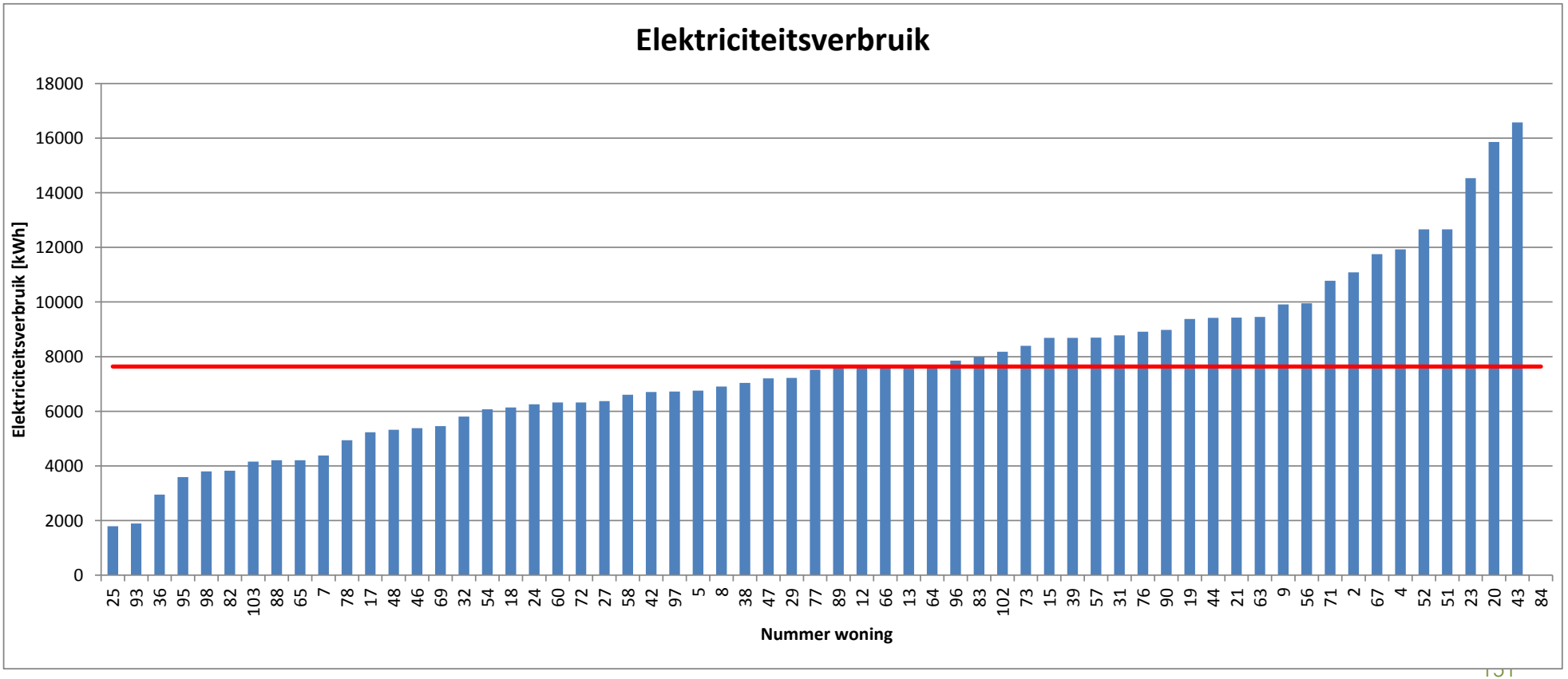


Figure C1-1: Electricity use occupants October 2010-2012 collected by Cauberg-Huygen

In de volgende grafiek is het warmteverbruik te zien vanaf het moment van bewoning (circa augustus 2010) tot halverwege september 2012. De rode lijn geeft aan wat het gemiddelde warmteverbruik is in uw buurt over de afgelopen twee jaar. Dit is 38,2 GJ warmte. Uit onderzoek van VROM is geconcludeerd dat een standaard nieuwbouw tussenwoning per jaar ca. 30,7 GJ warmte verbruikt. Per twee jaar is dat dus 61,4 GJ. Het gemiddelde warmteverbruik van de passiefhuizen van Almere (38,2 GJ) ligt dus ruim 35% lager ten opzichte van het landelijk gemiddelde warmteverbruik van een nieuwbouw tussenwoning.

Met uw unieke bewonersnummer kunt u zien wat uw warmteverbruik is ten opzichte van de andere bewoners.

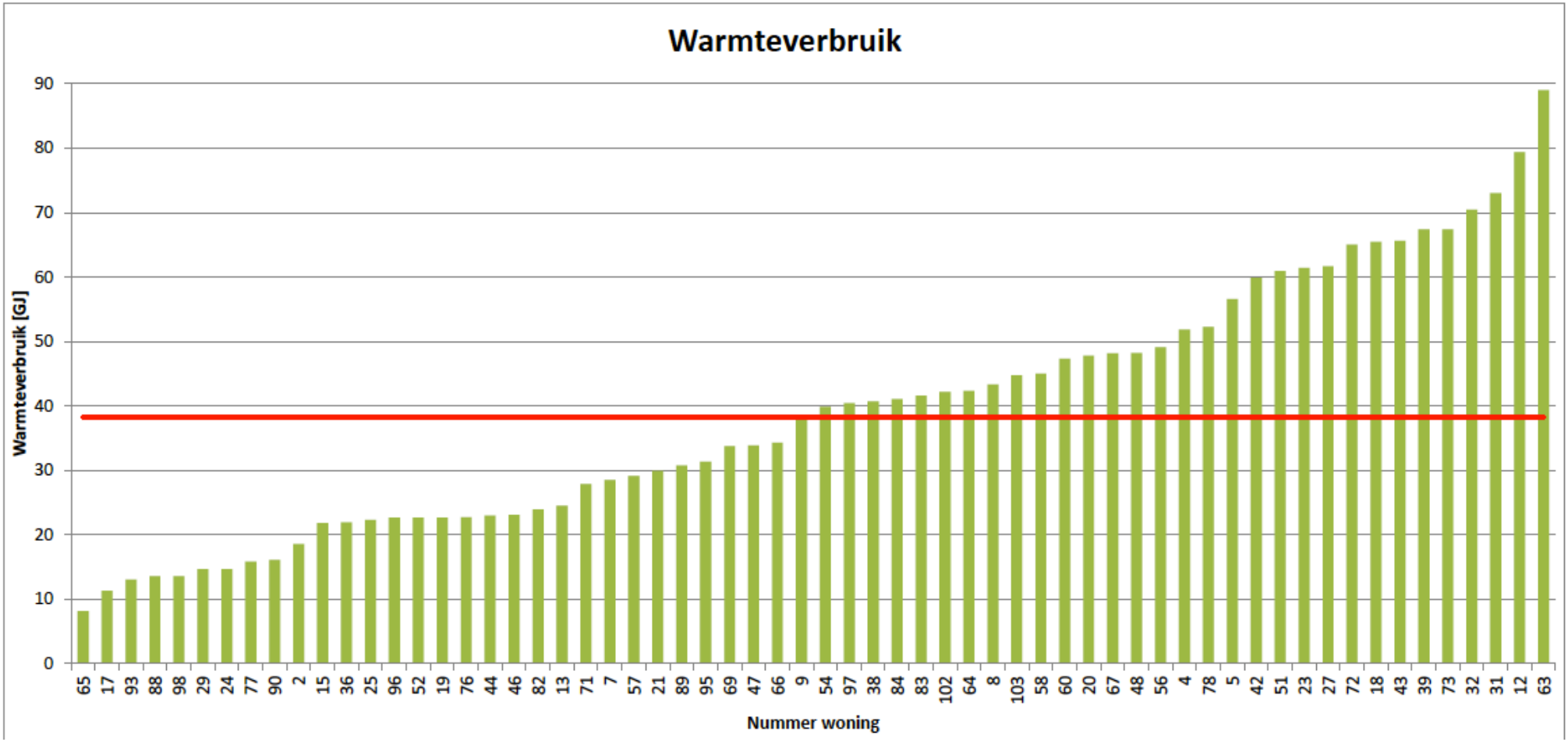


Figure C1-2: Heat use occupants October 2010 - 2012 collected by Cauberg-Huygen

APPENDIX C2 Occupant energy use data own survey

Adress	Electricity usage 2011 & 2012 (kWh)				Heat usage 2011 & 2012 (GJ)				Total energy usage 2011-2012 (MJ)
code	2011	2012	Average	MJ	2011	2012	Average	MJ	MJ
A	2448	3760	3104	11174	23.4	31.1	27	27285	38459
B	622	1065	844	3037	8.7	9.3	9	8995	12032
C	2187	10843	2187	7873	6.0	11.1	9	8550	16423
D	-	-	4750*	17100	-	-	15*	15000	32100
E	-	-	3750*	13500	-	-	7.5*	7500	21000
F	1904	2617	2261	8138	15.8	18.8	17	17295	25433
G	2000	2000	2000	7200	20.0	21.0	21	20500	27700
H	-	-	-	-	-	-	-	-	-
I	3891	4358	4125	14848	7.3	6.8	7	7070	21918
J	-	-	-	-	-	-	-	-	-
K	3572	3926	3749	13496	9.3	10.2	10	9725	23221
L	1520	1559	1540	5542	5.6	8.9	7	7270	12812
M	3129	3007	3068	11045	15.0	13.0	14	14000	25045
N	1656	2160	1908	6869	21.3	10.0	16	15645	22514
O	3773	1154	2464	8869	19.6	21.0	20	20300	29169

** Estimated based on user survey data from previous study Cauberg-Huygen. Appendix C1 Figure C1-1 and Figure C1-2*

APPENDIX D MOBIUS EPC calculations

Algemene gegevens

Bestandsnaam	:	\\driebergen\gebruikers\Edward\PROJEC~2\4036TO~1\28_COL~1\epc\28COLU~1.EPG
Projectomschrijving	:	Passiefhuizen Columbuskwartier
Opdrachtgever	:	AgentschapNL
Projectinformatie	:	Oude berekeningen, EPC type E oorspr = 0,42
		NPR5129, typen C, D1t/mD3, E,Ehoek, F1t/mF3. EPC varieert tussen 0,39 (F1) en 0,49(C).
Omschrijving bouwwerk	:	Passiefhuizen Columbuskwartier
Adres	:	Willem Barendszroute (oa)
Berekeningstype	:	woningbouw
Gebruikte eisentabel	:	Eisen Bouwbesluit 2012, aangewezen op 1 maart 2013

Schematisering

Klimatiseringszones

Klim. zone	*Omschrijving*	*Transportmedium warmte*	*koeling*	*Verwarmings-systeem*	*Koelsysteem*	*Ventilatiesysteem*
A	Totaal	water	n.v.t.	Verwarmingssysteem 1	(geen)	Ventilatiesysteem 1

Rekenzones

Rekenzone	*Omschrijving*	*Gebruiksfunctie*	*Ag [m²]*
A.1	Totaal	woonfunctie	92,80
			+
Totale gebruiksoppervlakte energiegebouw (Ag;tot)			92,80 m²

Transmissie

Definitie scheidingsconstructies rekenzone A.1 - Totaal

scheidingsvlak	*begrenzing*	*oriëntatie*	*A [m²]*	*Hkr [m]*	*Rc [m²K/W]*	*U [W/m²K]*	*hoek [°]*	*ZTA [-]*	*zonwering*	*belemmering*
Voorgevel	buitenlucht									
Gevels totaal		ZO	20,30		7,20		90			minimaal
Panelen spui		ZO	0,60		1,25		90			minimaal
ramen totaal		ZO	3,80			0,85	90	0,50	geen	minimaal
deur		ZO	2,20			0,80	90	0,00	geen	minimaal
Achtergevel	buitenlucht									
gevels totaal		NW	17,10		7,20		90			minimaal
panelen spui		NW	1,00		1,25		90			minimaal
ramen totaal		NW	8,90			0,85	90	0,50	geen	minimaal
Vloer	kruipruimte									
totaal		N	46,40	0,50	5,00					
Dak	buitenlucht boven									
totaal		N	46,40		9,50		0			minimaal
			+							
			146,70							

Lineaire koudebruggen

Er is gerekend volgens de forfaitaire methode m.b.t. de koudebruggen.
Bij de forfaitaire methode wordt een correctie op de U-waarde toegepast.

Definitie lineaire koudebruggen rekenzone A.1 - Totaal

scheidingsvlak	*koudebrug*	*P [m]*
Vloer	vloerperimeter	9,70

Thermische capaciteit

Rekenzone	*volgens bijlage H*	*bouwtype*	*Cm [kJ/K]*
A.1 Totaal	nee	traditioneel, gemengd zwaar	41 760
			+
			41 760

Infiltratie

qv10;spec [dm³/s-m²]	*eigen waarde*	*hoogte*	*lengte gebouw [m]*	*breedte*	*uitvoeringsvariant*
0,150	ja	6,00	4,80	9,00	tussengebouw, plat

Verwarming

Verwarmingssysteem 1 - Verwarmingssysteem 1

installatiekenmerken	type verwarmingssysteem	:	individueel systeem
	temperatuurniveau	:	Hoog
	gebouwgebonden warmtelevering op afstand	:	nee
	individuele bemetering	:	ja
Preferent toestel	hoofdtype toestel	:	externe warmte
	vermogen	:	1,36 kW
	opwekkingsrendement	:	1,670
	NVN7125	:	Almere Nuon Energiecentrale Diemen Almere Stad, Noorderplassen
	energiedrager	:	warmte
hulpenergie	bepaling	:	forfaitair

Warm tapwater

Warmtapwatersysteem 1 - Tapwatersysteem 1

installatiekenmerken	type tapwatersysteem	:	collectief systeem geen voorraadvaten
	zonneboiler	:	geen
	afleverset	:	ja
	gekoppeld verwarmingssysteem	:	-
	type toestel	:	externe warmte
	opwekkingsrendement	:	1,650
	NVN7125	:	Almere Nuon Energiecentrale Diemen Almere Stad, Noorderplassen
	energiedrager	:	warmte
distributierendement	forfaitair	:	nee
	nW;dis [-]	:	1,00
douchewarmteterugwinning	aanwezig	:	nee
afgifte	tapsysteem geldt voor	:	keuken en badkamer
	methode A uitgebreid	:	nee
	inwendige diameter leidingen keuken	:	<= 8 mm

aangewezen rekenzones	*Ag [m²]*	*Ag;tapw [m²]*
A.1 Totaal	93	93

Koeling

Er zijn geen koelsystemen ingevoerd.

Ventilatie

Ventilatiesysteem 1 - Ventilatiesysteem 1

ventilatiesysteem	:	D. Mechanische toevoer, mechanische afvoer
ventilatiesysteemvariant	:	D.2b2 - WTW, geen zonering, geen sturing, volledig bypass
geïnstalleerde capaciteit onbekend	:	ja
1a) natuurlijke toevoer van buiten	:	0,00 dm³/s
1b) natuurlijke toevoer via een ruimte (serre of atrium)	:	0,00 dm³/s
1c) mechanische toevoer van buitenlucht (decentraal)	:	0,00 dm³/s
1d) mechanische toevoer van voorverwarmde of gekoelde buitenlucht	:	39,90 dm³/s
met toe- en/of afvoerkanaal	:	ja
luchtdichtheidsklasse	:	LUKA D
Maximale ventilatiecapaciteit bij koudebehoefte	:	nee
Maximale spuiventilatiecapaciteit bij koudebehoefte	:	ja
type warmteterugwinning	:	Kwaliteitsverklaring
kwaliteitsverklaring	:	
rendement Nwtw	:	0,950
correctiefactor Frend	:	0,80

Ventilatoren

Effectief vermogen ventilatoren is forfaitair bepaald.

Ventilatiesysteem	*Gelijkstroom*
Ventilatiesysteem 1	ja

PV-systemen

PV-systeem	*Apv* [m²]	*helling* [°]	*oriëntatie*	*bouwintegratie*	*type cel*	*Spv* [Wp/m²]
PV-systeem 1	10,50	15	ZO	sterk geventileerd	kwaliteitsverklaring	75

Zonnecollectoren

Er zijn geen zonnecollectoren ingevoerd.

Verlichting

Er is gerekend volgens de forfaitaire methode m.b.t. de verlichting.

28COLU~1.EPG Passiefhuizen Columbuskwartier · E/E = 0,503

Resultaten

Primair energiegebruik	*[MJ]*
Verwarming	4 460
Warm tapwater	8 212
Koeling	786
Bevochtiging	0
Ventilatoren	3 289
Verlichting	4 276
Totaal	**21 023**
Elektriciteitsproductie gebouwgebonden	-1 875
Afgenomen energie	**19 148**
Geëxporteerde energie	0
Elektriciteitsproductie niet-gebouwgebonden	-4 340
EPtot	**14 808**
EP;adm;tot	29 433
Specifieke energieprestatie per m²	160
	[-]
EPtot / EP;adm;tot	0,503
EPC	0,31
EPC voldoet aan bouwbesluit 2012	ja
	[m²]
Ag;tot	92,80
Averlies	132,78

Informatief

CO2-emissie totaal	1 455,27	kg

Kwaliteitsverklaringen

	type	*merk*	*toestel*	*subtype*
1	warmtelevering	Almere	Nuon Energiecentrale Diemen	Almere Stad, Noorderplassen

APPENDIX E1 Survey Cauberg-Huygen 2011

Vragenlijst over het wonen in de zeer energiezuinige (passief)huizen in het Columbuskwartier in Almere

Voor bewoners van de volgende straten: Olivier Bruyneelstraat, Willem Barentszroute, Robert Pearystraat

Almere, mei 2011
Kenmerk: 2011.164 RTR/qs

Beste bewoner,

Zoals u weet woont u in een bijzondere woning; een passiefwoning. Uw woning is heel goed geïsoleerd. Voor het verwarmen van uw woning is weinig energie nodig en u maakt zelfs gebruik van zonne-energie. Nog maar weinig huurders in Nederland wonen in zo'n woning.

In uw woning zijn verschillende installaties geplaatst. Ook is er een dik pak isolatie aangebracht. Maar hoe is het om in zo'n bijzondere woning te wonen? Wat moet u allemaal extra of anders doen, en is het wel comfortabel?

Op bovenstaande vragen willen wij, en andere deskundigen in Nederland, graag een antwoord.
U heeft inmiddels ervaring met het wonen in deze bijzondere woning. Wilt u daarom deze vragenlijst invullen? Uw ervaringen worden gebruikt om toekomstige woningen nog beter te ontwerpen.

U kunt de ingevulde vragenlijst terugsturen in de bijgevoegde antwoordenvelop (een postzegel is niet nodig).

Het is ook nog steeds mogelijk om uw energiegebruik te laten monitoren. Naast een overzicht van het gemiddelde warmte en elektriciteitsverbruik per maand, krijgt u tips om nog minder energie te gebruiken. U kunt de meterstanden doorgeven aan p.doorn@chri.nl.

Wij hopen op uw medewerking.

CAUBERG-HUYGEN
RAADGEVENDE INGENIEURS BV

Enquête

Naam bewoner	:	(hoeft niet ingevuld te worden)
Leeftijd hoofdbewoner(s)	:	
Gezinssamenstelling	aantal volwassen:	aantal kinderen.....
Leeftijd kinderen	:.....jaar/.....jaar/.....jaar	
Adres	:	(hoeft niet ingevuld te worden)
Datum van invullen enquête	:	
Startdatum bewoning	:	
Woningtype:	: 2 laags / 3 laags / hoekwoning / tussenwoning / rugwoning	

Deel 1: Algemeen

1.a Wat waren de belangrijkste redenen voor de keuze voor uw woning?

(maximaal 3 redenen aankruisen)

- o De grootte van de woning
- o De ligging van de woning ten opzichte van voorzieningen en scholen
- o De hoogte van de huur
- o Lage energiekosten
- o Bereikbaar met openbaar vervoer
- o Prettige woonomgeving
- o U wilde graag in een passiefhuis wonen
- o U had dringend een woning nodig
- o U had weinig alternatieven
- o Dicht bij het werk
- o Anders, namelijk .....

1.b Wat vindt u belangrijk aan uw woning?

	zeer onbelangrijk	onbelangrijk	neutraal	belangrijk	zeer belangrijk
milieuvriendelijk	0	0	0	0	0
de lage energiekosten	0	0	0	0	0
een gezond binnenmilieu	0	0	0	0	0
veel ruimte	0	0	0	0	0
de wijk	0	0	0	0	0
de tuin	0	0	0	0	0
dat het een passiefhuis is	0	0	0	0	0

- o Anders, namelijk .....

1.c Bent u over het algemeen tevreden over uw woning? Welk (school)cijfer (1-10) zou u de woning geven?

- Ja, cijfer .....
- Nee, cijfer .....

1.d Indien nee, waarom niet? Ruimte voor toelichting

.....

1e. Algemene vragen over de bewonersvoorlichting

	Helemaal mee eens	Mee eens	Neutraal	Mee oneens	Helemaal mee oneens	Geen mening
De informatie die GoedeStede mij verstrekte voor het tekenen van het huurcontract was volledig en duidelijk.	0	0	0	0	0	0
De uitnodiging die ik van GoedeStede ontving voor de bezichtiging van de woning was duidelijk.	0	0	0	0	0	0
Ik ben tevreden over de manier waarop de bezichtigingen (tijdens de kijk- en meetmiddagen, persoonlijke bezichtiging ed.) waren georganiseerd.	0	0	0	0	0	0
De begeleiding die ik van een medewerker van GoedeStede kreeg tijdens de bezichtiging was naar tevredenheid.	0	0	0	0	0	0
Ik ben tevreden over de sleuteloverdracht/oplevering van de woning.	0	0	0	0	0	0
Ik kreeg een goede gebruikersinstructie.	0	0	0	0	0	0
Mijn woning werd in goede staat opgeleverd.	0	0	0	0	0	0
Ik ben tevreden over de manier waarop de gebreken in de woning werden opgelost.	0	0	0	0	0	0

1.f Heeft u een klacht gemeld bij GoedeStede in de eerste 3 maanden?

- Ja
- Nee

1g. Algemene indruk woning

De volgende vragen gaan over hoe u in algemene zin het wonen in uw woning ervaart.

	Helemaal mee eens	Mee eens	Neutraal	Mee oneens	Helemaal mee oneens	Geen mening
Ik ben tevreden over de grootte van mijn woning	0	0	0	0	0	0
Ik ben tevreden over de indeling van mijn woning	0	0	0	0	0	0
Ik ben tevreden over de grootte van mijn woonkamer	0	0	0	0	0	0
Ik ben tevreden over de badkamer	0	0	0	0	0	0
Ik ben tevreden over de grootte van mijn slaapkamer(s)	0	0	0	0	0	0
Ik ben tevreden over het aantal kamers van mijn woning	0	0	0	0	0	0
Ik ben tevreden over de uitstraling van mijn woning	0	0	0	0	0	0
Ik ben tevreden over de prijs/kwaliteitverhouding van mijn woning	0	0	0	0	0	0
Ik ben tevreden over de grootte van mijn tuin en/of buitenruimte	0	0	0	0	0	0
Ik ben tevreden over het sanitair	0	0	0	0	0	0
Ik ben tevreden over de keuken	0	0	0	0	0	0
Ik ben tevreden over de verwarmingsinstallatie	0	0	0	0	0	0
Ik ben tevreden over de vochthuishouding in mijn woning	0	0	0	0	0	0
Ik ben tevreden over de kwaliteit van de geluidsisolatie van mijn woning bij geluiden van buiten	0	0	0	0	0	0
Ik ben tevreden over het geluid dat de installaties maken	0	0	0	0	0	0
Ik ben tevreden over de energiezuinigheid van mijn woning	0	0	0	0	0	0

Ik woon prettig in mijn woning	0	0	0	0	0	0

1h. Algemene indruk van de buurt/woonomgeving

De volgende stellingen gaan over voorzieningen, de uitstraling en de veiligheid van de buurt.

	Helemaal mee eens	Mee eens	Neutraal	Mee oneens	Helemaal mee oneens	Geen mening
Ik ben tevreden over de bereikbaarheid van de buurt met het openbaar vervoer	0	0	0	0	0	0
Ik voel me thuis in de buurt	0	0	0	0	0	0
Ik ben tevreden over de bestrating in mijn woonomgeving	0					
Ik ben tevreden over het groen om mijn voortuin	0	0	0	0	0	0
Ik ben tevreden over de sfeer in de buurt	0	0	0	0	0	0
Ik voel me veilig in mijn buurt	0	0	0	0	0	0
Ik ben tevreden over de aanwezigheid van winkels voor de dagelijkse boodschappen	0	0	0	0	0	0
Ik ben tevreden over de aanwezigheid van medische voorzieningen (zoals een dokter, apotheek of tandarts	0	0	0	0	0	0
Ik ben tevreden over de aanwezigheid van voorzieningen voor kinderen (zoals kinderdagverblijven, speelplaatsen, buurthuizen, basisscholen	0	0	0	0	0	0

Hieronder worden specifieke vragen gesteld over de aanwezige installaties in uw woning (hoe u die gebruikt en hoe u dat ervaart). Wij willen u vragen of u ook deze vragen zou willen beantwoorden. Indien een vraag niet duidelijk is, mag u die gerust over slaan.

Deel 2: Het kunnen bedienen van de installatie en de voorzieningen
Deze vragen gaan over of u als bewoner de aanwezige installatie goed kunt bedienen. De vragen zijn uitgesplitst in algemene vragen en specifieke vragen.

Algemene vragen

Hoe tevreden bent u over.....? *Denk daarbij aan bedieningsgemak, capaciteit, comfort etc.*	zeer on-tevreden	onte-vreden	neutraal	tevreden	zeer te-vreden
Het systeem voor het opwekken van warmte voor warm tapwater (stadswarmte)	0	0	0	0	0
Het warmte-opwekkingsapparaat (stadswarmte)	0	0	0	0	0
Het warmte-afgifte-systeem (radiatoren)	0	0	0	0	0
De temperatuurregeling	0	0	0	0	0

Hoe tevreden bent u over het ventilatatiesysteem?	zeer on-tevreden	onte-vreden	neutraal	tevreden	zeer te-vreden
Bedieningsgemak	0	0	0	0	0
Capaciteit	0	0	0	0	0
Comfort (bijvoorbeeld tocht)	0	0	0	0	0
Geluid	0	0	0	0	0
Onderhoud	0	0	0	0	0

Specifieke vragen
(meer antwoorden zijn mogelijk)

2.a Hoe beoordeelt u de temperatuurregeling met de radiatorknoppen?

- De radiatorknoppen zitten op een onhandige plek
- De cijfers op de radiatorknop zijn moeilijk afleesbaar
- De radiatorknoppen zijn goed bereikbaar en eenvoudig afleesbaar
- Anders, namelijk .....

2.b Hoe beoordeelt u de bediening van het ventilatiesysteem?

- De standenschakelaar van de ventilatie is goed bereikbaar en eenvoudig afleesbaar
- De standen van het ventilatiesysteem zijn moeilijk afleesbaar
- De standenschakelaar is voor mij moeilijk bereikbaar

- Anders, namelijk .....

2.c Hoe beoordeelt u de bediening van de ventilatieluiken in het kozijn (rechts en links naast raam)?

- De grendels voor de ventilatieluiken zijn lastig bereikbaar en bedienbaar
- Ik kan niet bij de grendels van de ventilatieluiken
- De grendels voor de ventilatieluiken zijn goed bereikbaar en eenvoudig bedienbaar
- Anders, namelijk .....

Deel 3: Hoe gebruikt u de woning, de installatie en de voorzieningen
(meer antwoorden zijn mogelijk)

3.a Wat doet u wanneer u het in de woonkamer te koel vindt?

- Ik zet de radiatorknop in de woonkamer op stand 4 of 5
- Ik sluit de ramen en de ventilatieluiken
- Ik zet het ventilatiesysteem op stand 1
- Anders, namelijk .....

3.b Wat doet u wanneer u het in de slaapkamer te koel vindt?

- Ik zet de slaapkamerdeur open en de radiator in de entree en de badkamer op 4 of 5
- Ik sluit de ramen en de ventilatieluiken
- Ik zet het ventilatiesysteem op stand 1
- Ik plaats een elektrische bijverwarming
- Anders, namelijk .....

3.c. Hoe vaak gebruikt u de genoemde radiatoren gedurende de winter?

	elke dag	bijna elke dag	zo nu en dan	bijna nooit	nooit
radiator in de woonkamer	0	0	0	0	0
radiator in de gang 1e verdieping	0	0	0	0	0
radiator in de badkamer	0	0	0	0	0
radiator op zolder (bij 3 laags)	0	0	0	0	0

3.d Op welke stand heeft u de radiatorknop van de onderstaande radiatoren het merendeel van de tijd ingesteld?

	stand 1	stand 2	stand 3	stand 4	stand 5
radiator in de woonkamer	0	0	0	0	0

radiator in de gang 1e verdieping	0	0	0	0	0
radiator in de badkamer	0	0	0	0	0
radiator op zolder (bij 3 laags)	0	0	0	0	0

3.e Hoeveel personen zijn overdag en/of s'avonds gemiddeld aanwezig:

- Overdag (ca. 08.00 tot 18.00) : ..... personen aanwezig
- 's Avonds/'s nachts (ca. 18.00 tot 08.00) : ..... personen aanwezig
- Anders, namelijk .....

3.f Hoe ventileert u in de zomer?

	altijd	meestal	soms	bijna nooit	nooit
Ik zet het ventilatiesysteem op de hoogste stand	0	0	0	0	0
Tijdens het koken zet ik een raam op een kiertje	0	0	0	0	0
Tijdens het douchen laat ik de deur op een kier staan	0	0	0	0	0
Ik houd overdag de ramen dicht	0	0	0	0	0
Ik doe 's nachts de ventilatieluiken open	0	0	0	0	0

3.g Hoe ventileert u in de winter?

	altijd	meestal	soms	bijna nooit	nooit
Ik zet het ventilatiesysteem op de laagste stand	0	0	0	0	0
Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje	0	0	0	0	0
Tijdens het koken zet ik een raam op een kiertje	0	0	0	0	0
Tijdens het douchen laat ik de deur op een kiertje staan	0	0	0	0	0
Ik houd overdag de ramen dicht	0	0	0	0	0
Ik doe 's nachts de ventilatieluiken open	0	0	0	0	0

3.h Hoe gebruikt u de ventilatieluiken?

	altijd	meestal	soms	bijna nooit	nooit
Ik zet de luiken in de zomer overdag open	0	0	0	0	0
Ik doe de luiken dicht wanneer er niemand thuis is	0	0	0	0	0
Ik doe de luiken in de zomer overdag dicht wanneer het buiten warm is	0	0	0	0	0
Ik doe de luiken in de zomer 's nachts open en overdag dicht	0	0	0	0	0
Ik zet de luiken in de zomer en winter, overdag en 's nachts op een kiertje	0	0	0	0	0

3.i Hoe vaak opent u deuren en ramen om in de zomer aanvullend te ventileren?

	elke dag	bijna elke dag	zo nu en dan	bijna nooit	nooit
deur naar tuin	0	0	0	0	0
raam in keuken	0	0	0	0	0
ramen in slaapkamers	0	0	0	0	0

3.j Hoe vaak opent u deuren en ramen om in het stookseizoen aanvullend te ventileren?

	elke dag	bijna elke dag	zo nu en dan	bijna nooit	nooit
deur naar tuin	0	0	0	0	0
raam in keuken	0	0	0	0	0
ramen in slaapkamers	0	0	0	0	0

3.k De ventilatievoorziening heeft een drietal standen: 1 (laag), 2 (midden) en 3 (hoog). In welke stand heeft u de ventilatieregeling het vaakst staan in de onderstaande situaties?

	stand 1	stand 2	stand 3
's nachts	0	0	0
overdag (bewoner niet thuis)	0	0	0
overdag (bewoner wel thuis)	0	0	0
tijdens koken	0	0	0
tijdens douchen	0	0	0

3.l Heeft u de afgelopen zomer de temperatuur ingesteld/gecontroleerd waarbij de bypass van de ventilatievoorziening in werking gaat?

- Nee, volgens mij functioneerde de bypass wel prima
- Nee, ik weet niet hoe dat moet of wat dat is
- Ja, ik heb er naar gekeken
- Anders, namelijk .....

Deel 4: Ervaringen en waardering van de verwarming en temperatuur

Algemeen:

Hoe tevreden bent u over de behaaglijkheid in de.....? *Denk aan comfort, indirecte warmte toetreding door ligging t.o.v. zon*	zeer on-tevreden	onte-vreden	neu-traal	te-vreden	zeer te-vreden
woonkamer	0	0	0	0	0
slaapkamer(s)	0	0	0	0	0
keuken	0	0	0	0	0

Specifiek:

4.a Hoe ervaart u (gemiddeld) de binnentemperatuur in de zomer?

	te warm	warm	aan-genaam	fris	te koud
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0
op de 2e verdieping (indien aanwezig)	0	0	0	0	0

4.b Hoe ervaart u (gemiddeld) de binnentemperatuur in de winter?

	te warm	warm	aan-genaam	fris	te koud
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0
op de 2e verdieping (indien aanwezig)	0	0	0	0	0

4.c Zijn er wat u betreft genoeg radiatoren aanwezig om de woning te verwarmen?

- Ja
- Nee,
- Indien nee, waar zou u extra radiatoren willen hebben? .....

4.d Hoe waardeert u de opwarmsnelheid indien u het warmer wilt hebben?

	erg snel	snel	normaal	traag	te traag
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0
In de slaapkamers op de 2e verdieping (indien aanwezig)	0	0	0	0	0

Deel 5: Ervaringen en waardering van de ventilatie

Algemeen:

Heeft u last van....?	zeer veel	veel	neutraal	weinig	geen
vocht in uw woning	0	0	0	0	0
tocht in uw woning	0	0	0	0	0

Specifiek:

5.a Voelt u weleens tocht (terwijl u de ramen en deuren dicht hebt)?

	altijd	meestal	soms	bijna nooit	nooit
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0

op de 2e verdieping (indien aanwezig)	0	0	0	0	0

5.b Hoe ervaart u de temperatuur van de lucht die ingeblazen wordt in de zomer?

	te warm	warm	aan-genaam	fris	te koud
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0
op de 2e verdieping (indien aanwezig)	0	0	0	0	0

5.c Indien u bij 5.b 'te warm' hebt geantwoord; heeft u bij de balansventilatie installatie een temperatuur ingesteld (bijv. 18^{0}C) waarbij de bypass functie in werking treedt?

- o Ja
- o Nee
- o Nee, ik weet niet hoe ik dat moet doen
- o Anders namelijk.....

5.d Hoe ervaart u de temperatuur van de lucht die ingeblazen wordt in de winter?

	te warm	warm	aan-genaam	fris	te koud
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0
op de 2e verdieping (indien aanwezig)	0	0	0	0	0

5.e Hoe waardeert u de werking van het ventilatiesysteem?

	zeer tevreden	tevreden	neutraal	niet tevreden	Weet niet
ventilatie in de keuken tijdens het koken	0	0	0	0	0
geurverspreiding door de woning	0	0	0	0	0

geluid van het ventilatiesysteem in de keuken	0	0	0	0	0
ventilatie badkamer na het douchen	0	0	0	0	0
geluid van het ventilatiesysteem in de badkamer	0	0	0	0	0
ventilatie van het toilet	0	0	0	0	0
geluid van het ventilatiesysteem in de woonkamer	0	0	0	0	0
geluid van het ventilatiesysteem in de slaapkamer	0	0	0	0	0
bediening van het ventilatiesysteem	0	0	0	0	0
het onderhoud aan het ventilatiesysteem	0	0	0	0	0

5.f Hoe waardeert u de werking van de ventilatieluiken (de verticale luiken naast de ramen die 's nachts geopend kunnen worden als het overdag erg warm is geweest)?

	zeer tevreden	tevreden	neutraal	niet tevreden	weet niet
voor het zomers koel houden van de woonkamer	0	0	0	0	0
voor het zomers koel houden van de slaapkamers op de 1e verdieping	0	0	0	0	0
voor het zomers koel houden van de slaapkamer op de 2e verdieping (indien van toepassing)	0	0	0	0	0

5.g Hoe vaak hebt u het afgelopen jaar de filters van de warmte terugwin (wtw-) installatie vervangen/schoongemaakt?

- 0 keer
- 1 keer
- 2 keer
- Anders, namelijk ….

5.h Hoe ervaart u het vervangen/schoonmaken van deze filters?

- Erg vervelend om te doen
- Valt wel mee, hoort erbij
- Anders, namelijk ….

5.i Hoe ervaart u de bereikbaarheid van de filters? Is het makkelijk/moeilijk om de filters te vervangen?

- Ik kan de filter makkelijk vervangen
- Ik kan de filters niet zo gemakkelijk vervangen
- Anders, namelijk ….

Deel 6. Luchtvochtigheid, condensvorming en zon-/daglicht toetreding

6.a Hebt u wel eens condensvorming op de ramen? Merkt u wel eens dat de ramen beslaan of nat zijn?

	altijd	meestal	soms	bijna nooit	nooit
in de woonkamer	0	0	0	0	0
in de keuken	0	0	0	0	0
in de badkamer	0	0	0	0	0
in de slaapkamers op de 1e verdieping	0	0	0	0	0
op de 2e verdieping (indien aanwezig)	0	0	0	0	0

6.b Als condens optreedt, is dat dan storend?

- Ja
- Nee

6.c Als er condens op de ramen staat, waar bevindt het zich dan?

(meer antwoorden mogelijk)

- Binnen op het hele oppervlak
- Binnen, alleen op de randen
- Buiten op het hele oppervlak
- Buiten, alleen op de randen
- Anders, namelijk ….

6d. Hoe ervaart u het binnenkomende zonlicht in de woning?

- Ik vind de hoeveelheid zon die binnenkomt prima
- Er komt te veel zon binnen, waardoor het snel te warm is
- Anders, namelijk ….

Deel 7: De werking en uitleg van de diverse installaties

7a. Begrijpt u de werking van de verschillende voorzieningen?

	heel duidelijk	duidelijk	voldoende	on-voldoende	begrijp er niets van
ventilatie met warmte terugwinunit	0	0	0	0	0
de bypass op de warmte terugwinunit	0	0	0	0	0
de filters in het ventilatiesysteem	0	0	0	0	0
de luiken voor de zomernachtventilatie	0	0	0	0	0
de PV panelen	0	0	0	0	0

7b. Is de voorlichting/uitleg over het gebruik van de verwarming, de ventilatie en de ventilatieluiken duidelijk geweest voor u?

	heel duidelijk	duidelijk	voldoende	on-voldoende	begrijp er niets van
het warmer krijgen van de slaapkamers	0	0	0	0	0
ventilatiesysteem met standenschakelaar	0	0	0	0	0
de bypass op de warmte terugwinunit	0	0	0	0	0
vervangen van de filters in het ventilatiesysteem	0	0	0	0	0
bedienen van de luiken voor de zomernachtventilatie	0	0	0	0	0
gebruik van ramen voor ventilatie	0	0	0	0	0
de PV panelen en de verrekening met het energiebedrijf	0	0	0	0	0

Deel 8. Energiebesparing

8.a Denkt u dat u door de toegepaste maatregelen in deze woning energie bespaart?

- Ja

- Nee

8.b Zijn er energiebesparingsmaatregelen die u mist in uw woning?

- Nee
- Ja, namelijk .....

8.c Zijn er energiebesparingsmaatregelen in uw woning waarvan u zegt: 'die hadden ze beter niet toe kunnen passen'?

- Nee
- Ja, namelijk .....

Zou u in de toekomst willen meewerken aan een paneldiscussie met GoedeStede en huurders?

- Nee
- Ja, en dit is mijn e-mailadres .....

Bedankt voor het invullen van de enquête!

Als u nog opmerkingen heeft op de woning die niet naar voren zijn gekomen in deze enquête, dan kunt u die hierna vermelden:

APPENDIX E2 Own Survey

ONDERZOEK ENERGIEGEDRAG ENERGIEZUINIGE WONINGEN

1. Inleiding

Lees dit eerst!
Deze vragenlijst gaat erover hoe u over energiebesparing denkt en wat het energiegebruik van uw woning is. Deze vragenlijst maakt deel uit van een grootschalig onderzoek aan de TU Delft. Het onderzoek gaat over de invloed van de bewoner op het energiegebruik van moderne energiezuinige woningen.

Zoals u weet woont u in een bijzondere woning, namelijk een passieve woning. Dit soort woningen op grote schaal zijn momenteel nog uniek in Nederland maar zullen in de toekomst verplicht gebouwd moeten worden. Wij willen graag van dit gerealiseerde project leren, zodat we de woningen nog beter kunnen ontwerpen en de productie van dit soort woningen kunnen stimuleren.

Het invullen van deze vragenlijst duurt ongeveer 30 minuten. Sommige vragen kunnen moeilijk zijn en soms lijken vragen op elkaar. Toch willen we u vragen alle vragen te beantwoorden om een goede analyse van de resultaten te kunnen maken. Voor het onderzoek is het daarnaast het beste dat u de vragen zo eerlijk mogelijk beantwoordt. Alle gegevens zullen vertrouwelijk behandeld worden.

Gebruik bij het invullen een *donkere pen* (blauw of zwart). Kruis steeds maar één antwoord aan. Wanneer u meerdere antwoorden mag aankruisen, staat dit bij de vraag vermeld. **Indien u uw antwoord wilt veranderen**, streep dan het oude (foute) antwoord door en kruis het nieuwe antwoord aan. Eventueel kunt u voor het nieuwe antwoord nog een pijltje zetten.

Heeft u een huishouden van meerdere personen, dan verzoeken wij de vragenlijst te laten invullen door degene die het binnenklimaat het meest bepaalt. *(denk aan ramen openen, ventilatie en verwarming regelen)*

Om het u zo makkelijk mogelijk te maken kunt u de vragenlijst ook online invullen door de onderstaande link in uw internetbrowser in te typen:

https://bouwkunde.collector-survey.tudelft.nl/nq.cfm?q=A0BC8317-B08E-429F-B00C-91CD7CE097FD

Onder de deelnemers aan dit onderzoek zullen ook **3 cadeaubonnen** ter waarde van € 20,- worden verloot. Indien u kans wilt maken op deze prijs, vul dan in het vak dat bestemd is voor opmerkingen uw e-mailadres in. Alleen volledig ingevulde vragenlijsten dingen mee naar deze tegoedbonnen.

Als u tot slot vragen heeft, dan kunt u mij e-mailen (A.Cowan@student.tudelft.nl) of bellen (06-83163609).

Alvast hartelijk dank voor uw medewerking!

Anne Cowan

Student
TU Delft, Faculteit Bouwkunde,Bouwtechnologie bouwkunde, Klimaatontwerp

Dr. ir. Martin Tenpierik

Universitair docent
TU Delft, Faculteit

2. Algemeen

Wat is uw adres? …… *(Straatnaam, huisnummer)*

Wat is uw geslacht?

☐ Man
☐ Vrouw

Wat is uw leeftijd? ……. Jaar

Wat is uw nationaliteit? …….

Wat is uw hoogst voltooide opleiding?

☐ Geen onderwijs / basisonderwijs / lagere school
☐ LBO / VBO / VMBO (kader- en beroepsgerichte leerweg)
☐ MAVO / VMBO (theoretische en gemengde leerweg)
☐ MBO
☐ HAVO / VWO / WO-propedeuse
☐ HBO / WO-bachelor of kandidaats
☐ WO-doctoraal of master
☐ Anders, namelijk ……

Uit hoeveel personen bestaat uw huishouden?

Aantal volwassenen: ……. Aantal kinderen: …….

Wat is uw voornaamste dagelijkse bezigheid?

☐ Betaald werk, namelijk ……
☐ Onbetaald werk buitenshuis
☐ Huishouden / verzorging gezinsleden
☐ Deels (betaald of onbetaald) werk en deels huishouden
☐ Opleiding
☐ Anders, namelijk ……

Wanneer bent ingetrokken in de woning (maand/jaar)?

……/…….

Wat waren de belangrijkste redenen voor de keuze voor uw woning?

	Zeer onbelangrijk	Onbelangrijk	Neutraal	Belangrijk	Zeer belangrijk
De grootte van de woning	☐	☐	☐	☐	☐
De hoogte van de huur	☐	☐	☐	☐	☐
Lage energiekosten	☐	☐	☐	☐	☐
Prettige woonomgeving	☐	☐	☐	☐	☐
U wilde graag in een passiefhuis wonen	☐	☐	☐	☐	☐
U had dringend een woning nodig	☐	☐	☐	☐	☐
Dicht bij werk	☐	☐	☐	☐	☐
U had weinig alternatieven	☐	☐	☐	☐	☐

Wat vindt u belangrijk aan uw woning?

	Zeer onbelangrijk	Onbelangrijk	Neutraal	Belangrijk	Zeer belangrijk
Milieuvriendelijk	☐	☐	☐	☐	☐
De lage energiekosten	☐	☐	☐	☐	☐

Een gezond binnenmilieu	☐	☐	☐	☐	☐
Veel ruimte	☐	☐	☐	☐	☐
De wijk	☐	☐	☐	☐	☐
De tuin	☐	☐	☐	☐	☐
Dat het een passiefhuis is	☐	☐	☐	☐	☐

Op welke dagdelen bent u door de week meestal thuis? *U kunt hier meerdere antwoorden aankruisen!*

☐ Ochtend ☐ Avond
☐ Middag ☐ nacht

Op welke dagdelen bent u in het weekend meestal thuis? *U kunt hier meerdere antwoorden aankruisen!*

☐ Ochtend ☐ Avond
☐ Middag ☐ nacht

Hoeveel weken gaat u per jaar op vakantie?

☐ Ik ga niet op vakantie ☐ 3 of 4 weken
☐ 1 of 2 weken ☐ Langer dan 4 weken

Hoeveel contact heeft u met buurtbewoners?

☐ Geen ☐ Redelijk veel
☐ Een beetje ☐ Zeer veel

In wat voor soort woning woonde u voor deze woning?

☐ Portiekwoning / flat / appartement ☐ Eengezinshuis - twee onder een kap
☐ Eengezinshuis/rijwoning - tussenwoning ☐ Vrijstaand eengezinshuis
☐ Eengezinshuis/rijwoning - hoekwoning ☐ Anders, namelijk ……

In welke bouwperiode is uw vorige woning gebouwd?

☐ Voor 1900 ☐ 1960-1980
☐ 1900 - 1920 ☐ 1990-2005
☐ 1930 - 1950 ☐ Na 2005

Bent u van plan voorlopig in uw huidige woning te blijven wonen?

☐ Ja ☐ Nee maar ik heb nog geen verhuisplannen
☐ Misschien ☐ Nee en ik heb al verhuisplannen

3. COMFORT

a. zomer

Hoe ervaart u de temperatuur in de zomer?

	Veel te koud	Beetje te koud	Prima	Beetje te warm	Veel te warm
In de woonkamer	☐	☐	☐	☐	☐
In de keuken	☐	☐	☐	☐	☐
In de badkamer	☐	☐	☐	☐	☐
In de slaapkamers	☐	☐	☐	☐	☐

Zou u in de zomer graag een andere temperatuur wensen?

	Veel kouder	Beetje koeler	Geen verandering	Beetje warmer	Veel warmer
In de woonkamer	☐	☐	☐	☐	☐
In de keuken	☐	☐	☐	☐	☐
In de badkamer	☐	☐	☐	☐	☐
In de slaapkamers	☐	☐	☐	☐	☐

Hoe ervaart u de temperatuur van de lucht die ingeblazen wordt via de ventilatie in de zomer?

	Te warm	Warm	Aangenaam	Fris	Te koud
In de woonkamer	☐	☐	☐	☐	☐
In de keuken	☐	☐	☐	☐	☐
In de badkamer	☐	☐	☐	☐	☐
In de slaapkamers	☐	☐	☐	☐	☐

Hoe ventileert u in de zomer?

	Altijd	Meestal	Soms	Bijna nooit	Nooit
Ik zet het ventilatiesysteem op de laagste stand	☐	☐	☐	☐	☐
Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje	☐	☐	☐	☐	☐
Tijdens het douchen laat ik de deur op een kier staan	☐	☐	☐	☐	☐
Ik houd overdag de ramen dicht	☐	☐	☐	☐	☐
Ik doe 's nachts de ventilatieluiken open	☐	☐	☐	☐	☐

Hoe vaak opent u deuren en ramen om in de zomer aanvullend te ventileren?

	Elke dag	Bijna elke dag	Zo nu en dan	Bijna nooit	Nooit
Deur naar tuin	☐	☐	☐	☐	☐
Raam in keuken	☐	☐	☐	☐	☐
Ramen in slaapkamers	☐	☐	☐	☐	☐

Wat doet u wanneer u het in de woonkamer te warm vindt? *(meerdere antwoorden mogelijk)*

- ☐ Niks, woonkamer is nooit te warm
- ☐ Ik open de ramen en de ventilatieluiken
- ☐ Ik plaats een extra ventilator
- ☐ Ik plaats een losse airconditioning
- ☐ Anders, namelijk……..

Wat doet u wanneer u het in de slaapkamer te warm vindt? *(meerdere antwoorden mogelijk)*

- ☐ Niks, slaapkamer is nooit te warm
- ☐ Ik open de ramen en de ventilatieluiken
- ☐ Ik plaats een extra ventilator
- ☐ Ik plaats een losse airconditioning
- ☐ Anders, namelijk……..

b. *Winter*

Hoe ervaart u de temperatuur in de winter

	Veel te koud	Beetje te koud	Prima	Beetje te warm	Veel te warm
In de woonkamer	☐	☐	☐	☐	☐
In de keuken	☐	☐	☐	☐	☐
In de badkamer	☐	☐	☐	☐	☐
In de slaapkamers	☐	☐	☐	☐	☐

Zou u in de winter graag een andere temperatuur wensen?

	Veel kouder	Beetje koeler	Geen verandering	Beetje warmer	Veel warmer
In de woonkamer	☐	☐	☐	☐	☐
In de keuken	☐	☐	☐	☐	☐
In de badkamer	☐	☐	☐	☐	☐
In de slaapkamers	☐	☐	☐	☐	☐

Zijn er wat u betreft genoeg radiatoren aanwezig om de woning te verwarmen?

☐ Ja
☐ Nee
☐ Indien nee, waar zou u een extra radiator willen?.....

Hoe ervaart u de temperatuur van de lucht die ingeblazen wordt via de ventilatie in de winter?

	Te warm	Warm	Aangenaam	Fris	Te koud
In de woonkamer	☐	☐	☐	☐	☐
In de keuken	☐	☐	☐	☐	☐
In de badkamer	☐	☐	☐	☐	☐
In de slaapkamers	☐	☐	☐	☐	☐

Wat doet u wanneer u het in de woonkamer te koel vindt? *(meerdere antwoorden mogelijk)*

☐ Ik zet de radiatorknop in de woonkamer hoger
☐ Niks, ik trek dikkere kleding aan
☐ Ik sluit de ramen en de ventilatieluiken
☐ Ik zet het ventilatiesysteem op stand 1
☐ Anders, namelijk……..

Wat doet u wanneer u het in de slaapkamer te koel vindt? *(meerdere antwoorden mogelijk)*

☐ Ik zet de slaapkamer deur open en de radiator in de entree en de badkamer hoger
☐ Ik sluit de ramen en de ventilatieluiken
☐ Ik zet het ventilatiesysteem op stand 1
☐ Ik plaats een elektrische bijverwarming
☐ Anders, namelijk……..

Hoe ventileert u in de winter?

	Altijd	Meestal	Soms	Bijna nooit	Nooit
Ik zet het ventilatiesysteem op de hoogste stand	☐	☐	☐	☐	☐
Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje	☐	☐	☐	☐	☐
Tijdens het douchen laat ik de deur op een kier staan	☐	☐	☐	☐	☐
Ik houd overdag de ramen dicht	☐	☐	☐	☐	☐
Ik doe 's nachts de ventilatieluiken open	☐	☐	☐	☐	☐

Hoe vaak opent u deuren en ramen om in de winter aanvullend te ventileren

	Elke dag	Bijna elke dag	Zo nu en dan	Bijna nooit	Nooit
Deur naar tuin	☐	☐	☐	☐	☐
Raam in keuken	☐	☐	☐	☐	☐
Ramen in slaapkamers	☐	☐	☐	☐	☐

Hoe gebruikt u de ventilatieluiken?

	Altijd	Meestal	Soms	Bijna nooit	Nooit
Ik zet de luiken in de zomer overdag open	☐	☐	☐	☐	☐
Ik doe de luiken dicht wanneer er niemand thuis is	☐	☐	☐	☐	☐
Ik doe de luiken in de zomer overdag dicht wanneer het buiten warm is	☐	☐	☐	☐	☐
Ik doe de luiken in de zomer 's nachts open en overdag dicht	☐	☐	☐	☐	☐
Ik zet de luiken in de zomer en winter, overdag en 's nachts op een kiertje	☐	☐	☐	☐	☐

4. TEVREDENHEID

Hoe tevreden bent u over….? (*Denk daarbij aan bedieningsgemak, capaciteit, comfort, etc..)*

	Zeer ontevreden	Ontevreden	Neutraal	Tevreden	Zeer tevreden
Het systeem voor het opwekken van warmte voor warm tapwater (stadwarmte)	☐	☐	☐	☐	☐
Het warmte-opwekkingsapparaat (stadswarmte)	☐	☐	☐	☐	☐
Het warmte-afgifte-systeem (radiatoren)	☐	☐	☐	☐	☐
Temperatuurregeling	☐	☐	☐	☐	☐

Hoe tevreden bent u over het ventilatiesysteem?

	Zeer ontevreden	Ontevreden	Neutraal	Tevreden	Zeer tevreden
Bedieningsgemak	☐	☐	☐	☐	☐
Capaciteit	☐	☐	☐	☐	☐
Comfort (bijvoorbeeld tocht)	☐	☐	☐	☐	☐

Onderhoud	☐	☐	☐	☐
Geluid	☐	☐	☐	☐

Bent u het eens of oneens met de volgende uitspraken:

	Helemaal oneens	Oneens	Neutraal	Eens	Helemaal eens
Ik woon prettig in mijn woning	☐	☐	☐	☐	☐
Ik voel mij veilig in mijn woning	☐	☐	☐	☐	☐
Ik weet hoe ik de aanwezige klimaatinstallaties moet bedienen	☐	☐	☐	☐	☐
Ik vind het eng om de aanwezige installaties te bedienen	☐	☐	☐	☐	☐

5. Energiegedrag

Wat vindt u van uw eigen energierekening?

☐ Zeer laag
☐ Laag
☐ Niet laag / Niet hoog
☐ Hoog
☐ Zeer hoog
☐ Weet ik niet

Hoeveel doet u thuis aan energiebesparing?

☐ Zeer veel
☐ Veel
☐ Een beetje
☐ Weinig
☐ Niets

☐ **Denkt u dat u nog meer energie zou kunnen besparen dan u nu doet?**

☐ Ja, heel veel meer
☐ Ja, veel meer
☐ Ja, een beetje
☐ Ja, maar weinig
☐ Nee, niets

Als u uzelf vergelijkt met mensen uit uw omgeving, doet u dan meer of minder aan energiebesparing?

☐ Veel meer dan anderen
☐ Iets meer dan anderen
☐ Ongeveer even veel als anderen
☐ Iets minder dan anderen
☐ Veel minder dan anderen

Wat doet u zoal om energie te besparen?

	Nooit	Zelden	Soms	Vaak	Altijd
• De stekker van huishoudelijke apparaten uit het stopcontact halen wanneer deze niet in gebruik zijn.	☐	☐	☐	☐	☐
• In huis de deuren zo veel mogelijk dicht houden.	☐	☐	☐	☐	☐
• Wassen op lage temperaturen.	☐	☐	☐	☐	☐
• Zo kort mogelijk douchen	☐	☐	☐	☐	☐
• De verwarming uit zetten in kamers waar niemand is.	☐	☐	☐	☐	☐
• De verwarming een uur voordat u gaat slapen uitzetten.	☐	☐	☐	☐	☐
• De lichten uit doen in kamers waar niemand is.	☐	☐	☐	☐	☐
• Ingevroren voedsel ontdooien in de koelkast.	☐	☐	☐	☐	☐

• Alleen afgekoelde etenswaren in de koelkast zetten.	☐	☐	☐	☐	☐
• Gordijnen sluiten om de warmte binnen te houden	☐	☐	☐	☐	☐
• De thermosstaat uitzetten wanneer u op vakantie gaat.	☐	☐	☐	☐	☐

Gebruikt u spaarlampen?

☐ Ja, overal in huis ☐ Ja, maar niet overal in huis ☐ Nee

Heeft u een waterbesparende douchekop?

☐ Ja ☐ Nee ☐ Weet ik niet

Let u op het energieverbruik bij de aanschaf van (huishoudelijke) apparaten?

☐ Altijd ☐ Bijna nooit
☐ Bijna altijd ☐ Nooit
☐ Soms

Wat is meestal ongeveer de temperatuur in uw slaapkamer in de winter overdag?

☐ < 16 °C ☐ 20 – 22 °C
☐ 16 – 18 °C ☐ > 22 °C
☐ 18 – 20 °C

Wat is meestal ongeveer de temperatuur in uw woonkamer in de winter overdag?

☐ < 18 °C ☐ 22 – 24 °C
☐ 18 – 20 °C ☐ > 24 °C
☐ 20 – 22 °C

Welke stelling is het meest op u van toepassing? Ik ben van plan om in de toekomst…

☐ Zeer zeker energie te besparen ☐ Waarschijnlijk geen energie te besparen
☐ Zeker energie te besparen ☐ Zeer zeker geen energie te besparen
☐ Misschien energie te besparen

Hoe energiezuinig denkt u dat uw woning is?

☐ Heel zuinig ☐ Niet zo zuinig
☐ Vrij zuinig ☐ Helemaal niet zuinig
☐ Niet zuinig / Niet onzuinig ☐ Weet ik echt niet

Weet u uit uw hoofd hoeveel stroom (in kWh) u ongeveer verbruikt per jaar?

☐ Ja ☐ Twijfel ☐ Nee

Weet u uit uw hoofd hoeveel stroom (ongeveer) kost per kWh?

☐ Ja ☐ Twijfel ☐ Nee

Weet u uit uw hoofd hoeveel warmte (in GigaJoule, GJ) u ongeveer verbruikt per jaar?

☐ Ja ☐ Twijfel ☐ Nee

Weet u uit uw hoofd hoeveel warmte (ongeveer) kost per GigaJoule (GJ)?

☐ Ja ☐ Twijfel ☐ Nee

Weet u uit uw hoofd hoe hoog uw energierekening is (stroom en warmte)?

☐ Ja, precies ☐ Ja, ongeveer ☐ Nee

Hoeveel betaalt u (ongeveer) aan energie (stroom en warmte) per maand?

€ ……. per maand

Geef aan of de volgende stellingen volgens u juist of onjuist zijn.

Als u het antwoord niet weet kunt u 'Weet ik niet' aankruisen.	Juist	Onjuist	Weet ik niet
• Een spaarlamp gaat over het algemeen langer mee dan een gloeilamp.	☐	☐	☐
• Een plasmatelevisie verbruikt minder energie dan een gewone televisie.	☐	☐	☐
• Wassen op 90 °C kost ongeveer drie keer zo veel energie als wassen op 40 °C.	☐	☐	☐
• Als je overdag de thermostaat 1 graad lager zet, kun je €50,- per jaar besparen.	☐	☐	☐
• Apparaten met een B-label zijn zuiniger dan apparaten met een A-label.	☐	☐	☐
• Een telefoonoplader in het stopcontact verbruikt alleen stroom tijdens het opladen van de telefoon.	☐	☐	☐
• Een waterbesparende douchekop kan per jaar voor een besparing van meer dan €50,- zorgen.	☐	☐	☐
• Een bypass van de ventilatie installatie zorgt voor extra koeling in de zomer	☐	☐	☐
• Water koken in een waterkoker verbruikt minder energie dan water koken op het gasfornuis.	☐	☐	☐

Bent u het eens of oneens met de volgende uitspraken:

	Helemaal oneens	Oneens	Neutraal	Eens	Helemaal eens
• Energiebesparing vind ik teveel gedoe.	☐	☐	☐	☐	☐
• Energiebesparing vind ik moeilijk.	☐	☐	☐	☐	☐
• Energiebesparing kost mij teveel tijd.	☐	☐	☐	☐	☐
• Ik kan een bijdrage leveren aan een beter milieu door zuinig om te gaan met energie.	☐	☐	☐	☐	☐
• Ik kan geld besparen door zuinig om te gaan met energie.	☐	☐	☐	☐	☐
• Als ik energie bespaar gaat dat ten koste van het comfort in huis.	☐	☐	☐	☐	☐
• Als ik energie bespaar voel ik mij goed.	☐	☐	☐	☐	☐
• Als ik energie bespaar wordt dat door de mensen in mijn omgeving gewaardeerd.	☐	☐	☐	☐	☐
• Als ik energie bespaar kost dat mij meer geld dan het	☐	☐	☐	☐	☐

oplevert.

- Als ik energie bespaar ben ik tevreden over mijzelf. ☐ ☐ ☐ ☐ ☐
- Een beter milieu begint bij mijzelf. ☐ ☐ ☐ ☐ ☐

Geef aan of het u makkelijk of moeilijk lijkt om energie te besparen in de volgende situaties:

	Heel makkelijk	Redelijk makkelijk	Neutraal	Redelijk moeilijk	Heel moeilijk
• Als u de enige in het gezin bent die bespaart.	☐	☐	☐	☐	☐
• Als u direct kunt zien dat u energie bespaart.	☐	☐	☐	☐	☐
• Als u het druk hebt.	☐	☐	☐	☐	☐
• Als uw buren ook besparen.	☐	☐	☐	☐	☐
• Als u niet zo veel geld hebt.	☐	☐	☐	☐	☐
• Als u meer zou weten over energiebesparing.	☐	☐	☐	☐	☐
• Als u samen met anderen zou besparen.	☐	☐	☐	☐	☐
• Als u daarvoor eerst geld moet investeren.	☐	☐	☐	☐	☐
• Als u begeleid zou worden.	☐	☐	☐	☐	☐
• Als u voor uw besparing beloond zou worden door bijv. de gemeente.	☐	☐	☐	☐	☐
• Als u persoonlijk tips zou krijgen.	☐	☐	☐	☐	☐

Als het gaat over energiegebruik en / of energiebesparing, hoe belangrijk vindt u dan de mening van …

	Niet Belangrijk	Beetje belangrijk	Redelijk belangrijk	Heel belangrijk
Gezinsleden	☐	☐	☐	☐
Buurtbewoners	☐	☐	☐	☐
Familie/vrienden/kennissen	☐	☐	☐	☐
Collega's	☐	☐	☐	☐
Medewerkers van het energiebedrijf	☐	☐	☐	☐
Medewerkers van de woningcorporatie	☐	☐	☐	☐

Met wie praat u wel eens over energiegebruik of energiebesparing?

	Nooit	Zelden	Soms	Vaak
Gezinsleden	☐	☐	☐	☐
Buurtbewoners	☐	☐	☐	☐
Familie/vrienden/kennissen	☐	☐	☐	☐
Collega's	☐	☐	☐	☐
Medewerkers van het energiebedrijf	☐	☐	☐	☐
Medewerkers van de gemeente	☐	☐	☐	☐
Medewerkers van de woningcorporatie	☐	☐	☐	☐

6. Daadwerkelijk energiegebruik

Hoeveel stroom heeft u verbruikt per maand in 2011 en 2012?

Neem de getallen over van uw energie eindafrekening indien u die nog tot uw beschikking heeft.

	2011	2012
Totaal	……. kWh	……. kWh

Hoeveel GigaJoule (GJ) aan warmte heeft u verbruikt per maand in 2011 en 2012?

Neem de getallen over van uw energie eindafrekening indien u die nog tot uw beschikking heeft.

	2011	2012
Totaal	……. GJ	……. GJ

Indien u niet (meer) beschikt over gedetailleerde informatie over uw energiegebruik van de afgelopen jaren (2 vragen hiervoor), bent u bereid om de onderzoeker een machtiging te geven om deze informatie op te vragen bij uw energiemaatschappij?

☐ Ja; mijn energiemaatschappij was

in 2011 ……

in 2012 ……

Vul ook het bijgevoegd machtigingsformulier in.

☐ Nee

Slot

In vervolg op deze vragenlijst zullen vier woningen gedurende een paar weken worden gemonitord. Dit houdt in dat de thermische kwaliteit van de gevels worden onderzocht en gedurende een paar weken de temperatuur, de luchtvochtigheid, licht aan/uit, aanwezigheid, etc worden gemeten in diverse kamers.

Bent u bereid om uw woning gedurende een paar weken te laten onderzoeken?

☐ Ja *Vul ook uw e-mailadres in bij de volgende vraag.*

☐ Nee

Indien u tot slot nog opmerkingen heeft, vul deze dan hieronder in. Vul ook hier uw e-mailadres in

indien u wilt meedingen voor een van de drie **VVV-bonnen van € 20,-.**

e-mailadres:.....

Hartelijk dank voor uw tijd en medewerking!

APPENDIX F Results own survey

	Adress	vraag	code	vraag	vraag	vraag	code	vraag	volwassen	kind	vraag	code	open
1		Wat is uw geslacht?		Wat is uw leeftijd	Wat is uw nationaliteit	Wat is uw hoogst voltooide opleiding		Uit hoeveel personen bestaat uw huishouden?			Wat is uw voornaamste dagelijke bezigheid?		
	A	2 man	1	3 35	4 NL	5 HBO / WO-bachelor of kandidaats	5	6 3	2	1	7 Betaald werk, namelijk	0	*ICT consultant*
	B	man	1	43	NL	HBO / WO-bachelor of kandidaats	5	1	1	0	Betaald werk, namelijk	0	*Tech support In*
	C	man	1	41	NL	MBO	3	1	1	0	Anders	5	*werkloos*
	D	man	1	49	NL	LBO / VBO / VMBO (kader- en beroepsgerichte leerweg)	1	4	2	2	Betaald werk, namelijk	0	*Uitvoerder/bou*
	E	vrouw	0	40	NL	HBO / WO-bachelor of kandidaats	5	3	3	0	Deels (betaald of onbetaald) werk en deels huishouden	3	
	F	man	1	32	NL	MBO	3	3	2	1	Betaald werk, namelijk	0	*sales*
	G	vrouw	0	39	NL	MBO	3	3	1	2	Betaald werk, namelijk	0	*administratief m*
	H	man	1	25	NL	MBO	3	3	2	1	Opleiding	4	
	I	man	1	39	NL	MBO	3	3	2	1	Betaald werk, namelijk	0	*verkoopbinnend*
	J	vrouw	0	31	NL	MBO	3	3	1	2	Huishouden / verzorging gezinsleden	2	
	K	vrouw	0	45	NL	MAVO / VMBO (theoretische en gemengde leerweg	2	3	1	2	Betaald werk, namelijk	0	*kantoor*
	L	vrouw	0	65	NL	Anders, Mulo	7	1	1	0	Anders	5	*gepensioneerd*
	M	vrouw	0	43	NL	HAVO / VWO / WO-propedeuse	4	2	2	0	Betaald werk, namelijk	0	*rijlessen*
	N	vrouw	0	35	NL	MAVO / VMBO (theoretische en gemengde leerweg	2	2	1	1	Betaald werk, namelijk	0	*horeca*
	O	vrouw	0	46	NL	HAVO / VWO / WO-propedeuse	4	2	2	0	Betaald werk, namelijk	0	*verpleegkundige*

1 man
0 vrouw

GEMIDDELDE
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0 Geen onderwijs / basisonderwijs / lagere school
1 LBO / VBO / VMBO (kader- en beroepsgerichte leerweg)
2 MAVO / VMBO (theoretische en gemengde leerweg
3 MBO
4 HAVO / VWO / WO-propedeuse
5 HBO / WO-bachelor of kandidaats
6 WO-doctoraal of master
7 Anders, namelijk

0 Betaald werk, namelijk
1 Onbetaald werk buitenshuis
2 Huishouden / verzorging gezinsleden
3 Deels (betaald of onbetaald) werk en deels huishouden
4 Opleiding
5 Anders, namelijk

	vraag	vraag	De grootte van de woning	De hoogte van de huur	Lage energiekosten	Prettige woonomgeving	Bereikbaarheid open baar vervoer	U wilde graag in een passiefhuis wonen	U had dringend een woning nodig	Dicht bij werk	U had weinig alternatieven	Anders, namelijk	vraag	Milieuvriendelijk	de lage energiekosten	een gezond binnenmilieu	veel ruimte	de wijk	de tuin	dat het een passiefhuis is
8	Wanneer bent u ingetrokken in de woning (maand/jaar)?	Wat waren de belangrijkste redenen voor de keuze van uw woning?											10 Wat vindt u belangrijk aan uw woning?							
	05/2011	9	Belangrijk 4	Neutraal 3	Belangrijk 4	Neutraal 3	Neutraal 3	Neutraal 3	Neutraal 3	Neutraal 3	Neutraal 3	//		Neutraal 3	Belangrijk 4	Belangrijk 4	Belangrijk 4	Neutraal 3	Belangrijk 4	Neutraal 3
	08/2011		Belangrijk 4	Belangrijk 4	Zeer belangri 5	Neutraal 3	Neutraal 3	Zeer onbelangrijk 1	Belangrijk 4	Zeer belangrijk 5	Neutraal 3	Belangrijk 4 //		Belangrijk 4	Zeer belangrijk 5	Zeer belangrijk 5	Belangrijk 4	Belangrijk 4	Neutraal 4	Neutraal 3
	09/2010		Belangrijk 4	Belangrijk 4	Neutraal 3	Neutraal 3	Neutraal 3	Neutraal 3	Zeer belangrijk 5	Neutraal 3	Belangrijk 4	Zeer onbelangrijk 1 //		Neutraal 3	Neutraal 3	Neutraal 3	Belangrijk 4	Belangrijk 4	Neutraal 3	Neutraal 3
	00/2010		Belangrijk 4	Belangrijk 4	Zeer belangri 5	Belangrijk 4	Neutraal 3	Belangrijk 4	Belangrijk 4	Neutraal 3	Onbelangrijk 2	Zeer onbelangrijk 1 //		Belangrijk 4	Zeer belangrijk 5	Zeer belangrijk 5	Neutraal 3	Neutraal 3	Neutraal 3	Belangrijk 4
	09/2010		Belangrijk 4	Neutraal 3	Belangrijk 4	Belangrijk 4	Belangrijk 4	Zeer belangrijk 5	Zeer onbelangrijk 1	Onbelangrijk 2	Zeer onbelangrijk 1	Zeer onbelangrijk 1 //		Zeer belangri 5	Belangrijk 4	Zeer belangrijk 5	Belangrijk 4	Zeer onbelangrijk 1	Zeer belangrijk 5	Zeer belangrijk 5
	08/2010		Neutraal 3	Belangrijk 4	Neutraal 3	Belangrijk 4	Neutraal 3	Neutraal 3	Zeer belangrijk 5	Onbelangrijk 2	Neutraal 3	Neutraal 3 centrale locatie		Belangrijk 4	Belangrijk 4	Neutraal 3	Neutraal 3	Neutraal 3	Belangrijk 4	Belangrijk 4
	06/2010		Belangrijk 4	Belangrijk 4	Belangrijk 4	Zeer belangri 5	Belangrijk 4	Neutraal 3	Neutraal 3	Belangrijk 4	Neutraal 3	Belangrijk 4 groter wonen		Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Neutraal 3
	03/2013		Zeer belangri 5	Neutraal 3	Neutraal 3	Belangrijk 4	Neutraal 3	Onbelangrijk 2	Belangrijk 4	Neutraal 3	Belangrijk 4	Zeer belangrijk 5 verkregen middels won		Belangrijk 4	Neutraal 3	Neutraal 3	Zeer belangrijk 5	Belangrijk 4	Zeer belangrijk 5	Neutraal 3
	05/2010		Zeer belangri 5	Belangrijk 4	Belangrijk 4	Belangrijk 4	Onbelangrijk 2	Neutraal 3	Belangrijk 4	Neutraal 3	Neutraal 3	Neutraal 3 samenwonen		Neutraal 3	Neutraal 3	Belangrijk 4	Belangrijk 4	Belangrijk 4	Zeer belangrijk 5	Neutraal 3
	07/2012		Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4 //		Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4
	05/2010		Belangrijk 4	Belangrijk 4	Zeer belangri 5	Neutraal 3	Neutraal 3	Neutraal 3	Onbelangrijk 2	Onbelangrijk 2	Belangrijk 4	Nieuw huis		Belangrijk 4	Zeer belangrijk 5	Belangrijk 4	Belangrijk 4	Neutraal 3	Neutraal 3	Belangrijk 4
	07/2010		Belangrijk 4	Belangrijk 4	Belangrijk 4	Neutraal 3	Neutraal 3	Zeer onbelangrijk 1	Zeer belangrijk 5	Neutraal 3	Zeer belangrijk 5	Zeer belangrijk 5 wegens scheiding		Zeer onbelangri 1	Zeer belangrijk 5	Zeer onbelangrijk 1	Zeer belangrijk 5	Zeer onbelangrijk 1	Zeer belangrijk 5	Zeer onbelangrijk 1
	06/2010		Zeer belangri 5	Zeer belangri 5	Zeer belangri 5	Zeer belangri 5	Zeer belangri 5	Zeer belangrijk 5	Zeer belangrijk 5	Neutraal 3	Neutraal 3	Neutraal 3 //		Zeer belangri 5	Zeer belangrijk 5	Zeer belangrijk 5	Zeer belangrijk 5	Zeer belangrijk 5	Zeer belangrijk 5	Zeer belangrijk 5
	06/2010		Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Onbelangrijk 2	Onbelangrijk 2	Zeer belangrijk 5	Neutraal 3	Neutraal 3	Neutraal 3 //		Neutraal 3	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Belangrijk 4	Neutraal 3
	07/2010		Zeer belangri 5	Zeer belangri 5	Zeer belangri 5	Zeer belangri 5	Neutraal 3	Onbelangrijk 2	Zeer belangrijk 5	Neutraal 3	Zeer onbelangrijk 1	Zeer onbelangrijk 1 //		Zeer belangri 5	Zeer belangrijk 5	Zeer belangrijk 5	Zeer belangrijk 5	Belangrijk 4	Belangrijk 4	Neutraal 3

1 Zeer onbelangrijk
2 Onbelangrijk
3 Neutraal
4 Belangrijk
5 Zeer belangrijk

1 Zeer onbelangrijk
2 Onbelangrijk
3 Neutraal
4 Belangrijk
5 Zeer belangrijk

11 Op welke dagdelen bent u door de week meestal thuis?

vraag	ochtend		middag		avond		nacht	
	Nee	0	Nee	0	Ja	1	Ja	1
	Ja	1	Nee	0	Ja	1	Nee	0
	Nee	0	Ja	1	Ja	1	Ja	1
	Nee	0	Nee	0	Ja	1	Ja	1
	Nee	0	Ja	1	Ja	1	Ja	1
	Nee	0	Nee	0	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Nee	0	Nee	0	Nee	0	Ja	1
	Nee	0	Nee	0	Ja	1	Ja	1
	Nee	0	Ja	1	Ja	1	Ja	1
	Ja	1	Nee	0	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Nee	0	Nee	0	Ja	1	Nee	0
	Nee	0	Nee	0	Ja	1	Ja	1

1 Ja
0 Nee

12 Op welke dagdelen bent u in het weekend meestal thuis?

vraag	ochtend		middag		avond		nacht	
	Ja	1	Nee	0	Ja	1	Ja	1
	Ja	1	Nee	0	Ja	1	Nee	0
	Ja	1	Ja	1	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Ja	1	Ja	1	Nee	0	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Ja	1	Nee	0	Nee	0	Ja	1
	Nee	0	Ja	1	Ja	1	Ja	1
	Nee	0	Ja	1	Ja	1	Ja	1
	Ja	1	Nee	0	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Ja	1	Ja	1	Ja	1	Ja	1
	Nee	0	Nee	0	Ja	1	Nee	0
	Nee	0	Ja	1	Ja	1	Nee	0

1 Ja
0 Nee

13 Hoeveel weken gaat u per jaar op vakantie?

vraag	code
1 of 2 weken	1
1 of 2 weken	1
Ik ga niet op vakantie	0
3 of 4 weken	2
1 of 2 weken	1
3 of 4 weken	2
Ik ga niet op vakantie	0
Ik ga niet op vakantie	0
1 of 2 weken	1
1 of 2 weken	1
Ik ga niet op vakantie	0
1 of 2 weken	1
3 of 4 weken	2
1 of 2 weken	1
Langer dan 4 weken	3

0 Ik ga niet op vakantie
1 1 of 2 weken
2 3 of 4 weken
3 Langer dan 4 weken

14 Hoeveel contact heeft u met buurtbewoners?

vraag	code
Een beetje	1
Een beetje	1
Een beetje	1
Een beetje	1
Redelijk veel	2
Een beetje	1
Zeer veel	3
Een beetje	1
Een beetje	1
Een beetje	1
Een beetje	1
Een beetje	1
Een beetje	1
Een beetje	1
Redelijk veel	2

0 Geen
1 Een beetje
2 Redelijk veel
3 Zeer veel

15 In wat voor soort woning woonde u voor deze woning

vraag	code	anders
Eengezinshuis / rijwoning - tussenwoning	1	
Portiekwoning / flat / appartement	0	
Portiekwoning / flat / appartement	0	
Eengezinshuis / twee onder een kap	3	
Portiekwoning / flat / appartement	0	
Portiekwoning / flat / appartement	0	
Portiekwoning / flat / appartement	0	
Portiekwoning / flat / appartement	0	
Portiekwoning / flat / appartement	0	
Portiekwoning / flat / appartement	0	
Eengezinshuis / rijwoning - tussenwoning	1	
Anders, namelijk	5	seniorenwon
Eengezinshuis / rijwoning - tussenwoning	1	
Portiekwoning / flat / appartement	0	
Anders, namelijk	5	eengezinswo

1 Portiekwoning / flat / appartement
2 Eengezinshuis / rijwoning - tussenwoning
3 Eengezinshuis / rijwoning - hoekwoning
4 Eengezinshuis / twee onder een kap
4 Vrijstaande eengezinswoning
5 Anders, namelijk

16 In welke periode is uw vorige woning gebouwd?

vraag	code
1930-1950	3
1990-2005	5
Na 2005	6
1990-2005	5
1960-1980	4
1990-2005	5
1990-2005	5
Na 2005	6
1960-1980	4
1930-1950	3
1960-1980	4
1990-2005	5
1960-1980	4
1990-2005	5
1990-2005	5

1 Voor 1900
2 1900-1920
3 1930-1950
4 1960-1980
5 1990-2005
6 Na 2005

17 Bent u van plan voorlopig in uw huidige woning te blijven wonen?

vraag	code
Ja	0
Ja	0
Nee maar ik heb nog geen verhuisplannen	2
Ja	0
Nee maar ik heb nog geen verhuisplannen	2
Nee maar ik heb nog geen verhuisplannen	2
Ja	0
Ja	0
Ja	0
Ja	0
Ja	0
Ja	0
Ja	0
Ja	0
Ja	0

0 Ja
1 Misschien
2 Nee maar ik heb nog geen verhuisplannen
3 Nee en ik heb al verhuisplannen

18 Hoe ervaart u de temperatuur in de zomer

vraag	Woonkamer		Slaapkamer		Badkamer		Keuken	
	Prima	2	Prima	2	Beetje te warm	3	Prima	2
	Veel te warm	4	Beetje te wa	3	Prima	2	Veel te warm	4
	Prima	2	Prima	2	Prima	2	Prima	2
	Prima	2	Prima	2	Prima	2	Prima	2
	Prima	2	Veel te warm	4	Prima	2	Prima	2
	Prima	2	Beetje te wa	3	Prima	2	Prima	2
	Prima	2	Veel te warm	4	Prima	2	Prima	2
	Prima	2	Beetje te kou	1	Beetje te warm	3	Beetje te warm	3
	Beetje te wa	3	Beetje te wa	3	Prima	2	Beetje te warm	3
	Prima	2	Prima	2	Prima	2	Prima	2
	Beetje te wa	3	Prima	2	Prima	2	Prima	2
	Prima	2	Prima	2	Prima	2	Prima	2
	Prima	2	Prima	2	Prima	2	Prima	2
	Prima	2	Prima	2	Beetje te warm	3	Beetje te warm	3
	Beetje te wa	3	Prima	2	Prima	2	Prima	2

0 Veel te koud
1 Beetje te koud
2 Prima
3 Beetje te warm
4 Veel te warm

19 Zou u in uw woning in de zomer graag een andere temperatuur wensen?

vraag	Woonkamer		Slaapkamer		Badkamer		Keuken	
	Geen verandering	2	Geen verandering	2	Een beetje koeler	1	Geen verandering	2
	Een beetje warmer	3	Een beetje warmer	3	Geen verandering	2	Een beetje koeler	1
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
	Een beetje koeler	1	Een beetje koeler	1	Een beetje koeler	1	Een beetje koeler	1
	Een beetje koeler	1	Geen verandering	2	Geen verandering	2	Veel kouder	0
	Een beetje koeler	1	Een beetje koeler	1	Geen verandering	2	Een beetje koeler	1
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Veel kouder	0
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
	Een beetje koeler	1	Een beetje koeler	1	Geen verandering	2	Een beetje koeler	1
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Een beetje koeler	1
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
	Geen verandering	2	Geen verandering	2	Een beetje koeler	1	Een beetje koeler	1
	Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2

0 Veel kouder
1 Een beetje koeler
2 Geen verandering
3 Een beetje warmer
4 Veel warmer

20	vraag	Woonkamer		Slaapkamer		Badkamer		Keuken	
	Hoe ervaart u de temperatuur van de lucht die ingeblazen wordt via de ventilatie in de zomer?								
		Aangenaam	2	Aangenaam	2	Warm	1	Aangenaam	2
		Warm	1	Warm	1	Warm	1	Warm	1
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Te warm	0	Te warm	0	Te warm	0	Te warm	0
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Warm	1	Warm	1	Warm	1	Warm	1
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Te warm	0
		Aangenaam	2	Aangenaam	2		1	Aangenaam	2
		Warm	1	Warm	1	Aangenaam	2	Warm	1
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Aangenaam	2	Aangenaam	2	Warm	1	Warm	1
		Fris	3	Fris	3	Fris	3	Fris	3

0 Te warm
1 Warm
2 Aangenaam
3 Fris
4 Te koud

21	vraag	Ik zet het ventilatieaystaatem op de laagste stand		Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje		Tijdens het douchen laat ik de deur op een kier staan		Ik houd overdag de ramen dicht		Ik doe s nachts de ventilatieluiken open	
	Hoe ventileert u in de zomer										
		Bijna nooit	3		2	Bijna nooit	3	Bijna nooit	3	Soms	2
		Altijd	0	Altijd	0	Nooit	4	Meestal	1	Altijd	0
		Nooit	4	Meestal	1	Nooit	4	Soms	2	Altijd	0
		Nooit	4	Nooit	4	Nooit	4	Altijd	0	Bijna nooit	3
		Bijna nooit	3	Altijd	0	Altijd	0	Nooit	4	Altijd	0
		Bijna nooit	3	Soms	2	Bijna nooit	3	Soms	2	Soms	2
		Nooit	4	Meestal	1	Soms	2	Soms	2	Nooit	4
		Meestal	1	Meestal	1	Bijna nooit	3	Soms	2	Bijna nooit	3
		Meestal	1	Soms	2		2	Altijd	0	Meestal	1
		Meestal	1	Meestal	1	Meestal	1	Bijna nooit	3	Nooit	4
		Nooit	4	Soms	2	Nooit	4	Soms	2	Soms	2
		Nooit	4	Altijd	0	Nooit	4	Meestal	1	Bijna nooit	3
		Nooit	4	Soms	2	Nooit	4	Altijd	0	Bijna nooit	3
		Soms	2	Altijd	0	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3
		Nooit	4	Nooit	4	Soms	2	Meestal	1	Nooit	4

0 Altijd
1 Meestal
2 Soms
3 Bijna nooit
4 Nooit

22	vraag	Deur naar de tuin		Raam in de keuken		Ramen in de slaapkamers	
	Hoe vaak opent u deuren en ramen om in de zomer aanvullend te ventileren?						
		Bijna elke dag	1	Bijna elke dag	1	Bijna elke dag	1
		Bijna elke dag	1	3,Bijna nooit	3	Elke dag	0
		Bijna nooit	3	Bijna elke dag	1	Bijna elke dag	1
		Nooit	4	Nooit	4	Nooit	4
		Elke dag	0	Elke dag	0	Elke dag	0
		Bijna elke dag	1	Bijna elke dag	1	Bijna elke dag	1
		Bijna elke dag	1	Elke dag	0	Bijna elke dag	1
		Zo nu en dan	2	Zo nu en dan	2	Zo nu en dan	2
		Zo nu en dan	2	Zo nu en dan	2	Nooit	4
		Elke dag	0	Elke dag	0	Elke dag	0
		Bijna elke dag	1	Bijna elke dag	1	Bijna elke dag	1
		Bijna elke dag	1	Nooit	4	Elke dag	0
		Bijna nooit	3	Bijna nooit	3	Bijna nooit	3
		Elke dag	0	Elke dag	0	Elke dag	0
		Nooit	4		2	Nooit	4

0 Elke dag
1 Bijna elke dag
2 Zo nu en dan
3 Bijna nooit
4 4,Nooit

23	vraag	Nika, woonkamer is nooit te warm		Ik open de ramen en de ventilatieluiken		Ik plaats een extra ventilator		Ik plaats een losse airconditioning		Anders, namelijk	
	Wat doet u wanneer u het in de woonkamer te warm vindt?										
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
		Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Ja	1	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0

0 Nee
1 Ja

24	vraag	Nika, slaapkamer is nooit te warm		Ik open de ramen en de ventilatieluiken		Ik plaats een extra ventilator		Ik plaats een losse airconditioning		Anders, namelijk	
	Wat doet u wanneer u het in de slaapkamer te warm vindt?										
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
		Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Ja	1	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
		Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
		Nee	0	Ja	1	Nee	0	Nee	0	Nee	0

0 Nee
1 Ja

25	vraag	Woonkamer		Slaapkamer		Badkamer		Keuken	
	Hoe ervaart u de temperatuur in de winter								
		Beetje te koud	1	Beetje te koud	1	Prima	2	Beetje te koud	1
		Veel te koud	0	Veel te koud	0	Prima	2	Beetje te koud	1
		Prima	2	Prima	2	Prima	2	Beetje te koud	1
		Prima	2	Prima	2	Prima	2	Prima	2
		Beetje te koud	1	Prima	2	Prima	2	Prima	2
		Beetje te koud	1	Beetje te koud	1	Prima	2	Veel te koud	0
		Prima	2	Prima	2	Prima	2	Veel te warm	4
		Beetje te koud	1	Beetje te koud	1	Prima	2	Beetje te koud	1
		Prima	2	Prima	2	Prima	2	Beetje te koud	1
		Veel te koud	0	Veel te koud	0	Veel te koud	0	Veel te koud	0
		Prima	2	Prima	2	Prima	2	Beetje te koud	1
		Prima	2	Prima	2	Prima	2	Prima	2
		Prima	2	Prima	2	Prima	2	Prima	2
		Veel te koud	0	Veel te koud	0	Veel te koud	0	Veel te koud	0
		Prima	2	Prima	2	Prima	2	Beetje te koud	1

0 Veel te koud
1 Beetje te koud
2 Prima
3 Beetje te warm
4 Veel te warm

26	vraag	Woonkamer		Slaapkamer		Badkamer		Keuken	
	Zou u in uw woning in de winter graag een andere temperatuur wensen?								
		Een beetje warmer	3	Een beetje warmer	3	Geen verandering	2	Een beetje warmer	3
		Veel warmer	4	Veel warmer	4	Geen verandering	2	Een beetje warmer	3
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Een beetje warmer	3
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
		Een beetje warmer	3	Geen verandering	2	Geen verandering	2	Geen verandering	2
		Een beetje warmer	3	Een beetje warmer	3	Een beetje warmer	3	Veel warmer	4
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Veel kouder	0
		Een beetje warmer	3	Een beetje warmer	3	Geen verandering	2	Een beetje warmer	3
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Een beetje warmer	3
		Een beetje warmer	3	Een beetje warmer	3	Een beetje warmer	3	Een beetje warmer	3
		Een beetje warmer	3	Geen verandering	2	Geen verandering	2	Geen verandering	2
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Geen verandering	2
		Veel warmer	4	Veel warmer	4	Veel warmer	4	Veel warmer	4
		Geen verandering	2	Geen verandering	2	Geen verandering	2	Een beetje warmer	3

0 Veel kouder
1 Een beetje koeler
2 Geen verandering
3 Een beetje warmer
4 Veel warmer

27	vraag	code	anders
	Zijn er wat u betreft genoeg radiatoren aanwezig om de woning te verwarmen?		
		0	
		2	woonkamer
		2	alle slaapkamers
		0	
		0	
		2	slaapkamers
		0	
		2	slaapkamer
		2	slaapkamer
		2	slaapkamers
		2	kinderslaapkamer
		0	
		0	
		2	slaapkamer
		2	gang boven

0 Ja
1 Nee
2 Indien nee, waar zou u een extra radiator willen?

28	vraag	Woonkamer		Slaapkamer		Badkamer		Keuken	
	Hoe ervaart u de temperatuur van de lucht die ingeblazen wordt via de ventilatie in de winter?								
		Aangenaam	2	Aangenaam	2	Warm	1	Aangenaam	2
		Fris	3	Fris	3	Fris	3	Fris	3
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Fris	3
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
			3	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Fris	3
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Te warm	0
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Te koud	4	Te koud	4	Te koud	4	Te koud	4
		Aangenaam	2	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Te koud	4	Aangenaam	2	Aangenaam	2	Aangenaam	2
		Fris	3	Fris	3	Fris	3	Fris	3
		Fris	3	Fris	3	Fris	3	Fris	3
		Fris	3	Fris	3	Fris	3	Fris	3

0 Te warm
1 Warm
2 Aangenaam
3 Fris
4 Te koud

29

vraag	Ik zet de radiatorknop in de woonkamer hoger		Niks, ik trek dikkere kleding aan		Ik sluit de ramen en de ventilatieluiken		Ik zet het ventilatiesysteem op stand 1		Anders, namelijk	
Wat doet u wanneer u het in de woonkamer te koel vindt?										
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Ja	1	Nee	0	Nee	0
	Nee	0	Nee	0	Ja	1	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Ja	1	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Ja	1	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0		0	Nee	0	Nee	0	Nee	0

0 Nee
1 Ja

30

vraag	Ik zet de slaapkamer deur open en de radiator in de entree en de badkamer hoger		Ik sluit de ramen en de ventilatieluiken		Ik zet het ventilatiesysteem op stand 1		Ik plaats een elektrische bijverwarming		Anders, namelijk	
Wat doet u wanneer u het in de slaapkamer te koel vindt?										
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Ja	1	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Ja	1
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Ja	1	Nee	0	Nee	0	Nee	0
	Nee	0	Nee	0	Nee	0	Nee	0	Nee	0

0 Nee
1 Ja

31

vraag	Ik zet het ventilatiesysteem op de hoogste stand		Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje		Tijdens het douchen laat ik de deur op een kier staan		Ik houd overdag de ramen dicht		Ik doe s nachts de ventilatieluiken open	
Hoe ventileert u in de winter?										
	Meestal	1	Soms	2	Bijna nooit	3	Soms	2	Bijna nooit	3
	Nooit	4	Altijd	0	Nooit	4	Nooit	4	Altijd	0
	Nooit	4	Meestal	1	Nooit	4	Meestal	1	Soms	2
	Altijd	0	Soms	2	Nooit	4	Altijd	0	Bijna nooit	3
	Soms	2	Altijd	0	Altijd	0	Nooit	4	Altijd	0
	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3	Meestal	1	Nooit	4
	Meestal	1	Soms	2	Meestal	1	Soms	2	Nooit	4
	Soms	2	Meestal	1	Bijna nooit	3	Bijna nooit	3	Nooit	4
	Meestal	1	Nooit	4	Soms	2	Altijd	0	Bijna nooit	3
	Soms	2	Meestal	1	Meestal	1	Soms	2	Nooit	4
	Bijna nooit	3		2	Nooit	4	Soms	2	Nooit	4
	Nooit	4	Altijd	0	Nooit	4		0	Nooit	4
	Soms	2	Bijna nooit	3	Meestal	1	Meestal	1	Bijna nooit	3
	Soms	2	Soms	2	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3
	Bijna nooit	3	Bijna nooit	3	Soms	2	Altijd	0	Nooit	4

0 Altijd
1 Meestal
2 Soms
3 Bijna nooit
4 Nooit

32

vraag	Deur naar tuin		Raam in keuken		Ramen in slaapkamers	
Hoe vaak opent u deuren en ramen om in de winter aanvullend te ventileren?						
	Bijna nooit	3	Zo nu en dan	2	Zo nu en dan	2
	Nooit	4	Nooit	4	Elke dag	0
	Nooit	4	Zo nu en dan	2	Bijna elke dag	1
	Nooit	4	Nooit	4	Nooit	4
	Elke dag	0	Elke dag	0	Elke dag	0
	Bijna nooit	3	Nooit	4	Bijna nooit	3
	Zo nu en dan	2	Bijna elke dag	1	Zo nu en dan	2
	Nooit	4	Bijna elke dag	1	Zo nu en dan	2
	Bijna nooit	3	Zo nu en dan	2	Nooit	4
	Zo nu en dan	2	Zo nu en dan	2	Bijna elke dag	1
	Nooit	4	Zo nu en dan	2	Zo nu en dan	2
	Bijna nooit	3	Bijna nooit	3	Elke dag	0
	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3
	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3
	Zo nu en dan	2	Zo nu en dan	2	Bijna nooit	3

0 Elke dag
1 Bijna elke dag
2 Zo nu en dan
3 Bijna nooit
4 Nooit

33

vraag	Ik zet de luiken in de zomer overdag open		Ik doe de luiken dicht wanneer er niemand thuis is		Ik doe de luiken in de zomer overdag dicht wanneer het buiten warm is		Ik doe de luiken in de zomer s nachts open en overdag dicht		Ik zet de luiken in de zomer en winter, overdag en s nachts op een kiertje	
Hoe gebruikt u de ventilatieluiken?										
	Meestal	1	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3	Bijna nooit	3
	Altijd	0	Nooit	4	Soms	2	Nooit	4	Altijd	0
	Meestal	1	Bijna nooit	3	Soms	2	Soms	2	Meestal	1
	Bijna nooit	3	Altijd	0	Altijd	0	Soms	2	Nooit	4
	Altijd	0	Altijd	0	Soms	2	Bijna nooit	3	Altijd	0
	Bijna nooit	3	Meestal	1	Meestal	1	Meestal	1	Soms	2
	Meestal	1	Altijd	0	Soms	2	Nooit	4	Nooit	4
	Meestal	1	Bijna nooit	3	Soms	2	Soms	2	Nooit	4
	Soms	2	Soms	2	Meestal	1	Altijd	0	Soms	2
	Soms	2	Soms	2	Soms	2	Soms	2	Soms	2
	Meestal	1	Soms	2	Meestal	1	Bijna nooit	3	Bijna nooit	3
	Soms	2	Altijd	0	Meestal	1	Nooit	4	Nooit	4
	Bijna nooit	3	Altijd	0	Meestal	1	Nooit	4	Nooit	4
	Meestal	1	Bijna nooit	3	Soms	2	Soms	2	Soms	2
	Nooit	4	Nooit	4	Nooit	4	Nooit	4	Nooit	4

0 altijd
1 meestal
2 soms
3 bijna nooit
4 nooit

34

vraag	Het systeem voor het opwekken van warmte voor warm tapwater (stadwarmte)		Het warmte-opwekkingsapparaat (stadswarmte)		Het warmte-afgifte-systeem (radiatoren)		temperatuur regeling	
Hoe tevreden bent u over.....?								
	neutraal	2	neutraal	2	tevreden	3	tevreden	3
	zeer tevrede	4	neutraal	2	zeer ontevre	0	zeer ontevre	0
	tevreden	3	tevreden	3	neutraal	2	neutraal	2
	tevreden	3	tevreden	3	tevreden	3	ontevreden	1
	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	tevreden	3	tevreden	3	zeer ontevre	0	ontevreden	1
	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	neutraal	2	neutraal	2	tevreden	3	neutraal	2
	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	neutraal	2	neutraal	2	neutraal	2	tevreden	3
	tevreden	3	tevreden	3	tevreden	3	neutraal	2
	neutraal	2	neutraal	2	neutraal	2	ontevreden	1
	zeer tevrede	4	zeer tevrede	4	zeer tevrede	4	zeer tevrede	4

0 zeer ontevreden
1 ontevreden
2 neutraal
3 tevreden
4 zeer tevreden

35

vraag	Bedieningsgemak		Capaciteit		Comfort (bijvoorbeeld tocht)		Onderhoud		Geluid	
Hoe tevreden bent u over het ventilatiesysteem?										
	tevreden	3	tevreden	3	tevreden	3	neutraal	2	neutraal	2
	ontevreden	1	tevreden	3	tevreden	3	ontevreden	1	neutraal	2
	neutraal	2	neutraal	2	neutraal	2	zeer ontevre	0	neutraal	2
	tevreden	3	tevreden	3	tevreden	3	zeer ontevre	0	tevreden	3
	ontevreden	1	tevreden	3	tevreden	3	tevreden	3	zeer tevrede	4
	tevreden	3	tevreden	3	neutraal	2	neutraal	2	ontevreden	1
	tevreden	3	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	neutraal	2	neutraal	2	ontevreden	1	ontevreden	1	neutraal	2
	tevreden	3	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	neutraal	2	neutraal	2	neutraal	2	neutraal	2	neutraal	2
	tevreden	3	tevreden	3	tevreden	3	tevreden	3	tevreden	3
	tevreden	3	tevreden	3	neutraal	2	tevreden	3	tevreden	3
	neutraal	2	neutraal	2	ontevreden	1	neutraal	2	neutraal	2
	neutraal	2	neutraal	2	ontevreden	1	neutraal	2	neutraal	2
	zeer tevrede	4	zeer tevrede	4	zeer tevrede	4	zeer tevrede	4	zeer tevrede	4

0 zeer ontevreden
1 ontevreden
2 neutraal
3 tevreden
4 zeer tevreden

36

vraag	Ik woon prettig in mijn woning		Ik voel mij veilig in mijn woning		Ik weet hoe ik de aanwezige klimaatinstallaties moet bedienen		Ik vind het eng om de aanwezige installaties te bedienen	
Bent u het eens of oneens met de volgende uitspraken:								
	Eens	3	Eens	3	Eens	3	Oneens	1
	Eens	3	Helemaal een	4	Neutraal	2	Helemaal on	0
	Neutraal	2	Eens	3	Neutraal	2	Neutraal	2
	Eens	3	Eens	3	Helemaal on	0	Eens	3
	Eens	3	Eens	3	Eens	3	Helemaal on	0
	Eens	3	Eens	3	Eens	3	Helemaal on	0
	Eens	3	Eens	3	Eens	3	Helemaal on	0
	Eens	3	Eens	3	Oneens	1	Oneens	1
	Eens	3	Eens	3	Eens	3	Oneens	1
	Eens	3	Neutraal	2	Oneens	1	Eens	3
	Helemaal een	4	Helemaal een	4	Helemaal een	4	Oneens	1
	Helemaal een	4	Helemaal een	4	Helemaal een	4	Helemaal on	0
	Eens	3	Eens	3	Neutraal	2	Eens	3
	Neutraal	2	Eens	3	Neutraal	2	Oneens	1
	Helemaal een	4	Helemaal een	4	Neutraal	2	Helemaal een	4

0 Helemaal oneens
1 Oneens
2 Neutraal
3 Eens
4 Helemaal eens

37

vraag	code
Wat vind u van uw eigen energierekening?	
Hoog	3
Niet laag / niet hoog	2
Zeer hoog	4
Zeer hoog	4
Niet laag / niet hoog	2
Niet laag / niet hoog	2
Zeer hoog	4
Weet ik niet	5
Niet laag / niet hoog	2
Hoog	3
Hoog	3
Niet laag / niet hoog	2
Weet ik niet	5
Niet laag / niet hoog	2
Laag	1

0 Zeer laag
1 Laag
2 Niet laag / niet hoog
3 Hoog
4 Zeer hoog
5 Weet ik niet

38

vraag	code
Hoeveel doet u thuis aan energiebesparing?	
Een beetje	2
Een beetje	2
Weinig	3
Veel	1
Veel	1
Een beetje	2
Veel	1
Weinig	3
Weinig	3
Een beetje	2
Veel	1
Veel	1
Een beetje	2
Weinig	3
Veel	1

0 Zeer veel
1 Veel
2 Een beetje
3 Weinig
4 Niets

	vraag	code
	Denkt u dat u nog meer energie zou kunnen besparen dan u nu doet?	
39	Ja, een beetje	2
	Ja, een beetje	2
	Ja, een beetje	2
	Ja, maar weinig	3
	Ja, heel veel meer	0
	Ja, een beetje	2
	Ja, maar weinig	3
	Ja, een beetje	2
	Ja, een beetje	2
	Ja, veel meer	1
	Ja, maar weinig	3
	Nee, niets	4
	Ja, maar weinig	3
	Nee, niets	4

0 Ja, heel veel meer
1 Ja, veel meer
2 Ja, een beetje
3 Ja, maar weinig
4 Nee, niets

	vraag	code
	Als u uzelf vergelijkt met mensen uit uw omgeving, doet u dan meer of minder aan energiebesparing?	
40	Ongeveer even veel als anderen	2
	Veel minder dan anderen	4
	Iets minder dan anderen	3
	Ongeveer even veel als anderen	2
	Iets meer dan anderen	1
	Ongeveer even veel als anderen	2
	Iets meer dan anderen	1
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2
	Ongeveer even veel als anderen	2

0 Veel meer dan anderen
1 Iets meer dan anderen
2 Ongeveer even veel als anderen
3 Iets minder dan anderen
4 Veel minder dan anderen

	vraag	De stekker van huishoudelijke apparaten uit het stopcontact halen wanneer deze niet in gebruik zijn		In huis de deuren zoveel mogelijk dicht houden		Wassen op lage temperaturen		Zo kort mogelijk douchen		De verwarming uitzetten in kamers waar niemand is		de verwarming een uur voordat u gaat slapen uitzetten		De lichten uit doen in kamers waar niemand is		Ingevroren voedsel ontdooien in de koelkast		Alleen afgekoelde etenswaren in de koelkast zetten		De gordijnen sluiten om de warmte binnen te houden.		De thermostaat uitzetten wanneer u op vakantie gaat.	
	Wat doet u zoals om energie te besparen?																								
41		Vaak	3	Zelden	1	Vaak	3	Soms	2	Soms	2	Soms	2	Altijd	4	Soms	2	Soms	2	Vaak	3	Altijd	4
		Vaak	3	Altijd	4	Altijd	4	Soms	2	Altijd	4	Vaak	3	Altijd	4	Altijd	3	Vaak	3	Altijd	4	Altijd	4
		Zelden	1	Nooit	0	Soms	2	Soms	2	Soms	2	Zelden	1	Altijd	4	Altijd	4	Altijd	4	Zelden	1	Nooit	0
		Soms	2	Altijd	4	Zelden	1	Zelden	1	Altijd	4	Nooit	0	Altijd	4	Altijd	4	Altijd	4	Nooit	0	Vaak	3
		Altijd	4	Zelden	1	Vaak	3	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4
		Vaak	3	Vaak	3	Zelden	1	Zelden	1	Zelden	1	Vaak	3	Vaak	3	Vaak	3	Zelden	1	Altijd	4	Altijd	4
		Vaak	3	Vaak	3	Vaak	3	Altijd	3	Vaak	3	Altijd	4	Altijd	4	Nooit	0	Altijd	4	Altijd	4	Altijd	4
		Vaak	3	Vaak	3	Zelden	1	Altijd	4	Soms	2	Altijd	4	Zelden	1	Altijd	4	Soms	2	Soms	2	Altijd	4
		Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0
		Soms	2	Soms	2	Soms	2	Zelden	1	Soms	2	Altijd	4	Altijd	4	Zelden	1	Altijd	3	Zelden	1	Altijd	4
		Vaak	3	Altijd	4	Soms	2	Altijd	3	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Altijd	4
		Altijd	4	Altijd	4	Nooit	0	Altijd	4	Altijd	4	Altijd	4	Altijd	4	Soms	2	Altijd	4	Altijd	4	Altijd	4
		Nooit	0	Altijd	3	Zelden	1	Zelden	1	Zelden	1	Zelden	1	Zelden	1	Zelden	1	Zelden	3	Vaak	3	Soms	2
		Soms	2	Soms	2	Soms	2	Soms	2	Altijd	4	Altijd	4	Altijd	4	Altijd	3	Soms	2	Vaak	3	Altijd	4
		Soms	2	Altijd	4	Altijd	4	Altijd	3	Altijd	4	Zelden	1	Altijd	4	Altijd	4	Altijd	4	Vaak	3	Altijd	4

0 Nooit
1 Zelden
2 Soms
3 Vaak
4 Altijd

	vraag	code
	Gebruikt u spaarlampen?	
42	Ja, overal in huis	0
	Ja, maar niet overal in huis	1
	Nee	2
	Ja, overal in huis	0
	Ja, overal in huis	0
	Nee	1
	Ja, maar niet overal in huis	1
	Ja, maar niet overal in huis	1
	Ja, maar niet overal in huis	1
	Ja, maar niet overal in huis	1
	Ja, maar niet overal in huis	1
	Ja, overal in huis	0
	Ja, maar niet overal in huis	1
	Ja, maar niet overal in huis	1
	Ja, maar niet overal in huis	1

0 Ja, overal in huis
1 Ja, maar niet overal in huis
2 Nee

	vraag	code
	Heeft u een waterbesparende douchekop?	
43	Weet ik niet	2
	Nee	1
	Weet ik niet	2
	Ja	0
	Ja	0
	Nee	1
	Ja	0
	Weet ik niet	2
	Weet ik niet	2
	Nee	1
	Ja	0
	Ja	0
	Nee	1
	Nee	1
	Ja	0

0 Ja
1 Nee
2 Weet ik niet

	vraag	code
	Let u op het energieverbruik bij de aanschaf van (huishoudelijke) apparaten?	
44	Bijna altijd	1
	Bijna altijd	1
	Bijna nooit	3
	Altijd	0
	Bijna altijd	1
	Soms	2
	Altijd	0
	Soms	2
	Nooit	4
	Altijd	0
	Bijna altijd	1
	Bijna altijd	1
	Bijna nooit	3
	Soms	2
	Soms	2

0 Altijd
1 Bijna altijd
2 Soms
3 Bijna nooit
4 Nooit

	vraag	code
	Wat is ongeveer de temperatuur in uw slaapkamer in de winter overdag?	
45	18-20	2
	< 16	0
	< 16	0
	< 16	0
	< 16	0
	18-20	2
	16-18	1
	16-18	1
	16-18	1
	16-18	1
	16-18	1
	16-18	1
	20-22	3
	< 16	0
	< 16	0

0 < 16
1 16-18
2 18-20
3 20-22
4 >22

	vraag	code
	Wat is meestal ongeveer de temperatuur in uw woonkamer in de winter overdag?	
46	18-20	1
	<18	0
	20-22	2
	20-22	2
	<18	0
	20-22	2
	<18	0
	18-20	1
	20-22	2
	18-20	1
	18-20	1
	20-22	2
	22-24	3
	<18	0
	<18	0

0 <18
1 18-20
2 20-22
3 22-24
4 >24

	vraag	code
	Welke stelling is het meest op u van toepassing? Ik ben van plan om in de toekomst.....	
47	Zeker energie te besparen	1
	Misschien energie te besparen	2
	Misschien energie te besparen	2
	Waarschijnlijk geen energie te besparen	3
	Zeker energie te besparen	1
	Misschien energie te besparen	2
	Zeer zeker energie te besparen	0
	Zeker energie te besparen	1
	Waarschijnlijk geen energie te besparen	3
	Zeer zeker energie te besparen	0
	Zeker energie te besparen	1
	Waarschijnlijk geen energie te besparen	3
	Misschien energie te besparen	2
	Misschien energie te besparen	2
	Zeker energie te besparen	1

0 Zeer zeker energie te besparen
1 Zeker energie te besparen
2 Misschien energie te besparen
3 Waarschijnlijk geen energie te besparen
4 Zeer zeker geen energie te besparen

	vraag	code
	Hoe energiezuinig denkt u dat uw woning is?	
48	Vrij zuinig	1
	Niet zuinig / niet onzuinig	2
	Niet zuinig / niet onzuinig	2
	Vrij zuinig	1
	Vrij zuinig	1
	Heel zuinig	0
	Niet zuinig	3
	Niet zuinig / niet onzuinig	2
	Vrij zuinig	1
	Vrij zuinig	1
	Vrij zuinig	1
	Vrij zuinig	1
	Niet zuinig	3
	Vrij zuinig	1

0 Heel zuinig
1 Vrij zuinig
2 Niet zuinig / niet onzuinig
3 Niet zuinig
4 Helemaal niet zuinig
5 Weet ik niet

	vraag	code
	Weet u uit uw hoofd hoeveel stroom (in kWh) u ongeveer verbruikt per jaar?	
49	Twijfel	1
	Nee	2
	Nee	2
	Nee	2
	Ja	0
	Twijfel	1
	Ja	0
	Twijfel	1
	Nee	2
	Twijfel	1
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2

0 Ja
1 Twijfel
2 Nee

	vraag	code
	Weet u uit uw hoofd hoeveel stroom (ongeveer) kost per kWh?	
50	Nee	3
	Twijfel	2
	Nee	3
	Nee	3
	Twijfel	2
	Ja	1
	Ja	1
	Nee	3
	Nee	3
	Twijfel	2
	Nee	3
	Nee	3
	Nee	3
	Nee	3
	Nee	3

1 Ja
2 Twijfel
3 Nee

	vraag	code
	Weet u uit uw hoofd hoeveel warmte (in GigaJoule, GJ) u ongeveer verbruikt per jaar?	
51	Nee	2
	Twijfel	1
	Nee	2
	Nee	2
	Twijfel	1
	Nee	2
	Ja	0
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2

0 Ja
1 Twijfel
2 Nee

	vraag	code
	Weet u uit uw hoofd hoeveel warmte (ongeveer) kost per GigaJoule (GJ)?	
52	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Twijfel	1
	Twijfel	1
	Ja	0
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2
	Nee	2

0 Ja
1 Twijfel
2 Nee

	vraag	code
	Weet u uit uw hoofd hoe hoog uw energierekening is (stroom en warmte)?	
53	Ja	0
	Nee	2
	Twijfel	1
	Ja	0
	Ja	0
	Ja	0
	Twijfel	1
	Twijfel	1
	Nee	2
	Ja	0
	Ja	0
	Nee	2
	Nee	2
	Twijfel	1
	Nee	2

0 Ja
1 Twijfel
2 Nee

	vraag
	Hoeveel betaalt u (ongeveer) aan energie (stroom en warmte) per maand? - per maand:
54	160
	70.36
	200
	190
	136
	124
	120
	155
	150
	165
	129
	75
	125
	150
	119

Gemiddelde
138

	vraag	Een spaarlamp gaat over het algemeen langer mee dan een gloeilamp		Een plasmatelevisie verbruikt minder energie dan een gewone televisie		Wassen op 90 °C kost ongeveer drie keer zo veel energie als wassen op 40 °C		Als je overdag de thermostaat 1 graad lager zet, kun je €50,- per jaar besparen		Apparaten met een B-label zijn zuiniger dan apparaten met een A-label		Een telefoonoplader in het stopcontact verbruikt alleen stroom tijdens het opladen van de telefoon		Een waterbesparen de douchekop kan per jaar voor een besparing van meer dan €50,- zorgen		Een bypass van de ventilatie installatie zorgt voor extra koeling in de zomer		Water koken in een waterkoker verbruikt minder energie dan water koken op het gasfornuis	
	Geef aan of de volgende stellingen volgens u juist of onjuist zijn.																		
55		Onjuist	1	Juist	0	Juist	0	Weet ik niet	2	Onjuist	1	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2
		Juist	0	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Onjuist	1	Onjuist	1	Weet ik niet	2	Onjuist	1	Juist	0
		Weet ik niet	2	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2
		Juist	0	Onjuist	1	Juist	0	Juist	0	Onjuist	1	Onjuist	1	Juist	0	Juist	0	Weet ik niet	2
		Juist	0	Onjuist	1	Juist	0	Weet ik niet	2	Onjuist	1	Onjuist	1	Juist	0	Weet ik niet	2	Onjuist	1
		Juist	0	Juist	0	Weet ik niet	2	Juist	0	Onjuist	1	Onjuist	1	Juist	0	Juist	0	Weet ik niet	2
		Juist	0	Juist	0	Juist	0	Weet ik niet	2	Onjuist	1	Onjuist	1	Juist	0	Weet ik niet	2	Juist	0
		Juist	0	Onjuist	1	Juist	0	Juist	0	Onjuist	1	Onjuist	1	Juist	0	Weet ik niet	2	Juist	0
		Juist	0	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Juist	0	Weet ik niet	2
		\	\	\	\	\	\	\	\	\	\	\	\	\	\	\	\	\	\
		Juist	0	Juist	0	Juist	0	Juist	0	Onjuist	1	Onjuist	1	Juist	0	Juist	0	Onjuist	1
		Juist	0	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Onjuist	1	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2
		Juist	0	Weet ik niet	2	Weet ik niet	2	Juist	0	Juist	0	Juist	0	Onjuist	1	Weet ik niet	2	Weet ik niet	2
		Juist	0	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2
		Juist	0	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2	Onjuist	1	Onjuist	1	Weet ik niet	2	Weet ik niet	2	Weet ik niet	2

0 Juist
1 Onjuist
2 Weet ik niet

	vraag	Energiebesparen vind ik teveel gedoe		Energiebesparen vind ik moeilijk		Energiebesparen kost mij teveel tijd		Ik kan een bijdrage leveren aan een beter milieu door zuinig om te gaan met energie		Ik kan geld besparen door zuinig om te gaan met energie		Als ik energie bespaar gaat dat ten koste van het comfort in huis		Als ik energie bespaar voel ik mij goed		Als ik energie bespaar wordt dat door de mensen in mijn omgeving gewaardeerd		Als ik energie bespaar kost mij dat meer geld dan dat het oplevert		Als ik energie bespaar dan ben ik tevreden over mijzelf		Een beter milieu begint bij mijzelf	
	Bent u het eens of oneens met de volgende uitspraken:																						
56		Oneens	1	Oneens	1	Oneens	1	Neutraal	2	Eens	3	Neutraal	2	Neutraal	2	Neutraal	2	Oneens	1		3	Neutraal	2
		Eens	3	Neutraal	2	Oneens	1	Eens	3	Helemaal een	4	Eens	3	Neutraal	2	Oneens	1	Oneens	1	Oneens	1	Helemaal een	4
		Eens	3	Neutraal	2	Neutraal	2	Eens	3	Eens	3	Eens	3	Oneens	1	Neutraal	2	Oneens	1	Oneens	1	Neutraal	2
		Helemaal on	0	Neutraal	2	Helemaal on	0	Helemaal een	4	Helemaal een	4	Eens	3	Neutraal	2	Oneens	1	Helemaal on	0	Neutraal	2	Helemaal een	4
		Helemaal on	0	Neutraal	2	Helemaal on	0	Helemaal een	4	Helemaal een	4	Helemaal on	0	Helemaal een	4	Neutraal	2	Helemaal on	0	Neutraal	2	Helemaal een	4
		Oneens	1	Oneens	1	Neutraal	2	Eens	3	Helemaal een	4	Eens	3	Eens	3	Eens	3	Eens	3	Neutraal	2	Eens	3
		Helemaal on	0	Helemaal on	0	Helemaal on	0	Helemaal een	4	Eens	3	Oneens	1	Eens	3	Eens	3	Neutraal	2	Eens	3	Helemaal een	4
		Oneens	1	Eens	3	Eens	3	Eens	3	Helemaal een	4	Eens	3	Eens	3	Eens	3	Neutraal	2	Eens	3	Helemaal een	4
		Helemaal een	4	Eens	3	Helemaal een	4	Neutraal	2	Eens	3	Oneens	1	Helemaal on	0	Oneens	1	Oneens	1	Neutraal	2	Neutraal	2
			#		#		##		#		#		#		#		#		#		#		#
		Eens	3	Neutraal	2	Neutraal	2	Eens	3	Eens	3	Neutraal	2	Eens	3	Neutraal	2	Neutraal	2	Eens	3	Eens	3
		Neutraal	2	Neutraal	2	Neutraal	2	Eens	3	Eens	3	Eens	3	Helemaal on	0	Neutraal	2	Eens	3	Helemaal een	4		
		Eens	3	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Eens	3	Neutraal	2	Neutraal	2	Eens	3	Neutraal	2	Neutraal	2
		Eens	3	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2
		Oneens	1	Oneens	1	Oneens	1	Helemaal een	4	Helemaal een	4	Oneens	1	Helemaal een	4	Helemaal on	0	Helemaal on	0	Helemaal een	4	Helemaal een	4

0 Helemaal oneens
1 Oneens
2 Neutraal
3 Eens
4 Helemaal eens

	vraag	Als u de enige in het gezin bent die bespaart		Als u direct kunt zien dat u energie bespaart		Als u het druk hebt		Als uw buren ook besparen		Geef Als u niet zo veel geld hebt		Als u meer zou weten over energiebesparing		Als u samen met anderen zou besparen		Als u daarvoor eerst geld moet investeren		Als u begeleid zou worden		Als u voor uw besparing beloond zou worden door bijvoorbeeld de gemeente		Als u persoonlijke tips zou krijgen	
	Geef aan of u het makkelijk of moeilijk lijkt om energie te besparen in de volgende situaties:																						
57		Heel makkelijk	0	Redelijk makkelijk	1	Neutraal	2	Neutraal	2	Heel makkelijk	0	Heel makkelijk	0	Redelijk makkelijk	1	Redelijk moeilijk	3	Neutraal	2	Heel makkelijk	0	Redelijk makkelijk	1
		Redelijk moeilijk	3	Heel makkelijk	0	Redelijk makkelijk	1	Redelijk makkelijk	1	Heel makkelijk	0	Heel makkelijk	0	Redelijk makkelijk	1	Redelijk makkelijk	1	Heel makkelijk	0	Redelijk makkelijk	1	Heel makkelijk	0
		Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Redelijk moeilijk	3	Neutraal	2	Neutraal	2	Neutraal	2
		Heel moeilijk	4	Redelijk makkelijk	1	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Redelijk moeilijk	3	Neutraal	2	Redelijk makkelijk	1	Redelijk makkelijk	1
		Redelijk makkelijk	1	Heel makkelijk	0	Redelijk makkelijk	1	Neutraal	2	Heel makkelijk	0	Heel makkelijk	0	Heel makkelijk	0	Redelijk makkelijk	1	Heel makkelijk	0	Neutraal	2	Heel makkelijk	0
		Neutraal	2	Redelijk makkelijk	1	Redelijk moeilijk	3	Redelijk moeilijk	3	Redelijk makkelijk	1	Redelijk makkelijk	1	Redelijk moeilijk	3	Neutraal	2	Redelijk makkelijk	1	Redelijk makkelijk	1	Redelijk makkelijk	1
		Heel makkelijk	0	Redelijk moeilijk	3	Heel makkelijk	0	Heel moeilijk	4	Neutraal	2	Neutraal	2	Heel makkelijk	0	Redelijk moeilijk	3	Neutraal	2	Redelijk makkelijk	1	Redelijk makkelijk	1
		Redelijk moeilijk	3	Redelijk moeilijk	3	Redelijk moeilijk	3	Neutraal	2	Neutraal	2	Redelijk makkelijk	1	Redelijk makkelijk	1	Neutraal	2	Redelijk makkelijk	1	Redelijk makkelijk	1	Redelijk makkelijk	1
		Neutraal	2	Neutraal	2	Redelijk moeilijk	3	Neutraal	2	Redelijk makkel	1	Neutraal	2	Redelijk makkelijk	1	Heel moeilijk	4	Neutraal	2	Neutraal	2	Neutraal	2
		/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Redelijk makkelijk	1	Redelijk makkelijk	1	Neutraal	2	Neutraal	2	Redelijk makkel	1	Redelijk makkelijk	1	Redelijk makkelijk	1	Redelijk moeilijk	3	Neutraal	2	Redelijk makkelijk	1	Redelijk makkelijk	1
		Heel makkelijk	0	Heel makkelijk	0	Heel makkelijk	0	Neutraal	2	Heel makkelijk	0	Neutraal	2	Heel makkelijk	0	Neutraal	2	Heel makkelijk	0	Redelijk makkelijk	1	Neutraal	2
		Redelijk moeilijk	3	Neutraal	2	Neutraal	2	Neutraal	2	Redelijk moeilijk	3	Neutraal	2	Neutraal	2	Neutraal	2	Redelijk moeilijk	3	Neutraal	2	Neutraal	2
		Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2	Neutraal	2
		Heel makkelijk	0	Heel makkelijk	0	Neutraal	2	Neutraal	2	Heel makkelijk	0	Heel makkelijk	0	Heel makkelijk	0	Heel moeilijk	4	Heel makkelijk	0	Heel makkelijk	0	Heel makkelijk	0

0 Heel makkelijk
1 Redelijk makkelijk
2 Neutraal
3 Redelijk moeilijk
4 Heel moeilijk

	vraag	Gezinsleden		Buurtbewoners		Familie / vrienden / kennissen		Collega's		Medewerkers van het energiebedrijf		Medewerkers van de woningcorporatie		Medewerkers van de gemeente	
	Als het gaat om energiegebruik en/of energiebesparing, hoe belangrijk vindt u dan de mening van														
58		Beetje belan	1	Niet belangrijk	0	Beetje bela	1	Beetje bel	1	Beetje belangr	1	Niet belangrijk	0	Beetje belangr	1
		Niet belangr	0	Beetje belangr	1	Beetje bela	1	Beetje bel	1	Redelijk belan	2	Beetje belangr	1	Redelijk belan	2
		Niet belangr	0	Niet belangrijk	0	Niet belang	0	Niet belan	0	Niet belangrijk	0	Niet belangrijk	0	Niet belangrijk	0
		Heel belangr	3	Niet belangrijk	0	Niet belang	0	Niet belan	0	Redelijk belan	2	Redelijk belan	2	Redelijk belan	2
		Heel belangr	3	Niet belangrijk	0	Niet belang	0	Niet belan	0	Heel belangrijk	3	Heel belangrijk	3	Heel belangrijk	3
		Beetje belan	1	Niet belangrijk	0	Beetje bela	1	Beetje bel	1	Beetje belangr	1	Beetje belangr	1	Beetje belangr	1
		Heel belangr	3	Redelijk belan	2	Redelijk bel	2	Beetje bel	1	Beetje belangr	1	Beetje belangr	1	Beetje belangr	1
		Heel belangr	3	Redelijk belan	2	Redelijk bel	2	Beetje bel	1	Redelijk belan	2	Redelijk belan	2	Redelijk belan	2
		Niet belangr	0	Niet belangrijk	0	Niet belang	0	Niet belan	0	Niet belangrijk	0	Niet belangrijk	0	Niet belangrijk	0
		/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Redelijk bela	2	Beetje belangr	1	Redelijk bel	2	Redelijk b	2	Redelijk belan	2	Redelijk belan	2	Redelijk belan	2
		Niet belangr	0	Niet belangrijk	0	Niet belang	0	Niet belan	0	Beetje belangr	1	Beetje belangr	1	Beetje belangr	1
		Beetje belan	1	Niet belangrijk	0	Beetje bela	1	Niet belan	0	Niet belangrijk	0	Niet belangrijk	0	Niet belangrijk	0
		Beetje belan	1	Niet belangrijk	0	Niet belang	0	Niet belan	0	Niet belangrijk	0	Niet belangrijk	0	Niet belangrijk	0
		Heel belangr	3	Heel belangrijk	3	Heel belang	3	Heel belan	3	Heel belangrijk	3	Heel belangrijk	3	Heel belangrijk	3

	vraag	Gezinsleden		Buurtbewoners		Familie / vrienden / kennissen		Collega's		Medewerkers van het energiebedrijf		Medewerkers van de woningcorporatie		Medewerkers van de gemeente	
	Met wie praat u wel eens over energiegebruik of energiebesparing														
59		Soms	2	Zelden	1	Zelden	1	Zelden	1	Nooit	0	Nooit	0	Nooit	0
		Nooit	0	Soms	2	Zelden	1	Zelden	1	Zelden	1	Nooit	0	Nooit	0
		Nooit	0	Soms	2	Soms	2	Nooit	0	Zelden	1	Nooit	0	Nooit	0
		Vaak	3	Soms	2	Soms	2	Soms	2	Soms	2	Nooit	0	Nooit	0
		Vaak	3	Nooit	0	Vaak	3	Nooit	0	Nooit	0	Nooit	0	Nooit	0
		Soms	2	Soms	2	Soms	2	Soms	2	Zelden	1	Zelden	1	Zelden	1
		Soms	2	Soms	2	Vaak	3	Soms	2	Soms	2	Nooit	0	Nooit	0
		Vaak	3	Zelden	1	Soms	2	Soms	2	Soms	2	Soms	2	Nooit	0
		Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0
		/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Vaak	3	Zelden	1	Zelden	1	Zelden	1	Zelden	1	Zelden	1	Nooit	0
		Nooit	0	Vaak	3	Vaak	3	Nooit	0	Nooit	0	Nooit	0	Nooit	0
		Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0
		Soms	2	Soms	2	Nooit	0	Nooit	0	Nooit	0	Nooit	0	Nooit	0
		Zelden	1	Nooit	0	Soms	2	Soms	2	Nooit	0	Nooit	0	Nooit	0

	vraag	2011	2012
	Hoeveel stroom heeft u verbruikt in 2011, 2012 en (in kWh)?		
60		2448	3760
		622	1065
		2187	10843
		0	0
		0	0
		1904	2617
		2000	2000
		0	0
		3891	4358
		0	0
		3572	3926
		1520	1559
		3129	3007
		1656	2160
		3773	1154

	vraag	2011	2012
	Hoeveel Gigajoule (GJ) aan warmte heeft u verbruikt in 2011, 2012 ?		
61		23.43	31.14
		8.69	9.3
		6.01	11.09
		0	0
		0	0
		15.82	18.77
		20	21
		0	0
		7.32	6.82
		0	0
		9.28	10.17
		5.6	8.94
		15	13
		21.3	9.99
		19.58	21.02

	vraag	code
	bent u bereid om de onderzoeker een machtiging te geven om deze informatie op te vragen bij uw energiemaatschappij?	
62	Ja	0
	Nee	1
	Ja	0
	Nee	1
	Ja	0
	Nee	1
	Nee	1
	Nee	1
	Ja	0
	/	/
	Nee	1
	Nee	1
	Ja	0
	Ja	0

0 Niet belangrijk
1 Beetje belangrijk
2 Redelijk belangrijk
3 Heel belangrijk

0 Nooit
1 Zelden
2 Soms
3 Vaak

0 Ja
1 Nee

APPENDIX G1 User survey data Specific knowledge

	ADRES		How do you ventilate during summer		Ik zet het ventilatiesysteem op de laagste stand		Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje		Tijdens het douchen laat ik de deur op een kier staan		Ik houd overdag de ramen dicht		Ik doe s nachts de ventilatieluiken open		How do you ventilate during winter		Ik zet het ventilatiesysteem op de hoogste stand		Overdag zet ik het slaapkamerraam of het ventilatieluik op een kiertje		Tijdens het douchen laat ik de deur op een kier staan		Ik houd overdag de ramen dicht		Ik doe s nachts de ventilatieluiken open		How do you use ventilation panels		Ik zet de luiken in de zomer overdag open		Ik doe de luiken dicht wanneer er niemand thuis is		Ik doe de luiken in de zomer overdag dicht wanneer het buiten warm is		Ik doe de luiken in de zomer s nachts open en overdag dicht		Ik zet de luiken in de zomer en winter, overdag en s nachts op een kiertje		agree or disagree		Ik weet hoe ik de aanwezige klimaatinstallaties moet bedienen		TOTAL Specific knowledge
1	code	21													31													33											36.3				Total
	A			Bijna nooit	3	Soms	2	Bijna nooit	3	Bijna nooit	1	Soms	2			Meestal	3	Soms	2	Bijna nooit	1	Soms	2	Bijna nooit	3			Meestal	1	Bijna nooit	1	Bijna nooit	1	Bijna nooit	3					Eens	3		2	Little knowledge
	B			Altijd	0	Altijd	0	Nooit	4	Meestal	3	Altijd	4			Nooit	0	Altijd	0	Nooit	0	Nooit	1	Altijd	0			Altijd	0	Nooit	0	Soms	2	Nooit	0	Altijd	0			Neutraal	2		1	No knowledge
	C			Nooit	4	Meestal	1	Nooit	4	Soms	2	Altijd	4			Nooit	0	Meestal	1	Nooit	0	Meestal	3	Soms	2			Meestal	1	Bijna nooit	1	Soms	2	Soms	2	Meestal	1			Neutraal	2		2	Little knowledge
	D			Nooit	4	Nooit	4	Nooit	4	Altijd	4	Bijna nooit	1			Altijd	4	Soms	2	Nooit	0	Altijd	4	Bijna nooit	3			Bijna nooit	3	Altijd	4	Soms	2	Nooit	4					Helemaal on	0		3	Knowledge
	E			Bijna nooit	3	Altijd	0	Altijd	0	Nooit	0	Altijd	4			Soms	2	Altijd	0	Altijd	4	Nooit	0	Altijd	0			Altijd	0	Altijd	4	Soms	2	Bijna nooit	1	Altijd	0			Eens	3		1	No knowledge
	F			Bijna nooit	3	Soms	2	Bijna nooit	3	Soms	2	Soms	2			Bijna nooit	1	Bijna nooit	3	Bijna nooit	1	Meestal	3	Nooit	4			Bijna nooit	3	Meestal	3	Meestal	3	Meestal	3	Soms	2			Eens	3		3	Knowledge
	G			Nooit	4	Meestal	1	Soms	2	Soms	2	Nooit	0			Meestal	3	Soms	2	Meestal	3	Soms	2	Nooit	4			Meestal	1	Altijd	4	Soms	2	Nooit	0	Nooit	4			Oneens	1		2	Little knowledge
	H			Meestal	1	Meestal	1	Bijna nooit	3	Soms	2	Bijna nooit	1			Soms	2	Meestal	1	Bijna nooit	1	Bijna nooit	1	Nooit	4			Meestal	1	Bijna nooit	1	Soms	2	Soms	2	Nooit	4			Neutraal	2		2	Little knowledge
	I			Meestal	1	Soms	2			2	Altijd	4	Meestal	3			Meestal	3	Nooit	4	Soms	2	Altijd	4	Bijna nooit	3			Soms	2	Meestal	2	Soms	2	Meestal	3	Altijd	4			Eens	3		3	Knowledge
	J			Meestal	1	Meestal	1	Meestal	1	Bijna nooit	1	Nooit	0			Soms	2	Meestal	1	Meestal	3	Soms	2	Nooit	4			Soms	2	Soms	2	Soms	2	Soms	2	Soms	2			Oneens	1		2	Little knowledge
	K			Nooit	4	Soms	2	Nooit	4	Soms	2	Soms	2			Bijna nooit	1	Soms	2	Nooit	0	Soms	2	Nooit	4			Meestal	1	Soms	2	Soms	2	Meestal	3	Bijna nooit	3			Helemaal ee	4		2	Little knowledge
	L			Nooit	4	Altijd	0	Nooit	4	Meestal	3	Bijna nooit	1			Nooit	0	Altijd	0	Nooit	0			Nooit	4			Soms	2	Altijd	4	Meestal	3	Bijna nooit	1	Nooit	4			Helemaal ee	4		2	Little knowledge
	M			Nooit	4	Soms	2	Nooit	4	Altijd	4	Bijna nooit	1			Soms	2	Bijna nooit	3	Meestal	3	Altijd	3	Bijna nooit	3			Bijna nooit	3	Altijd	4	Meestal	3	Nooit	0	Nooit	4			Neutraal	2		3	Knowledge
	N			Soms	2	Altijd	0	Bijna nooit	3	Bijna nooit	1	Bijna nooit	1			Soms	2	Soms	2	Bijna nooit	1	Bijna nooit	1	Bijna nooit	3			Meestal	1	Bijna nooit	1	Soms	2	Soms	2	Nooit	4			Neutraal	2		2	Little knowledge
	O			Nooit	4	Nooit	4	Soms	4	Meestal	2	Nooit	3	0		Bijna nooit	1	Bijna nooit	3	Soms	3	Altijd	2	Nooit	4	4		Nooit	4	Nooit	4	Soms	0	Nooit	0	Nooit	0	4		Neutraal	2		2	Little knowledge
																																									average	2	

0 Altijd
1 Meestal
2 Soms
3 Bijna nooit
4 Nooit

0 Altijd
1 Meestal
2 Soms
3 Bijna nooit
4 Nooit

0 altijd
1 meestal
2 soms
3 bijna nooit
4 nooit

0 Helemaal oneens
1 Oneens
2 Neutraal
3 Eens
4 Helemaal eens

Figure G1-2: Used questions specific knowledge and survey results

specific knowledge			
house	specific I score	electricity	heat
A	2 Little knowledge	3104	27
B	1 No knowledge	844	9
C	2 Little knowledge	2187	9
D	3 Knowledge	4750	15
E	1 No knowledge	3750	8
F	3 Knowledge	2261	17
G	2 Little knowledge	2000	21
H	2 Little knowledge	0	0
I	3 Knowledge	4125	7
J	2 Little knowledge	0	0
K	2 Little knowledge	3749	10
L	2 Little knowledge	1540	7
M	3 Knowledge	3068	14
N	2 Little knowledge	1908	16
O	2 Little knowledge	2464	20

Figure G1-1: Total score specific knowledge with scale of

0	= Totally no knowledge	0
1	= No knowledge	2
2	= Little knowledge	8
3	= Knowledge	4
4	= A lot of knowledge	0

APPENDIX G2 User survey data Motivation

adress		Most important reasons for choosing this house			What do you find important concerning your house				Welke stelling is het meest op u van toepassing? Ik ben van plan om in de toekomst.....		Overall motivation	
code				passive house	environmental friendly		passive house		code		Total	
A		Neutral		2	Neutral	2	Neutral	2	Zeker energie te besparen	3	2	A little motivated
B		Very unimportant		0	Important	3	Neutral	2	Misschien energie te besparen	2	2	A little motivated
C		Neutral		2	Neutral	2	Neutral	2	Misschien energie te besparen	2	2	A little motivated
D	9.6	Important		3	Important	3	Important	3	Waarschijnlijk geen energie te besparen	1	3	Motivated
E		Very important		4	Very impor	4	Very impor	4	Zeker energie te besparen	3	4	Very motivated
F		Neutral		2	Important	3	Important	3	Misschien energie te besparen	2	3	Motivated
G		Neutral		2	Important	3	Neutral	2	Zeer zeker energie te besparen	4	3	Motivated
H		Unimportant		1	Important	3	Neutral	2	Zeker energie te besparen	3	2	A little motivated
I		Neutral		2	Neutral	2	Neutral	2	Waarschijnlijk geen energie te besparen	1	2	A little motivated
J		Important		3	Important	3	Important	3	Zeer zeker energie te besparen	4	3	Motivated
K		Neutral		2	Important	3	Important	3	Zeker energie te besparen	3	3	Motivated
L		Very unimportant		0	Very unimp	0	Very unimp	0	Waarschijnlijk geen energie te besparen	1	0	Totally not motivated
M		Very important		4	Very impor	4	Very impor	4	Misschien energie te besparen	2	4	Very motivated
N		Unimportant		1	Neutral	2	Neutral	2	Misschien energie te besparen	2	2	A little motivated
O		Unimportant		1	Very impor	4	Neutral	2	Zeker energie te besparen	3	3	Motivated
										average	2	

	10.1 & 10.7		47

0 Very unimportant
1 Unimportant
2 Neutral
3 Important
4 Very important

0 Very unimportant
1 Unimportant
2 Neutral
3 Important
4 Very important

0 Very certain to start saving energy
1 certain to start saving energy
2 maybe to start saving energy
3 Probably not to start saving energy
4 very certain not to start saving energy

Figure G2-2: Used questions motivation and survey results

motivation			
house	overall motivation	electricity	heat
A	2 A little moti	3104	27
B	2 A little moti	844	9
C	2 A little moti	2187	9
D	3 Motivated	4750	15
E	4 Very motiv	3750	8
F	3 Motivated	2261	17
G	3 Motivated	2000	21
H	2 A little moti	0	0
I	2 A little moti	4125	7
J	3 Motivated	0	0
K	3 Motivated	3749	10
L	0 Totally not	1540	7
M	4 Very motiv	3068	14
N	2 A little moti	1908	16
O	3 Motivated	2464	20

Figure G2-1: Total score motivation with scale

0 = Totally not motiv	1
1 = Not motivated	0
2 = A little motivate	6
3 = Motivated	6
4 = Very motivated	2

APPENDIX G3 User survey data Awareness

	Adress		How much do you do concerning energy saving		Do you think you can save more energy than you currently do		If you compare yourself with others, do you save more or less energy		How energy efficient you think your house is		Do you know your annual electricity usage by heart		Do you know your annual heatusage by heart		Awareness	
	code															
1	A	38	Een beetje	2	Ja, een beetje	2	Ongeveer even veel als anderen	2	Energy efficient	3	Not sure	2	No	0	2	A little aware
	B		Een beetje	2	Ja, een beetje	2	Veel minder dan anderen	0	Neutral	2	No	0	Not sure	2	1	Not aware
	C		Weinig	2	Ja, een beetje	2	Iets minder dan anderen	1	Neutral	2	No	0	No	0	1	Not aware
	D		Veel	3	Ja, maar weinig	1	Ongeveer even veel als anderen	2	Energy efficient	3	No	0	No	0	2	A little aware
	E		Veel	3	Ja, heel veel meer	4	Iets meer dan anderen	3	Energy efficient	3	Yes	4	Not sure	2	3	Aware
	F		Een beetje	2	Ja, een beetje	2	Ongeveer even veel als anderen	2	Very energy efficient	4	Not sure	2	No	0	2	A little aware
	G		Veel	3	Ja, maar weinig	1	Iets meer dan anderen	3	Not energy efficient	1	Yes	4	Yes	4	3	Aware
	H		Weinig	2	Ja, een beetje	2	Ongeveer even veel als anderen	2	Neutral	2	Not sure	2	No	0	2	A little aware
	I		Weinig	2	Ja, een beetje	2	Ongeveer even veel als anderen	2	Energy efficient	3	No	0	No	0	2	A little aware
	J		Een beetje	2	Ja, veel meer	3	Ongeveer even veel als anderen	2	Energy efficient	3	Not sure	2	No	0	2	A little aware
	K		Veel	3	Ja, maar weinig	1	Ongeveer even veel als anderen	2	Energy efficient	3	No	0	No	0	2	A little aware
	L		Veel	3	Nee, niets	0	Ongeveer even veel als anderen	2	Energy efficient	3	No	0	No	0	1	Not aware
	M		Een beetje	2	Ja, maar weinig	1	Ongeveer even veel als anderen	2	Energy efficient	3	No	0	No	0	1	Not aware
	N		Weinig	2	Nee, niets	0	Ongeveer even veel als anderen	2	Not energy efficient	2	No	0	No	0	1	Not aware
	O		Veel	3	Ja, een beetje	2	Ongeveer even veel als anderen	2	Energy efficient	3	No	0	No	0	2	A little aware
														average	2	

4	Very much	4	Yes, a whole lot more	4	A lot more than others	4	Very energy efficient	4	Yes	4 Yes
3	a lot	3	Yes, a lot more	3	A little bit more than others	3	Energy efficient			
2	a bit	2	Yes, a little bit	2	About the same	2	Neutral	2	Not sure	2 Not sure
1	not so much	1	Yes, not so much	1	A little bit less than others	1	Not energy efficient			
0	nothing	0	No, nothing	0	A whole lot less than others	0	Totally not energy efficient	0	No	0 No

Figure G3-2: Used questions Awareness and survey results

Awareness				
house	awareness	score	electricity	heat
A	2	A little aware	3104	27
B	1	Not aware	844	9
C	1	Not aware	2187	9
D	2	A little aware	4750	15
E	3	Aware	3750	8
F	2	A little aware	2261	17
G	3	Aware	2000	21
H	2	A little aware	0	0
I	2	A little aware	4125	7
J	2	A little aware	0	0
K	2	A little aware	3749	10
L	1	Not aware	1540	7
M	1	Not aware	3068	14
N	1	Not aware	1908	16
O	2	A little aware	2464	20

Figure G3-1: Total score Awareness with scale

0 =	Totally not aware	0
1 =	Not aware	5
2 =	A little aware	8
3 =	Aware	2
4 =	Very aware	0

APPENDIX G4 User survey data Attitude

	Adress		Agree of disagree	Energiebesparen vind ik teveel gedoe	Energiebesparen vind ik moeilijk	Energiebesparen kost mij teveel tijd	Ik kan een bijdrage leveren aan een beter milieu door zuinig om te gaan met energie	Ik kan geld besparen door zuinig om te gaan met energie	Als ik energie bespaar gaat dat ten koste van het comfort in huis	Als ik energie bespaar voel ik mij goed	Als ik energie bespaar wordt dat door de mensen in mijn omgeving gewardeerd	Als ik energie bespaar kost mij dat meer geld dan dat het oplevert	Als ik energie bespaar dan ben ik tevreden over mijzelf	Een beter milieu begint bij mijzelf		Attitude
	code															Totaal
1	A	56		Oneens	3 Oneens	3 Oneens	3 Neutraal	2 Eens	3 Neutraal	2 Neutraal	2 Neutraal	2 Oneens	3 Eens	3 Neutraal	2	3 Positive
	B			Eens	1 Neutraal	2 Oneens	3 Eens	3 Helemaal eens	4 Eens	1 Neutraal	2 Oneens	1 Oneens	3 Oneens	1 Helemaal eens	4	2 Neutral
	C			Eens	1 Neutraal	2 Neutraal	2 Eens	3 Eens	3 Eens	1 Oneens	1 Neutraal	2 Oneens	3 Oneens	1 Neutraal	1	2 Neutral
	D			Helemaal oneens	4 Neutraal	2 Helemaal c	4 Helemaal eens	4 Helemaal eens	4 Eens	1 Neutraal	2 Oneens	1 Helemaal c	4 Neutraal	2 Helemaal eens	4	3 Positive
	E			Helemaal oneens	4 Neutraal	2 Helemaal c	4 Helemaal eens	4 Helemaal eens	3 Helemaal c	4 Helemaal e	4 Neutraal	2 Helemaal c	4 Neutraal	2 Helemaal eens	4	3 Positive
	F			Oneens	3 Oneens	3 Neutraal	2 Eens	3 Helemaal eens	3 Eens	1 Eens	3 Eens	3 Eens	1 Neutraal	2 Eens	3	2 Positive
	G			Helemaal oneens	4 Helemaal c	4 Helemaal c	4 Helemaal eens	4 Eens	3 Oneens	3 Eens	3 Eens	3 Neutraal	2 Eens	3 Helemaal eens	4	3 Positive
	H			Oneens	3 Eens	1 Eens	1 Eens	3 Helemaal eens	4 Eens	1 Eens	3 Eens	3 Neutraal	2 Eens	3 Helemaal eens	4	3 Positive
	I			Helemaal eens	0 Eens	1 Helemaal e	0 Neutraal	2 Eens	3 Oneens	3 Helemaal c	0 Oneens	1 Oneens	3 Neutraal	2 Neutraal	2	2 Neutral
	K			Eens	1 Neutraal	2 Neutraal	2 Eens	3 Eens	3 Neutraal	2 Eens	3 Neutraal	2 Neutraal	2 Eens	3 Eens	3	2 Neutral
	L			Neutraal	2 Neutraal	2 Neutraal	2 Eens	3 Eens	3 Eens	1 Eens	3 Helemaal c	0 Neutraal	2 Eens	3 Helemaal eens	4	2 Neutral
	M			Eens	1 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Eens	1 Neutraal	2 Neutraal	2 Eens	1 Neutraal	2 Neutraal	2	2 Neutral
	N			Eens	1 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2 Neutraal	2	2 Neutral
	O			Oneens	3 Oneens	3 Oneens	3 Helemaal eens	4 Helemaal eens	4 Oneens	3 Helemaal e	4 Helemaal c	0 Helemaal c	4 Helemaal e	4 Helemaal eens	4	3 Positive

Helemaal oneens	5
Oneens	4
Neutraal	3
Eens	2
Helemaal eens	1

Very positive	4
Positive	3
Neutral	2
Negative	1
Very negative	0

Figure G4-2: Used questions Attitude and survey results

Attitude					
house	attitude	score	electricity	heat	energy
A	3	Positive	3104	27.285	38459.4
B	2	Neutral	843.5	8.995	12031.6
C	2	Neutral	2187	8.55	16423.2
D	3	Positive	4750	15	32100
E	3	Positive	3750	7.5	21000
F	2	Positive	2260.5	17.295	25432.8
G	3	Positive	2000	20.5	27700
H	3	Positive	0	0	0
I	2	Neutral	4124.5	7.07	21918.2
K	2	Neutral	3749	9.725	23221.4
L	2	Neutral	1539.5	7.27	12812.2
M	2	Neutral	3068	14	25044.8
N	2	Neutral	1908	15.645	22513.8
O	3	Positive	2463.5	20.3	29168.6

Figure G4-1: Total score Attitude with scale

0 =	Very negative	0
1 =	Negative	0
2 =	Neutral	7
3 =	Positive	7
4 =	Very positive	0

APPENDIX G5 User survey data Current energy saving behaviour

	adress		What do you do concerning energy saving at home			What do you do to save energy	De stekker van huishoudelijke apparaten uit het stopcontact halen wanneer deze niet in gebruik zijn	Wassen op lage temperaturen	Zo kort mogelijk douchen	De verwarming uitzetten in kamers waar niemand is	de verwarming een uur voordat u gaat slapen uitzetten	De lichten uit doen in kamers waar niemand is	Ingevroren voedsel ontdooien in de koelkast	Alleen afgekoelde etenswaren in de koelkast zetten	De gordijnen sluiten om de warmte binnen te houden.	De thermostaat uitzetten wanneer u op vakantie gaat.		Do you use energy saving lamps		Do you have a watersaving showerhead		Do you take notice of the energy label when buying new appliances		What is the average temperature in the livingroom in winter		Current energy behaviour
	code																									
1	A	38	Een beetje	2	41		Vaak	3 Vaak	3 Soms	2 Soms	2 Soms	2 Altijd	4 Soms	2 Soms	2 Vaak	3 Altijd	4	42	Ja, overal in huis	4	43	Weet ik niet	0	44	Bijna altijd	3	46	18-20	3	3 Much
	B		Een beetje	2			Vaak	3 Altijd	4 Soms	2 Altijd	4 Vaak	3 Altijd	4 Altijd	3 Vaak	3 Altijd	4 Altijd	4		Ja, maar niet overal in huis	2		Nee	0		Bijna altijd	3		<18	4	3 Much
	C		Weinig	1			Zelden	1 Soms	2 Soms	2 Soms	2 Zelden	1 Altijd	4 Altijd	4 Altijd	4 Altijd	1 Nooit	0		Nee	0		Weet ik niet	0		Bijna nooit	1		20-22	2	2 A little
	D		Veel	3			Soms	2 Zelden	1 Zelden	1 Altijd	4 Nooit	0 Altijd	4 Altijd	4 Altijd	4 Nooit	0 Vaak	3		Ja, overal in huis	4		Ja	4		Altijd	4		20-22	2	3 Much
	E		Veel	3			Altijd	4 Vaak	3 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4		Ja, overal in huis	4		Ja	4		Bijna altijd	3		<18	4	4 Very much
	F		Een beetje	2			Vaak	3 Vaak	3 Zelden	1 Zelden	1 Zelden	1 Vaak	3 Vaak	3 Vaak	3 Zelden	1 Altijd	4		Ja, maar niet overal in huis	2		Nee	0		Soms	2		20-22	2	2 A little
	G		Veel	3			Vaak	3 Vaak	3 Altijd	3 Vaak	3 Altijd	4 Altijd	4 Nooit	0 Altijd	4 Altijd	4 Altijd	4		Ja, maar niet overal in huis	2		Ja	4		Altijd	4		<18	4	3 Much
	H		Weinig	1			Vaak	3 Vaak	3 Zelden	1 Altijd	4 Soms	2 Altijd	4 Zelden	1 Altijd	4 Soms	2 Soms	2		Ja, maar niet overal in huis	2		Weet ik niet	0		Soms	2		18-20	3	2 A little
	I		Weinig	1			Nooit	0 Nooit	0 Nooit	0 Nooit	0 Nooit	0 Nooit	0 Nooit	0 Nooit	0 Nooit	0 Nooit	0		Ja, maar niet overal in huis	2		Weet ik niet	0		Nooit	0		20-22	2	0 Nothing
	J		Een beetje	2			Soms	2 Soms	2 Zelden	1 Soms	2 Altijd	4 Altijd	4 Zelden	1 Altijd	3 Zelden	1 Altijd	4		Ja, maar niet overal in huis	2		Nee	0		Altijd	4		18-20	3	2 A little
	K		Veel	3			Vaak	3 Soms	2 Altijd	3 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Altijd	4		Ja, maar niet overal in huis	2		Ja	4		Bijna altijd	3		18-20	3	3 Much
	L		Veel	3			Altijd	4 Nooit	0 Altijd	4 Altijd	4 Altijd	4 Altijd	4 Soms	2 Altijd	4 Altijd	4 Altijd	4		Ja, overal in huis	4		Ja	4		Bijna altijd	3		20-22	2	3 Much
	M		Een beetje	2			Nooit	0 Zelden	1 Zelden	1 Zelden	1 Zelden	1 Zelden	1 Zelden	1 Zelden	3 Vaak	3 Soms	2		Ja, maar niet overal in huis	2		Nee	0		Bijna nooit	1		22-24	1	1 Very little
	N		Weinig	1			Soms	2 Soms	2 Soms	2 Altijd	4 Altijd	4 Altijd	4 Altijd	3 Soms	2 Vaak	3 Altijd	4		Ja, maar niet overal in huis	2		Nee	0		Soms	2		<18	4	3 Much
	O		Veel	3			Soms	2 Altijd	4 Altijd	3 Altijd	4 Zelden	1 Altijd	4 Altijd	4 Altijd	4 Vaak	3 Altijd	4		Ja, maar niet overal in huis	2		Ja	4		Soms	2		<18	4	3 Much

4 Zeer veel
3 Veel
2 Een beetje
1 Weinig
0 Niets

0 Nooit
1 Zelden
2 Soms
3 Vaak
4 Altijd

4 Ja, overal in huis
2 Ja, maar niet overal in huis
0 Nee

4 Ja
0 Nee
0 Weet ik niet

4 Altijd
3 Bijna altijd
2 Soms
1 Bijna nooit
0 Nooit

Figure G5-1: Used questions current energy saving behaviour and survey result

Current energy saving behaviour					
house	current	score	electricity	heat	energy
A		3 Much	3104	27	38459
B		3 Much	844	9	12032
C		2 A little	2187	9	16423
D		3 Much	4750	15	32100
E		4 Very much	3750	8	21000
F		2 A little	2261	17	25433
G		3 Much	2000	21	27700
H		2 A little	0	0	0
I		0 Nothing	4125	7	21918
J		2 A little	0	0	0
K		3 Much	3749	10	23221
L		3 Much	1540	7	12812
M		1 Very little	3068	14	25045
N		3 Much	1908	16	22514
O		3 Much	2464	20	29169

0 =	Nothing	1
1 =	Very little	1
2 =	A little	4
3 =	Much	8
4 =	Very much	1

Figure G5-2: Total score Current energy saving behaviour with scale

APPENDIX G6 User survey data Influence previous building type

	adress		What was the building type of your previous house			Which period was your previous house build		previous habits		
	code									combined
1	A	15	Eengezinshuis / rijwoning - tussenwoning	2	16	1930-1950	3	rij	3	6
	B		Portiekwoning / flat / appartement	1		1990-2005	5	app	5	2
	C		Portiekwoning / flat / appartement	1		Na 2005	6	app	6	1
	D		Eengezinshuis / twee onder een kap	3		1990-2005	5	fam	5	7
	E		Portiekwoning / flat / appartement	1		1960-1980	4	app	4	3
	F		Portiekwoning / flat / appartement	1		1990-2005	5	app	5	2
	G		Portiekwoning / flat / appartement	1		1990-2005	5	app	5	2
	H		Portiekwoning / flat / appartement	1		Na 2005	6	app	6	1
	I		Portiekwoning / flat / appartement	1		1960-1980	4	app	4	3
	J		Portiekwoning / flat / appartement	1		1930-1950	3	app	3	4
	K		Eengezinshuis / rijwoning - tussenwoning	2		1960-1980	4	rij	4	5
	L		Anders, namelijk	1		1990-2005	5	app	5	2
	M		Eengezinshuis / rijwoning - tussenwoning	2		1960-1980	4	rij	4	5
	N		Portiekwoning / flat / appartement	1		1990-2005	5	app	5	2
	O		Anders, namelijk	3		1990-2005	5	fam	5	7

1 Appartment
2 Terracced house
3 Family house

3 1930-1950
4 1960-1980
5 1990-2005
6 Na 2005

Figure G6-2: Used questions Influence previous building type and survey results

Building type & period						
house	building ty	type	building pe	electricity	heat	energy
A	6	rij	3	3104	27	38459
B	2	app	5	844	9	12032
C	1	app	6	2187	9	16423
D	7	fam	5	0	0	32100
E	3	app	4	0	0	21000
F	2	app	5	2261	17	25433
G	2	app	5	2000	21	27700
H	1	app	6	0	0	0
I	3	app	4	4125	7	21918
J	4	app	3	0	0	0
K	5	rij	4	3749	10	23221
L	2	app	5	1540	7	12812
M	5	rij	4	3068	14	25045
N	2	app	5	1908	16	22514
O	7	fam	5	2464	20	29169

type		period	
1	app	6	heel zuinig
2	app	5	zuinig
3	app	4	voldoende zuinig
4	app	3	gemiddeld zuinig
5	rij	4	beetje zuinig
6	rij	3	niet zuinig
7	fam	5	totaal niet zuinig

Figure G6-1: Total score Influence previous building type and scale

APPENDIX H Boxplots survey results

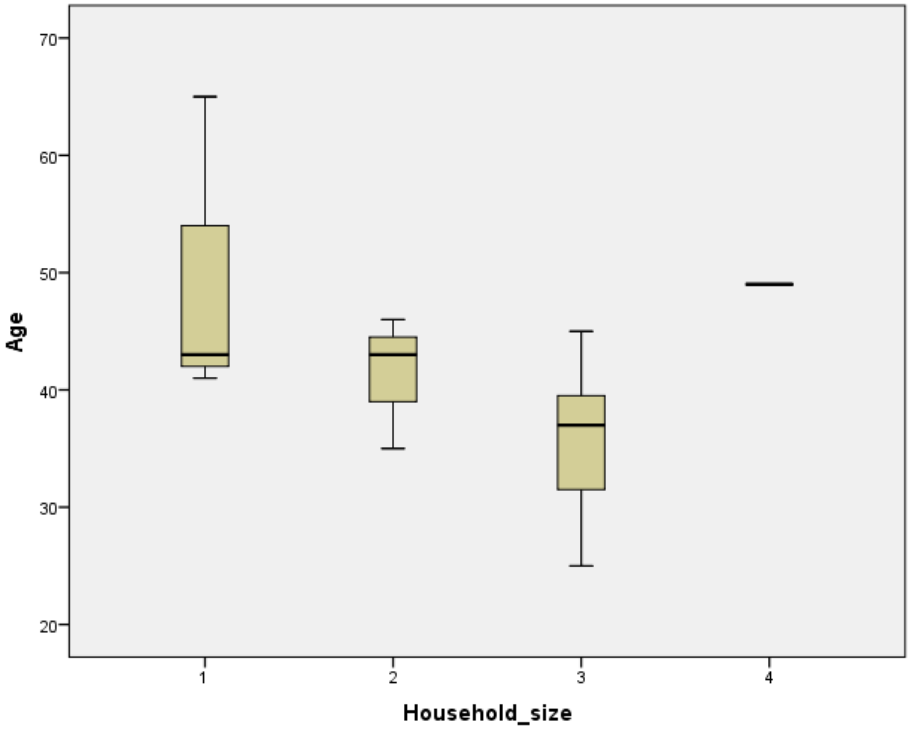


Table H-30: Boxplot Age - Household Size

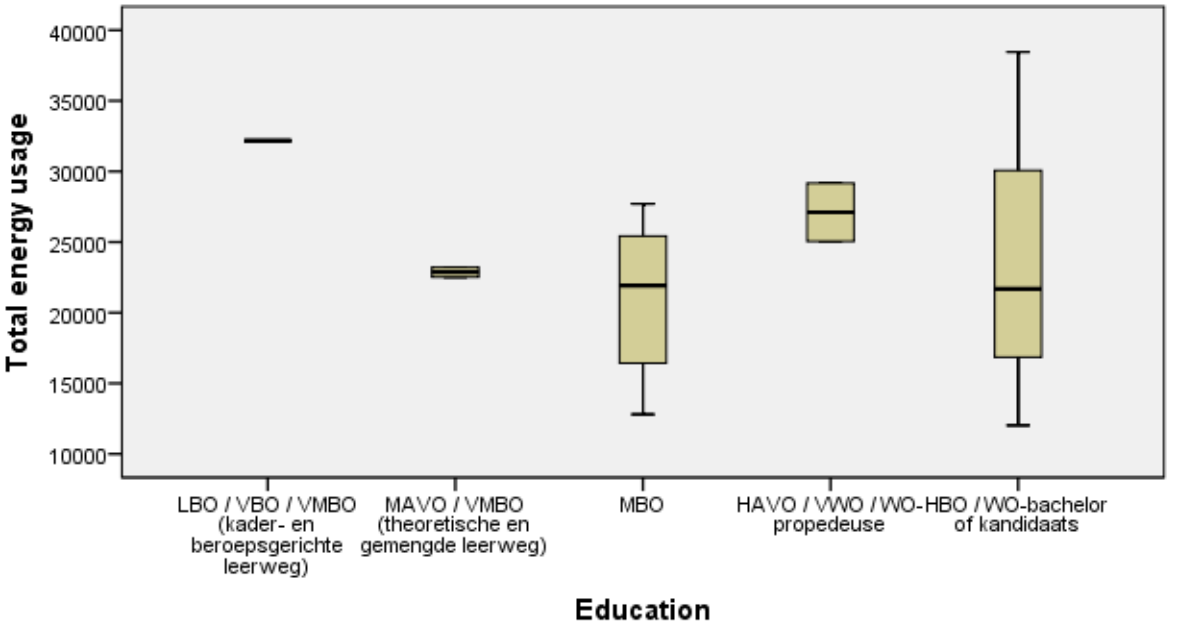


Table H-29: Boxplot Total energy use - Education

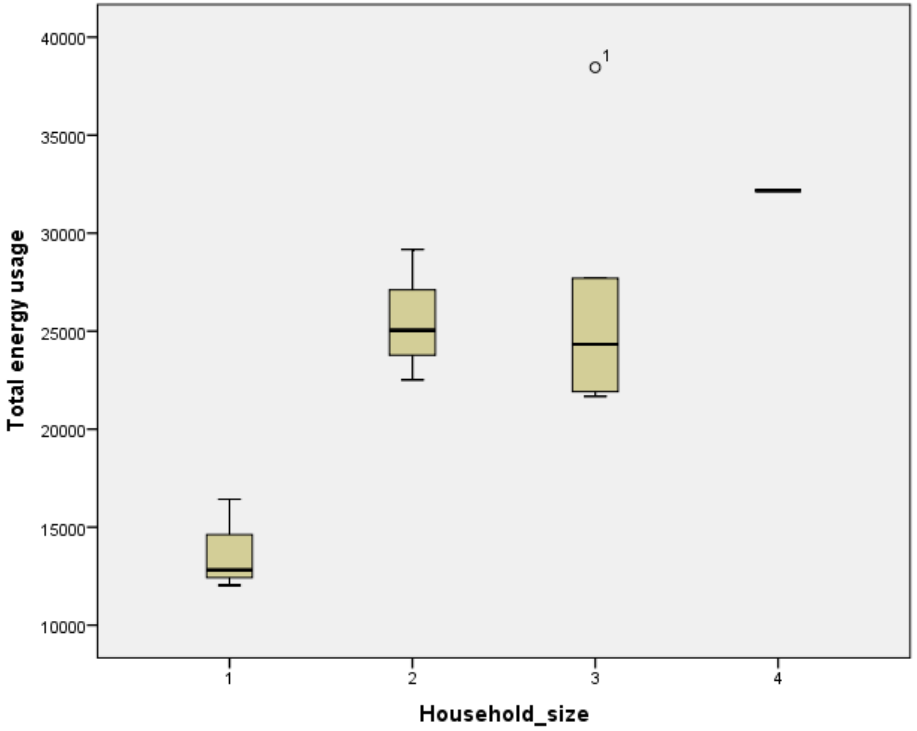


Table H-32: Boxplot Total energy use - Household size

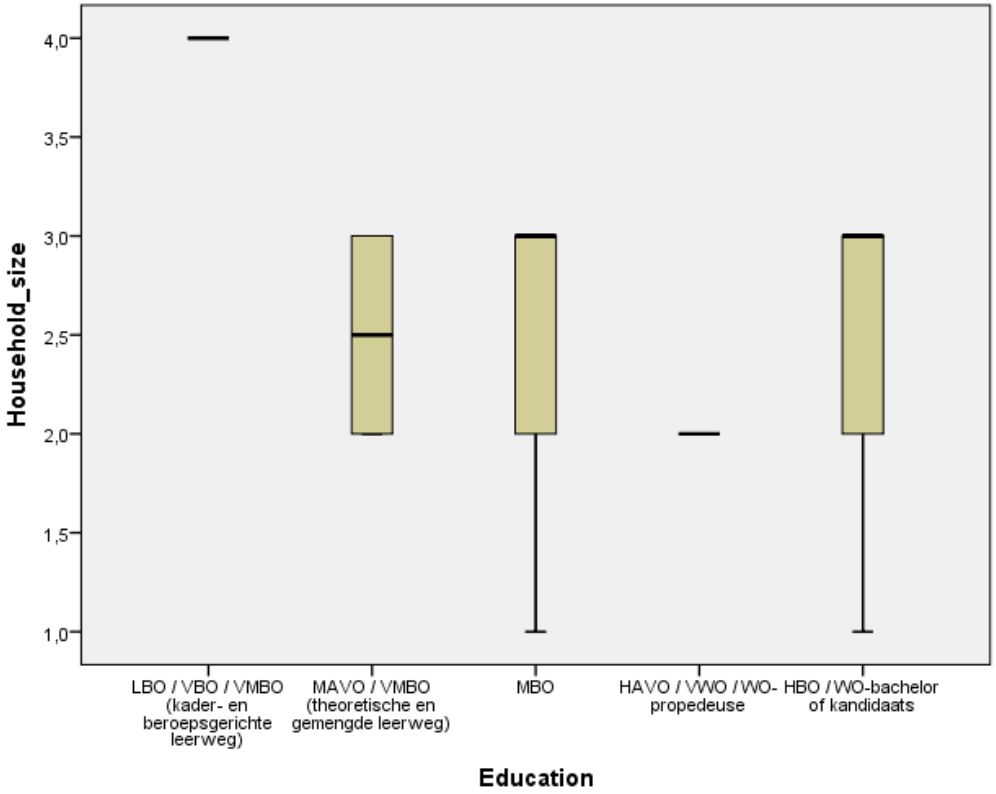


Table H-31: Boxplot Household size - Edication

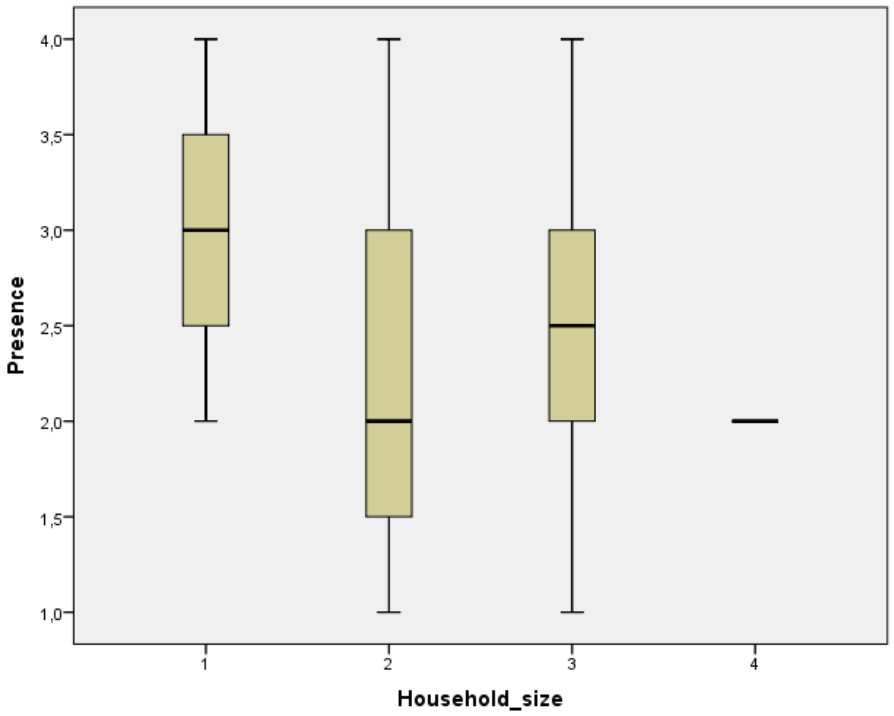


Table H-33: Boxplot Household size - Presence

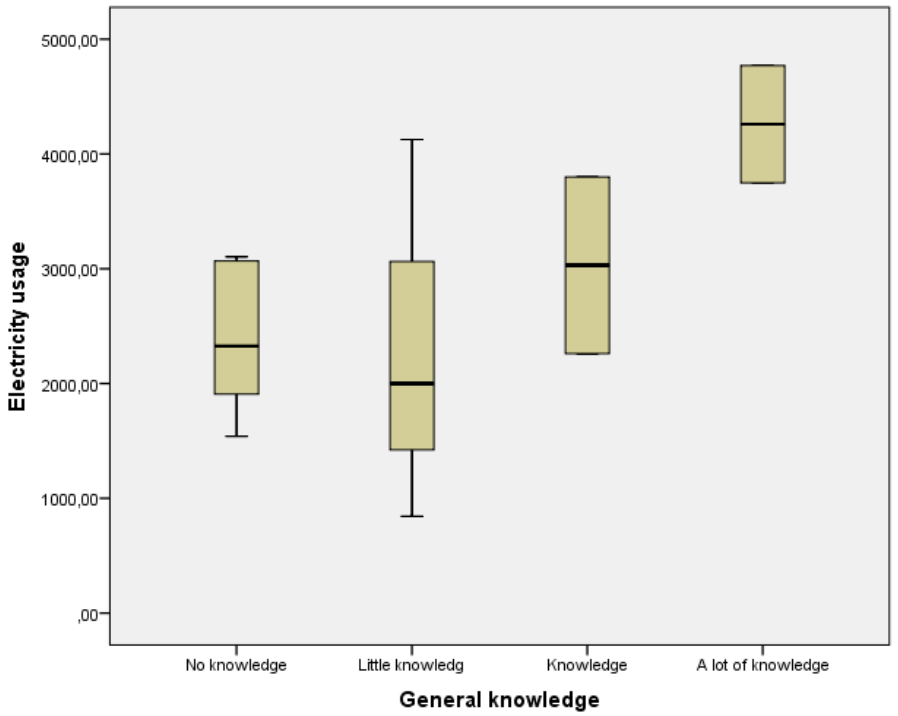


Table H-34: Boxplot General knowledge - Electricity use

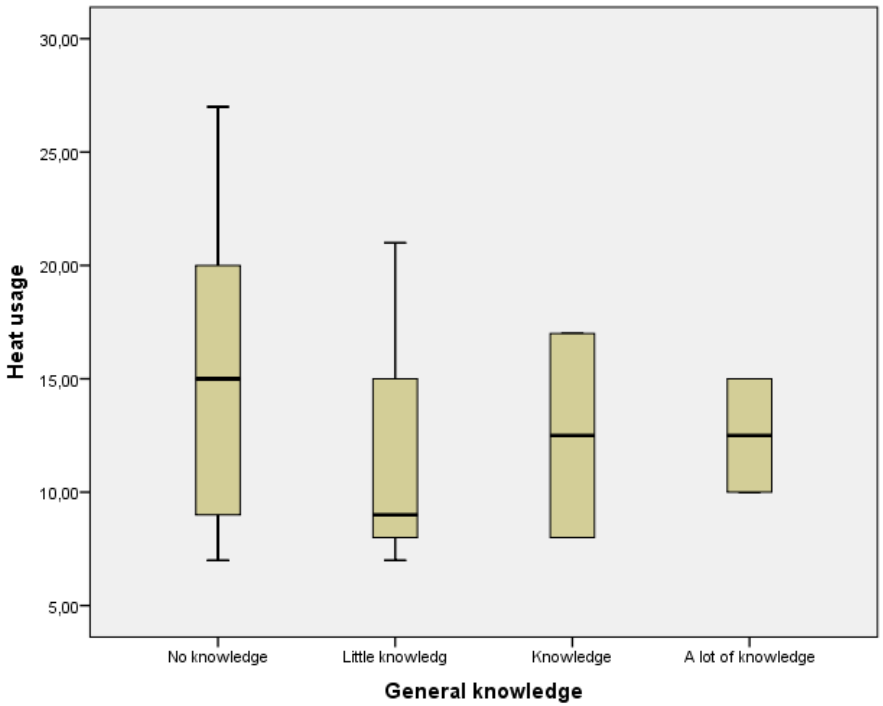


Table H-36: Boxplot General knowledge - Heat use

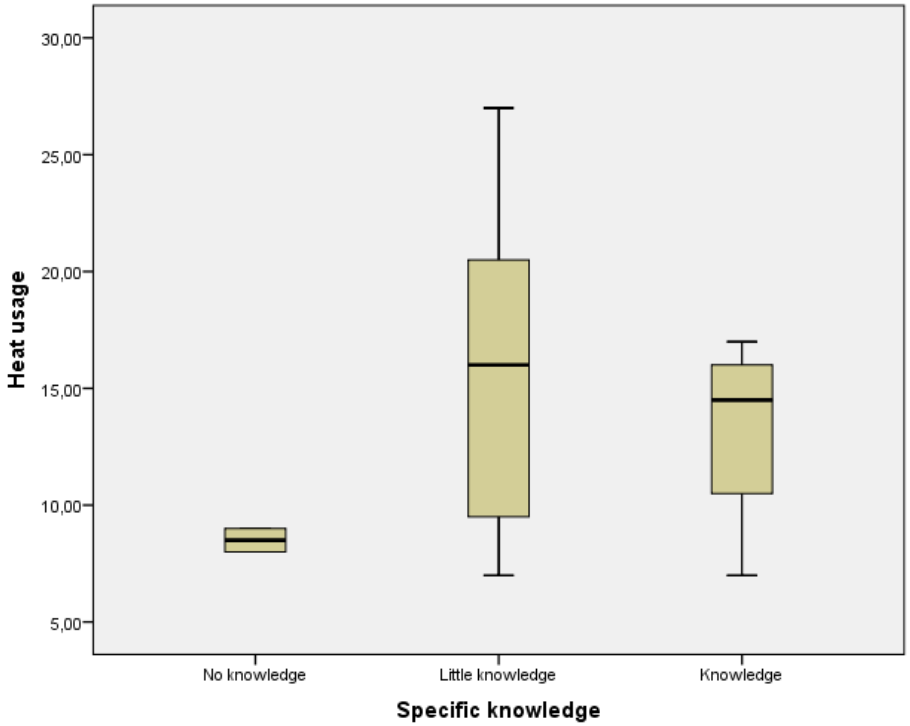


Table H-35: Boxplot Secific knowledge - Heat use

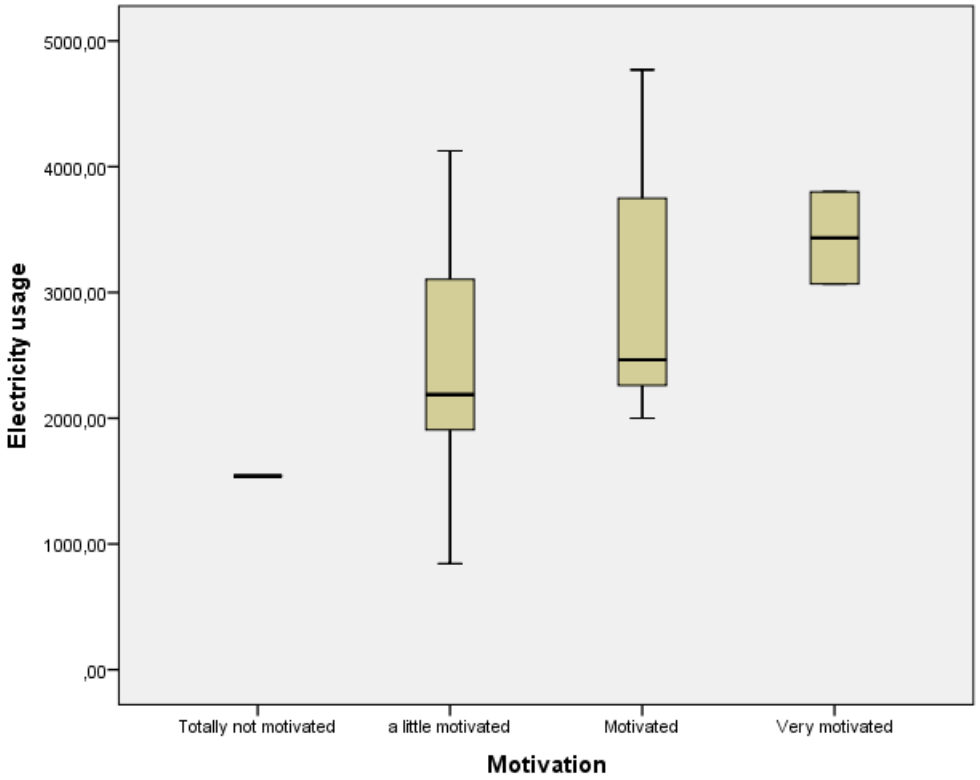


Table H-37: Boxplot Motivation - Electricity use

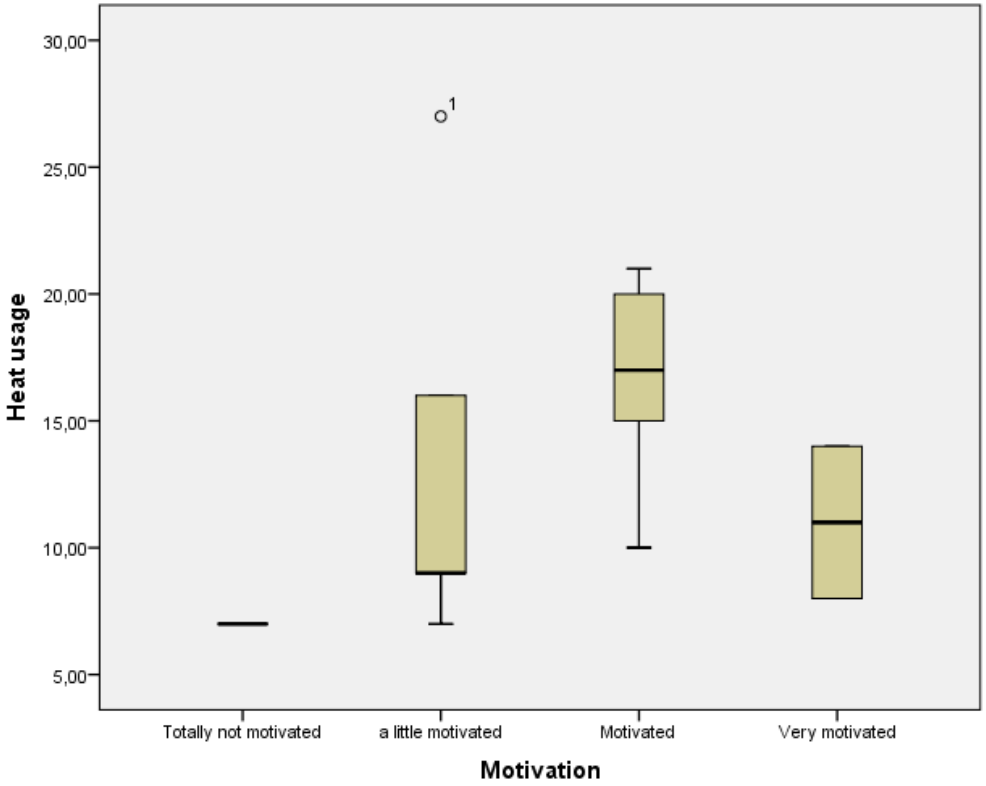


Table H-38: Boxplot Motivation - Heat use

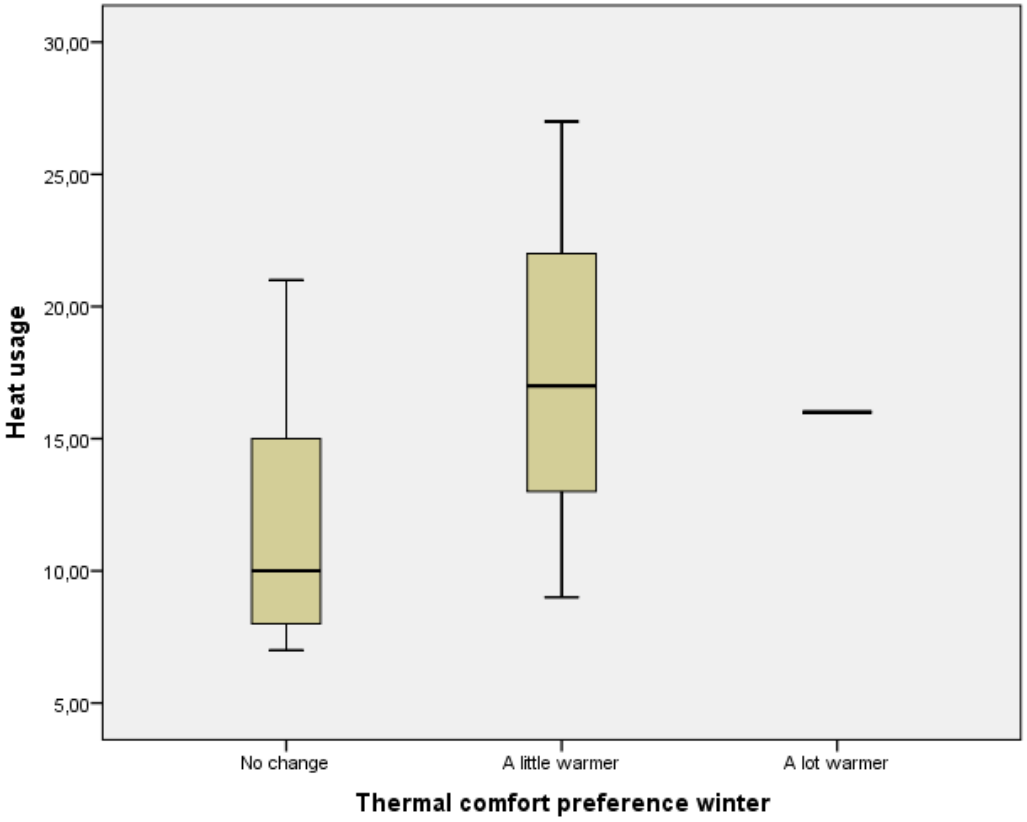


Table H-40: Boxplot Thermal comfort prefernce winter - Heat usage

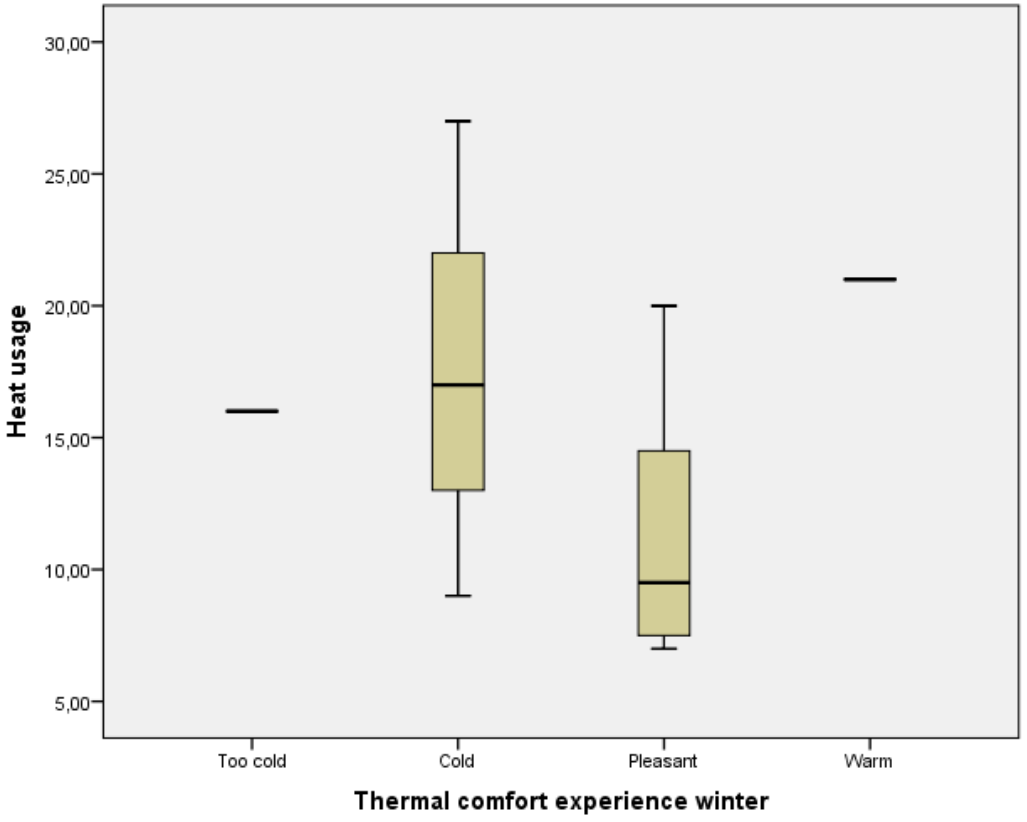


Table H-39: Boxplot Thermal comfort experience winter - Heat usage

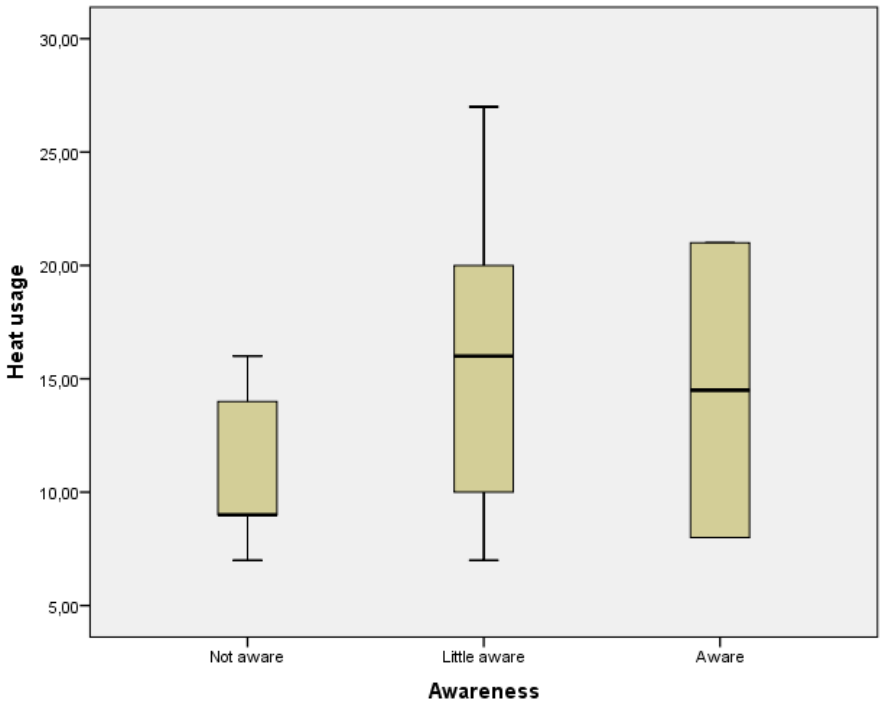


Table H-42: Boxplot Awareness - Heat use

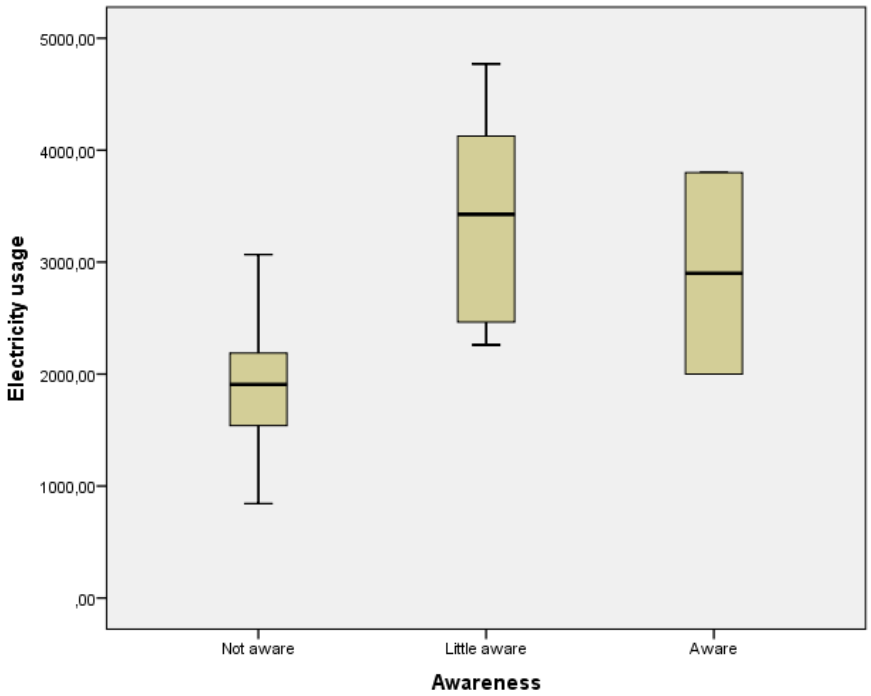


Table H-41: Boxplot Awareness - Electricity use

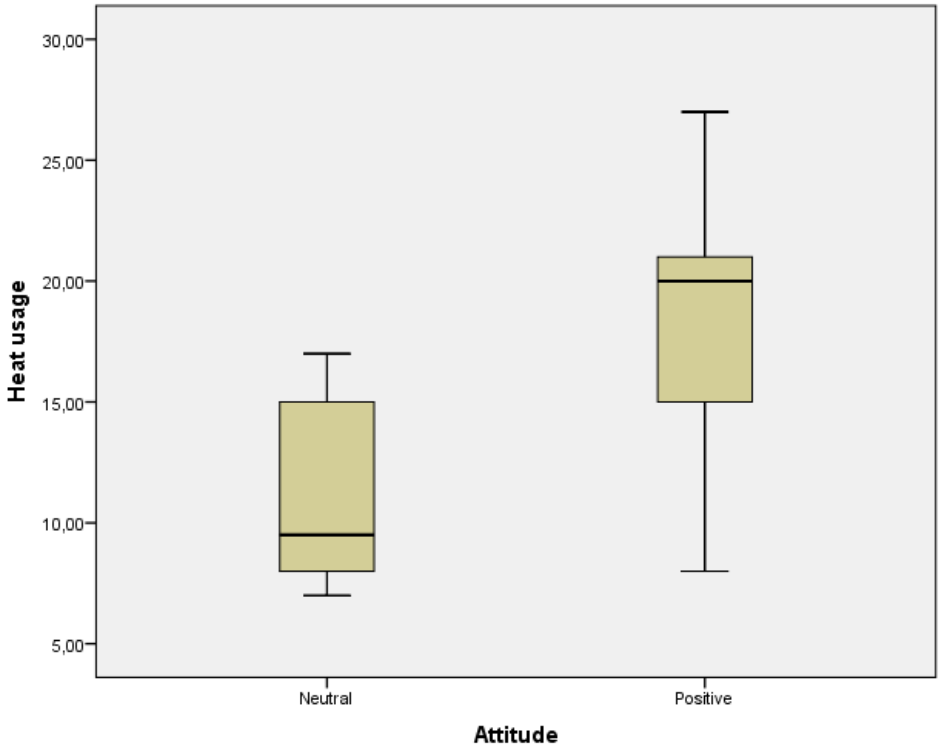


Table H-44: Boxplot Attitude - Heat use

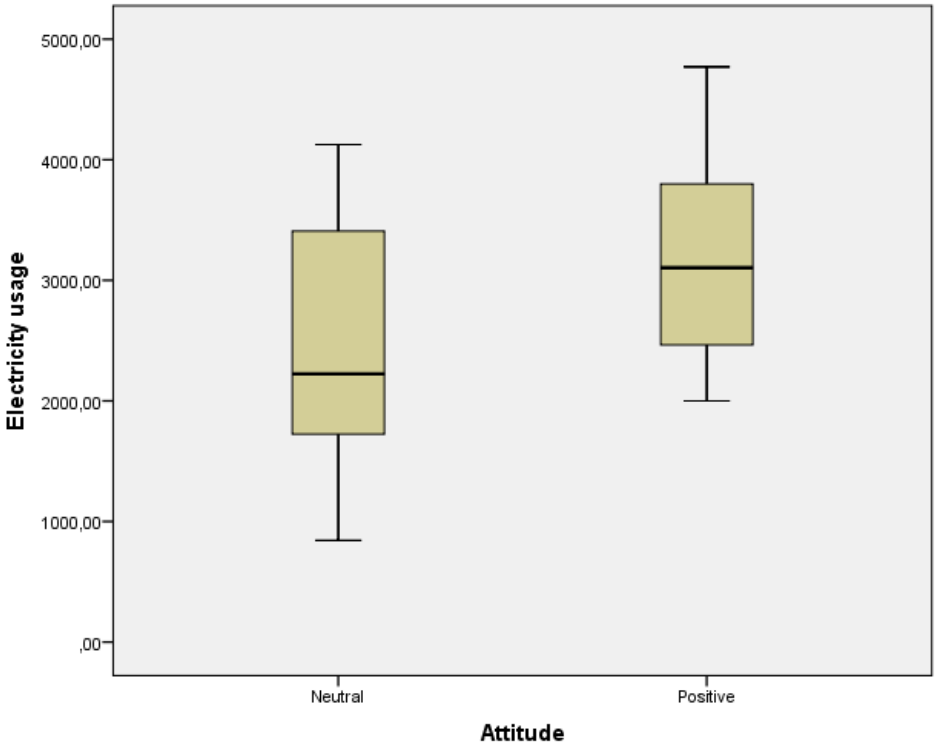


Table H-43: Boxplot - Attitude - Electricity use

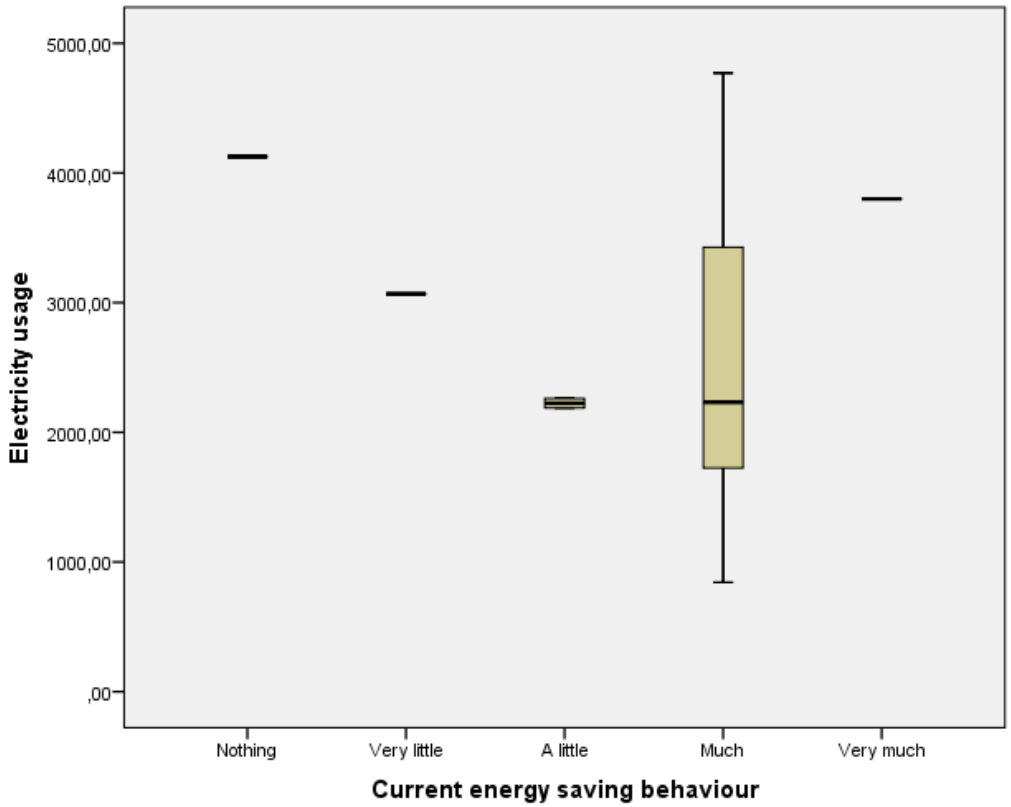


Table H-46: Boxplot Current energy saving behaviour - Electricity use

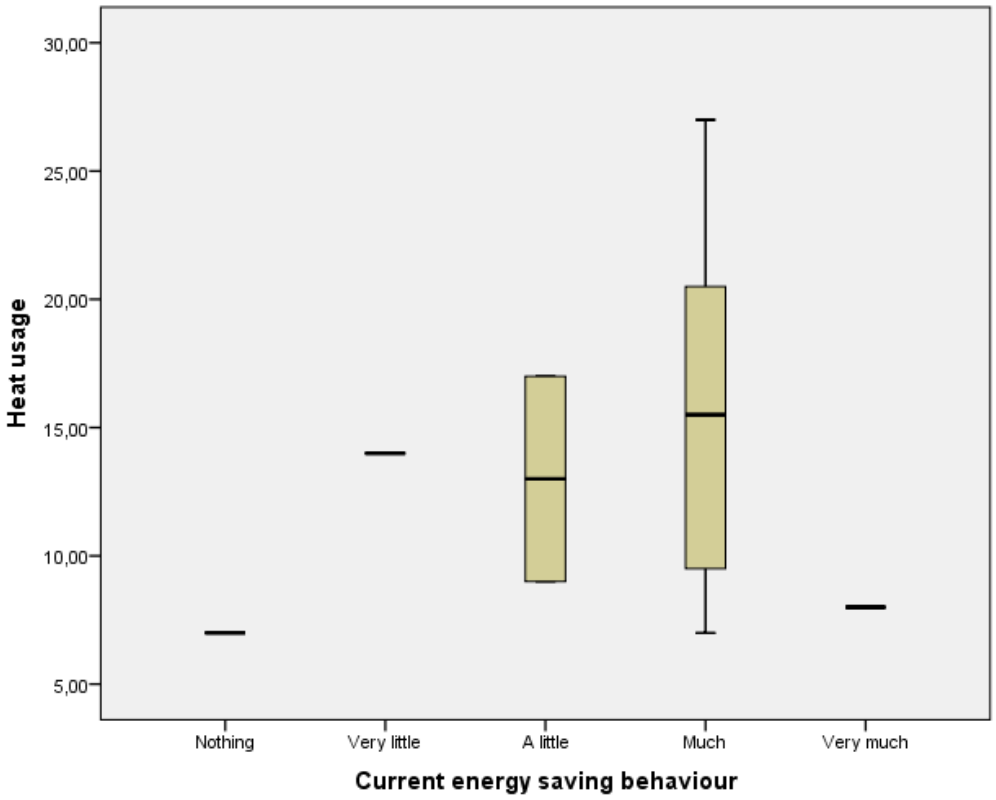


Table H-45: Boxplot Current energy saving behaviour - Heat use

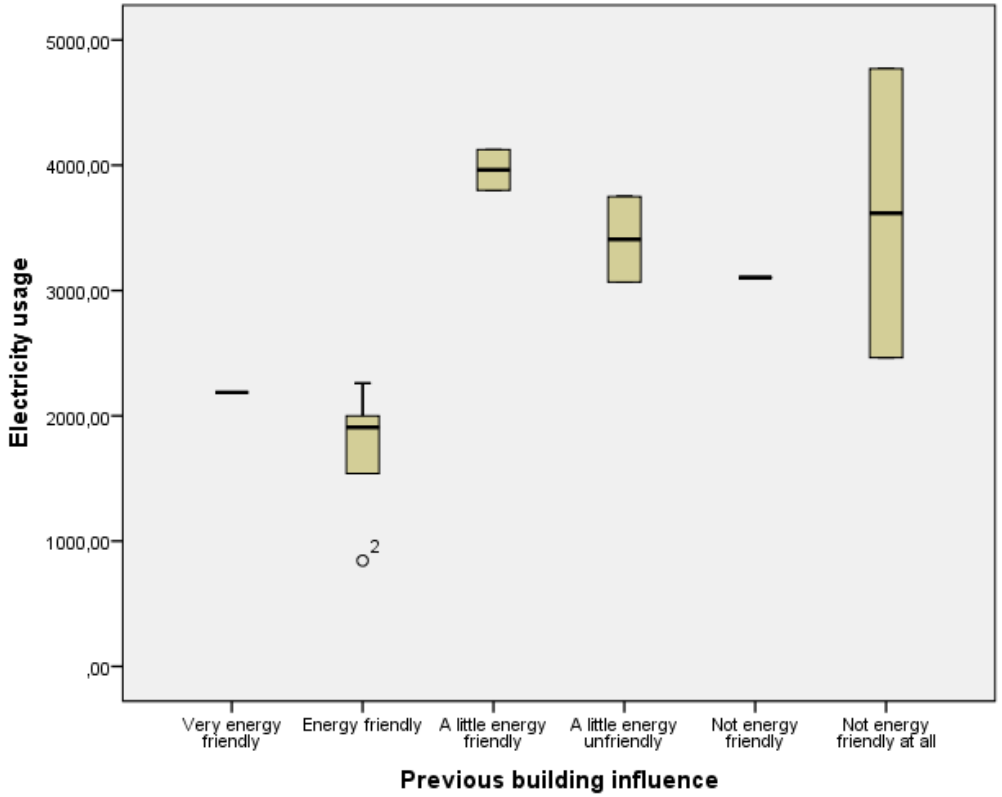


Table H-48: Boxplot Previous building influence - Electricity use

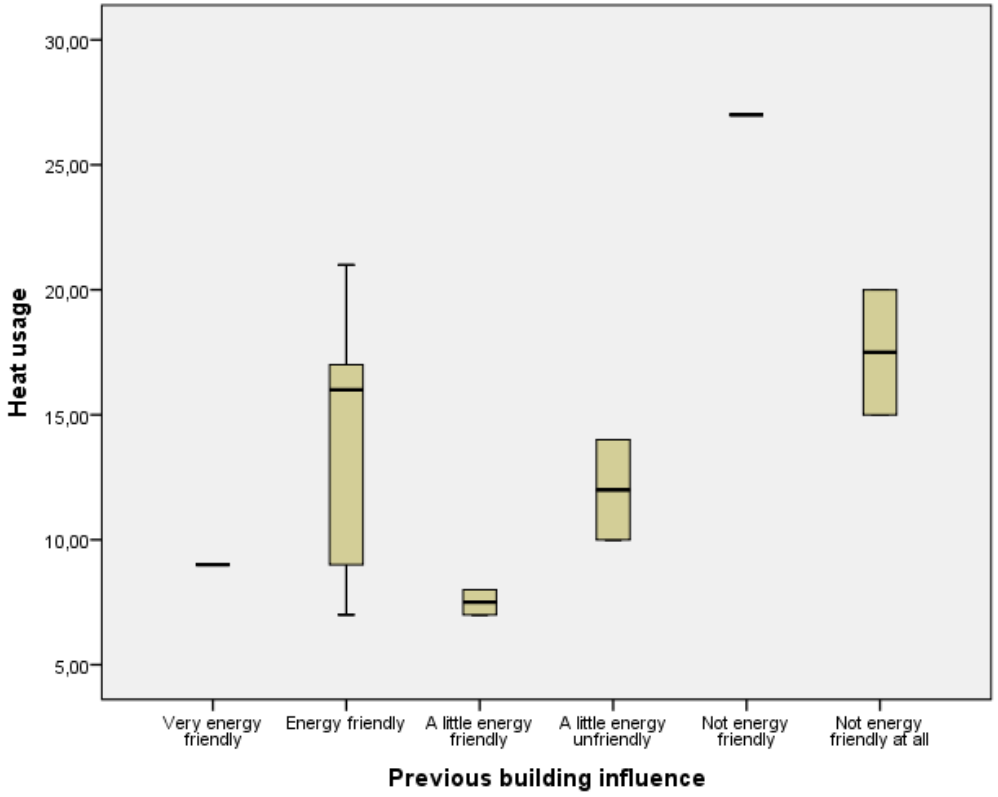


Table H-47: Boxplot Previous building influence - Heat use

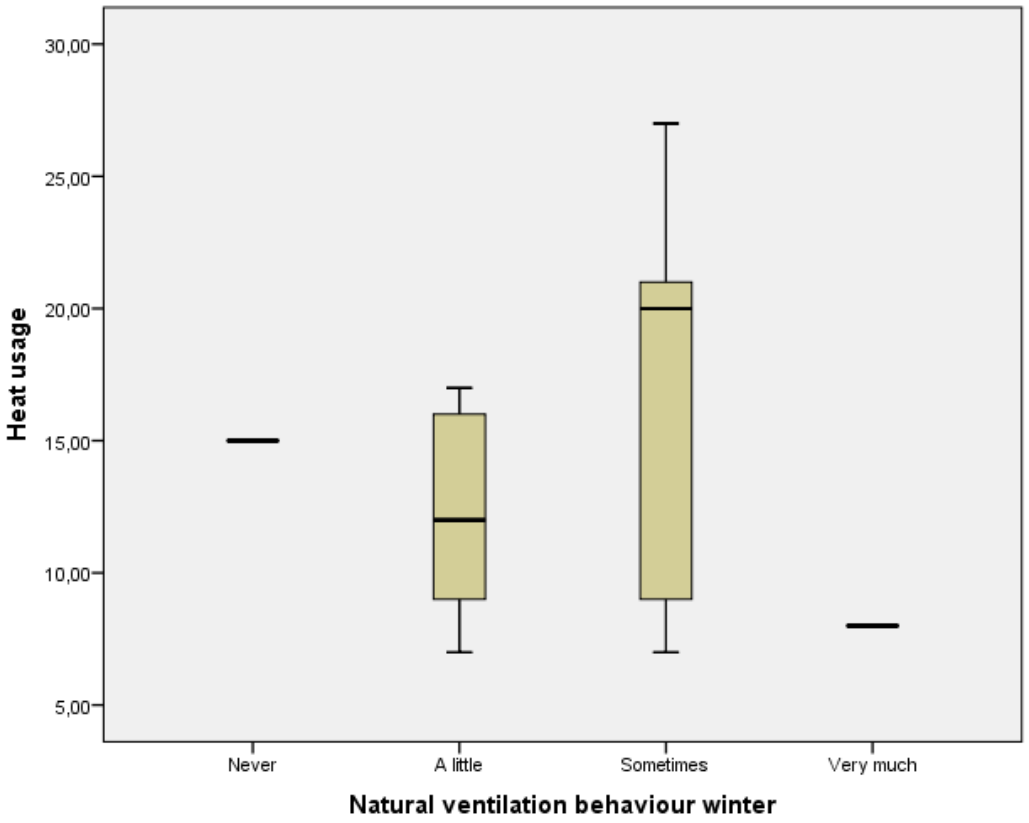


Table H-49: Boxplot Natural ventilation behaviour winter - Heat use

APPENDIX I Daily log

	Maandag		Badkamer						Keuken				Woonkamer						Slaapkamer 1		Slaapkamer 2		Slaapkamer 3		Zonwering	Meterstanden		
	Tijd	aanwezig	douche		radiator aan	deur naar gang open	wasmachine aan	droger aan	kookplaat gebruikt	vaatwasser aan	oven/magnetron aan (±minuten)	ventilatie luiken open	ventilatie luiken open	ramen/deuren open	mechanische ventilatie			stand thermosstaat (graden)	ramen open	deur naar gang open	ramen open	deur naar gang open	ramen open	deur naar gang open	naar beneden	electra	warmte	water
			aantal personen	*(±minuten)*											*stand 1*	*stand 2*	*stand 3*											
nacht	0:00 - 6:00																											
ochtend	7:00																											
	8:00																											
	9:00																											
	10:00																											
	11:00																											
	12:00																											
middag	13:00																											
	14:00																											
	15:00																											
	16:00																											
	17:00																											
avond	18:00																											
	19:00																											
	20:00																											
	21:00																											
	22:00																											
	23:00																											

(aankruisen indien van toepassing)

Figure I-1: Longitudinal questionnaire for occupants during monitoring period

APPENDIX J Monitoring results

Reading	Elapsed (minutes)	Date	Time	slaapkamer tuin T	slaapkamer tuin RV	Buitentemp lelystad	slaapkamer straat T	slaapkamer straat RV	woonkamer T	woon RV	keuken T	keuken RV
20	95	25/9	8:03	21.1	100	12.2	22.7	65.6	22.4	56.5	22.6	55.6
92	455	25/9	14:03	21.4	100	16.3	22.4	62.7	22.4	56.9	22.6	56.4
175	870	25/9	20:58	21.4	100	12.9	22.5	62.3	22.4	57.1	22.6	56.4
213	1060	26/9	0:08	21.4	100	13	22.6	64.2	22.4	57.3	22.6	56.4
308	1535	26/9	8:03	21.4	100	12.6	22.7	65.9	22.1	53.7	22.4	52.6
380	1895	26/9	14:03	19.9	54.5	15.4	22	53.2	22.1	50.6	22.5	48.6
463	2310	26/9	20:58	20.4	48.5	11.3	22	51	22.1	48	22.4	46.9
501	2500	27/9	0:08	20.4	53	10.5	22.2	53.3	22.1	48.1	22.3	47.6
596	2975	27/9	8:03	20.6	55	12.5	22.4	60.2	21.9	47.4	22.1	47.0
668	3335	27/9	14:03	19.3	40.5	15.3	21.4	49.5	21.9	46.4	22.3	45.9
751	3750	27/9	20:58	20.1	50.5	11.3	21.7	47.6	22.3	49.7	22.8	47.8
789	3940	28/9	0:08	19.9	47.5	9.5	21.9	50.5	22	45	22.3	44.4
884	4415	28/9	8:03	20.4	49.5	12.1	21.8	51.6	21.5	41.9	21.9	41.3
956	4775	28/9	14:03	20.1	43.5	16	21.6	51.3	21.6	42.3	22.1	41.9
1039	5190	28/9	20:58	19.9	47.5	12.4	21.3	49.1	21.5	42.9	22	42.1
1077	5380	29/9	0:08	19.9	48	12.1	21.7	51.7	21.5	42.2	21.8	42.3
1172	5855	29/9	8:03	19.9	45.5	13.7	21.9	53.5	21.3	42.4	21.7	41.4
1244	6215	29/9	14:03	20.1	46.5	14.7	21.7	48.3	21.8	45.1	22.2	44.1
1327	6630	29/9	20:58	20.1	52	10.5	22	49.2	22.3	52.1	23	48.9
1365	6820	30/9	0:08	20.1	49.5	10	22.1	50.2	22	48.1	22.4	46.7
1460	7295	30/9	8:03	20.4	52	11.2	22.2	55.9	21.9	47.1	22.1	46.4
1532	7655	30/9	14:03	20.6	66	16.1	22	51	22	46.8	22.3	45.8
1615	8070	30/9	20:58	20.4	100	9.9	22.2	50.5	22.1	45.8	22.6	44.1
1653	8260	1/10	0:08	20.4	85.5	11.5	22.3	52	21.9	44.3	22.2	43.4
1748	8735	1/10	8:03	20.1	73	12	22.1	53.4	21.7	43.8	22	42.4
1820	9095	1/10	14:03	20.1	60.5	17.3	22	49.3	21	38.7	21.6	38.1
1903	9510	1/10	20:58	20.1	61.5	15	21.8	55.9	21.7	44.8	22.2	43.6
1941	9700	2/10	0:08	20.1	53.5	13.4	22	55.3	21.7	43.4	22.1	42.5
2036	10175	2/10	8:03	19.9	48	14	21.9	56	21.7	43.9	21.8	43.5
2108	10535	2/10	14:03	19.9	46.5	17	21.7	52.1	21.8	42.9	22	42.3
2191	10950	2/10	20:58	19.9	40.5	13.1	21.6	50.7	21.8	40.9	22.1	40.3
2229	11140	3/10	0:08	20.1	44.5	12.9	21.7	52.3	21.7	40.9	21.8	40.9
2324	11615	3/10	8:03	20.6	52	13.6	21.7	53.2	21.7	40.8	21.8	41.7
2396	11975	3/10	14:03	20.4	48	13.7	21.4	51.1	21.9	41	22	41.1
2479	12390	3/10	20:58	20.4	48.5	11.2	21.5	50.1	22.1	45	22.4	44.8
2517	12580	4/10	0:08	20.4	48	10.5	21.6	50.4	22	43.5	22	43.3
2612	13055	4/10	8:03	20.6	56.5	10.5	21.7	51.9	22.1	47.2	22.2	46.9
2684	13415	4/10	14:03	20.6	97	14.1	21.7	54.8	22.3	53.2	22.4	51.1
2767	13830	4/10	20:58	20.9	100	10.2	22	58.5	22.6	56.4	22.6	56.1
2805	14020	5/10	0:08	20.6	100	10.4	22	59.9	22.4	56	22.4	56.1
2900	14495	5/10	8:03	21.1	100	13.8	22.2	62	22.4	55.5	22.4	55.6
2972	14855	5/10	14:03	21.1	100	15.4	22.1	62	22.4	58.1	22.5	58.2
3055	15270	5/10	20:58	21.1	100	11	22	61.6	22.5	57.1	22.7	56.5
3093	15460	6/10	0:08	21.1	100	9.8	22.1	62.4	22.4	56.4	22.4	56.5
3188	15935	6/10	8:03	20.9	100	10	22.1	65.3	22.3	53.8	22.3	54.0
3260	16295	6/10	14:03	21.1	100	13.8	21.9	63.1	22.3	52	22.4	51.3
3343	16710	6/10	20:58	21.1	100	6.3	22	61.7	22.4	52.1	22.7	51.5
3381	16900	7/10	0:08	20.9	100	5.2	22.1	62.6	22.3	51.1	22.4	51.1
3476	17375	7/10	8:03	20.9	100	11.7	22.1	65.9	22.3	49.7	22.4	49.9
3548	17735	7/10	14:03	21.1	100	13.8	21.7	61	22.1	51.6	22.3	51.4
3631	18150	7/10	20:58	20.9	100	5.6	21.8	60.2	22.2	53	22.5	52.4
3669	18340	8/10	0:08	20.9	100	4	21.8	61.6	22.3	53.7	22.5	53.7
3764	18815	8/10	8:03	20.9	100	7.9	22.1	65.6	22.3	53.9	22.3	53.6
3836	19175	8/10	14:03	20.9	100	13	22.1	65.6	22.5	58.4	22.5	57.9
3919	19590	8/10	20:58	21.4	100	5.3	22.2	65.2	22.7	62.2	23.2	64.4
3957	19780	9/10	0:08	21.1	100	3.5	22.2	65.4	22.6	60	22.7	60.2
4052	20255	9/10	8:03	21.4	100	10	22.3	66.9	22.5	58.7	22.5	58.5
4124	20615	9/10	14:03	21.1	100	12.9	22	62.5	22.2	50.7	22.2	52.8
4207	21030	9/10	20:58	21.1	91.5	6	21.7	58.1	22.3	50.5	22.4	50.7
4245	21220	10/10	0:08	20.9	92	6.1	21.8	58.1	22.3	49.7	22.3	50.5
4340	21695	10/10	8:03	20.6	82.5	8.8	21.9	58.6	22.1	47.3	22.1	48.1
4412	22055	10/10	14:03	20.6	76.5	12	21.8	57.1	22	44.1	22.1	45.4
4495	22470	10/10	20:58	20.6	73.5	5.2	21.8	55.6	22.2	46	22.3	46.3
4533	22660	11/10	0:08	20.6	80	3.8	21.8	58.1	21.9	45.2	22	46.0
4628	23135	11/10	8:03	20.6	90.5	8.1	21.8	60.6	22	45.9	22	46.6
4700	23495	11/10	14:03	20.1	74.5	13.8	21.5	58.2	21.7	46.5	22	46.5
4783	23910	11/10	20:58	20.1	78	8.6	21.3	60.8	21.6	49.8	21.7	49.5
4821	24100	12/10	0:08	20.1	83.5	9	21.4	63.3	21.7	49.8	21.7	50.0
4916	24575	12/10	8:03	20.4	100	11	21.4	66.3	21.7	48	21.7	49.4
4988	24935	12/10	14:03	20.1	100	12.3	21	62.6	21.4	45.8	21.4	46.6
5071	25350	12/10	20:58	20.1	94.5	8.2	20.9	59.6	22	50.6	22	50.8
5109	25540	13/10	0:08	20.1	91.5	7.6	21	60	21.9	50.5	21.8	50.7
5204	26015	13/10	8:03	20.1	84	8.8	21.4	63.9	21.5	47	21.5	48.4
5276	26375	13/10	14:03	20.1	91.5	10.7	20.7	57.5	21.7	51.1	21.7	51.5
5359	26790	13/10	20:58	20.1	88	8.2	20.9	59.6	21.8	51	21.9	52.8
5397	26980	14/10	0:08	19.9	83.5	7.7	21	60.3	21.8	50.7	21.7	52.3
5492	27455	14/10	8:03	20.1	87.5	7.3	21.1	62.1	21.7	49.5	21.5	51.7
5564	27815	14/10	14:03	20.1	100	11.2	20.9	60.2	21.7	50.4	21.6	51.6
5647	28230	14/10	20:58	20.1	100	7.9	20.9	60.1	21.8	53.8	21.7	54.6
5685	28420	15/10	0:08	20.1	100	7.1	20.9	60.7	21.8	53.1	21.6	53.8
5780	28895	15/10	8:03	19.9	100	9.6	21.2	63.5	21.6	51.1	21.4	53.0
5852	29255	15/10	14:03	19.9	90.5	12.6	20.9	60.5	21.5	50	21.1	51.8
5935	29670	15/10	20:58	19.9	89.5	10	20.8	59	21.5	50.8	21.3	52.5
5973	29860	16/10	0:08	19.9	91.5	9.5	20.7	59.4	21.5	50.2	21.2	51.9
6068	30335	16/10	8:03	19.9	82.5	8.8	20.9	62.4	21.5	50.1	21.3	52.0
6140	30695	16/10	14:03	19.9	84.5	14	20.5	59.3	21.5	51.5	21.2	52.5
6223	31110	16/10	20:58	19.9	96.5	10	20.4	58.8	21.5	51.5	21.3	53.0
6261	31300	17/10	0:08	19.9	92	8.4	20.6	60.2	21.6	52.2	21.3	53.4
6356	31775	17/10	8:03	20.1	96.5	9.4	21	64.5	21.7	54.1	21.4	55.1
6428	32135	17/10	14:03	20.1	93	14.9	20.3	56.9	21.6	52.2	21.4	53.6
6511	32550	17/10	20:58	19.9	79.5	13.6	20.1	58.6	21.8	53	21.7	53.1
6549	32740	18/10	0:08	19.9	78	13.2	20.3	59.7	21.7	52.9	21.7	53.5
6644	33215	18/10	8:03	19.9	78	15.3	20.7	64.9	21.5	52.2	21.3	53.4
6716	33575	18/10	14:03	20.6	63.5	17.7	20.5	61.4	21.3	51.5	21.2	53.4
6799	33990	18/10	20:58	20.4	93	13.3	19.7	62.4	19	61.4	19.8	58.9

List of periods out-of-specification

Luchttemper	None		min	17.5	37.5	3.5	19.7	47.6	20.6	38.7	19.8	38.1
Luchtvochtig	None		max	21.7	100	20.1	22.7	66.9	22.7	62.2	23.2	64.4

Figure J_1: Monitoring data house H

Date	Time	Buitentemp lelystad	T_woon	RV_woon	T_slaap(straat)	RV_slaap(straat)	T_slaap(tuin)	RV_slaap(tuin)	T_keuken	RV_keuken
25/9	8:03	12.2	21.6	61	21.2	64	19.7	67.6		
25/9	14:03	16.3	21.7	61.1	21.2	63.1	19.9	68.9		
25/9	20:58	12.9	22.1	62	21.4	64.8	20.1	69.6		
26/9	0:08	13	22	61.8	21.9	65.1	20	69.6		
26/9	8:03	12.6	21.6	57.4	21.3	60.6	19.7	63.7		
26/9	14:03	15.4	21.2	52.2	21.3	53.4	18.8	57.6		
26/9	20:58	11.3	21.3	45	21.1	49.8	19.3	57.5		
27/9	0:08	10.5	21.5	47.9	21	50.5	19.2	54		
27/9	8:03	12.5	21.4	46.3	20.9	48.4	18	51		
27/9	14:03	15.3	20.7	46.6	21	47.4	18.5	54		
27/9	20:58	11.3	21.5	47.3	21	46.5	19.3	51.8		
28/9	0:08	9.5	21.8	48	20.8	45	18.7	50		
28/9	8:03	12.1	20.7	42.8	20.8	43.8	17.7	47.2		
28/9	14:03	16	19	39.4	21	40.3	17.9	44.1		
28/9	20:58	12.4	21.1	44.9	21.1	42.2	18.1	48.6		
29/9	0:08	12.1	20.9	44.5	21.1	42.9	17.4	50		
29/9	8:03	13.7	20.4	42.9	20.7	42.8	16.2	51.7		
29/9	14:03	14.7	20.2	42.9	20.8	44	17.1	50.2		
29/9	20:58	10.5	21.2	44.5	21	43.2	17.2	48.5		
30/9	0:08	10	21.1	43.1	20.8	42.5	17	48.5		
30/9	8:03	11.2	20.5	42.3	20.6	42.7	16.2	49.1		
30/9	14:03	16.1	19.8	43.4	20.8	41.7	16.7	50.4		
30/9	20:58	9.9	21.4	47.4	20.7	41.7	16.6	49.1		
1/10	0:08	11.5	20.5	43	20.8	44.2	16.8	48.5		
1/10	8:03	12	20.8	42.1	20.4	41.2	15.5	47.8		
1/10	14:03	17.3	20.9	41.7	20.5	39.6	16.4	48.4		
1/10	20:58	15	20.4	42.9	20.5	46.3	16.9	48.3		
2/10	0:08	13.4	20.7	42.1	20.6	46.4	16.7	47.1		
2/10	8:03	14	20.6	40.6	20.5	42.8	15.8	45.7		
2/10	14:03	17	19.7	42.5	20.5	41.7	16.8	47.6		
2/10	20:58	13.1	21.3	43.7	20.5	41.2	17.1	45		
3/10	0:08	12.9	20.5	42.1	20.5	41.7	17.2	47.1		
3/10	8:03	13.6	20.8	39.4	20.4	39.6	16.8	44.1		
3/10	14:03	13.7	20.4	39.1	20.4	37.8	17	43.1		
3/10	20:58	11.2	21.5	41.5	20.6	39.4	17.8	45.9		
4/10	0:08	10.5	21.3	42.7	20.7	41.3	18.2	48.2		
4/10	8:03	10.5	20.9	52.3	20	52.5	18.5	56.7		
4/10	14:03	14.1	22	67.2	20.8	68.9	19.2	67.5		
4/10	20:58	10.2	22.3	63.4	21	64	19.5	67.8		
5/10	0:08	10.4	22.2	63.4	21	64	19.7	71.2		
5/10	8:03	13.8	21.5	61.8	21	63.8	19.4	71		
5/10	14:03	15.4	20.6	66.3	21.1	65.4	19.6	71.9		
5/10	20:58	11	21.9	63.9	21.3	62.5	20.3	70.4		
6/10	0:08	9.8	21.9	61.5	21.4	62.1	20.2	68.2		
6/10	8:03	10	20.8	56.2	21.1	59.7	19.2	62.9		
6/10	14:03	13.8	20.6	51.4	21.7	53.1	20	60.7		
6/10	20:58	6.3	21.3	54.5	21.6	55.9	19.3	63.9		
7/10	0:08	5.2	21.7	52.7	21.5	57.6	18.9	61.9		
7/10	8:03	11.7	21.3	52.2	21.2	53.9	18.6	59.4		
7/10	14:03	13.8	20.9	57.3	21.1	55.1	19.2	62.5	22.2	66
7/10	20:58	5.6	21.6	59.4	21.7	56.9	19.4	63.7	22.9	100
8/10	0:08	4	21.2	57.6	21.6	58.8	19.3	62.8	22.7	76
8/10	8:03	7.9	21.3	59.2	21	57.5	19.5	64.9	22.4	74
8/10	14:03	13	21.1	65	21	63.6	19.9	67.4	22.4	100
8/10	20:58	5.3	21.8	64.8	20.8	62.7	19.9	67.3	22.7	100
9/10	0:08	3.5	22	63.7	20.8	63	19.9	67.7	22.9	100
9/10	8:03	10	21.6	62.5	21	63	20.3	68.6	22.4	100
9/10	14:03	12.9	19.4	54.1	20	53.1	19.9	59.5	21.7	46
9/10	20:58	6	22	54.6	19.6	52.2	19.9	56.1	22.7	61.5
10/10	0:08	6.1	21.6	50.8	20.2	50.2	19.4	54	22.9	52
10/10	8:03	8.8	21.4	48.6	20.1	49.5	18.5	51.6	22.2	44.5
10/10	14:03	12	20.7	46.3	20.4	47.4	19.3	51.7	21.9	34
10/10	20:58	5.2	20.9	48.3	20.5	48.2	19.6	51.8	21.9	39.5
11/10	0:08	3.8	21.2	49.6	21	49.4	19.2	53.1	22.2	43.5
11/10	8:03	8.1	21.1	46.5	20.3	50.3	17.9	52.4	22.2	37
11/10	14:03	13.8	21.1	48.7	19.3	51.1	18.8	55.1	21.9	43.5
11/10	20:58	8.6	21.9	58.4	18.6	52	18.3	57	23.2	100
12/10	0:08	9	22.1	56.3	18.4	50	18.4	58.1	23.2	96.5
12/10	8:03	11	21.1	48	19.9	49.1	17.7	51.8	22.2	48
12/10	14:03	12.3	20.7	50.1	20.6	48.4	17.8	53.1	22.2	59.5
12/10	20:58	8.2	21.4	52.4	20.4	50.3	18.9	56.8	22.4	75.5
13/10	0:08	7.6	21.5	55.6	20.5	52.3	17.9	60.5	22.7	76.5
13/10	8:03	8.8	20.8	52.1	19.3	50.6	17.6	56.7	21.7	56
13/10	14:03	10.7	21.6	64.6	17.9	50.2	17.9	56.6	22.7	100
13/10	20:58	8.2	21.7	60.9	18.3	50.6	17.1	56.1	22.4	100
14/10	0:08	7.7	21.4	56.6	18.2	51.8	17.8	58.5	22.2	76
14/10	8:03	7.3	20.8	54.6	18.6	52.7	18.2	58.8	21.7	54.5
14/10	14:03	11.2	20.4	53.9	18.6	52.9	18.2	58.7	21.7	47.5
14/10	20:58	7.9	21.7	58.7	18.8	55.8	18.1	61.4	23.2	60
15/10	0:08	7.1	20.6	56.7	19.7	58.6	18.1	63	22.2	52
15/10	8:03	9.6	20.5	56	18.2	55.7	18.5	62.1	21.7	50
15/10	14:03	12.6	20.4	54.1	18	54.9	18.5	59.1	21.7	49.5
15/10	20:58	10	20.5	53.1	19	55.3	18	59.1	21.1	45.5
16/10	0:08	9.5	20.8	53.3	19.4	54.9	17.6	58.6	21.7	48.5
16/10	8:03	8.8	20.6	53.3	19.2	54.8	17.6	58.8	21.4	49.5
16/10	14:03	14	20.6	57.7	19.5	57.7	18.1	63.8	21.4	54.5
16/10	20:58	10	21.5	56.7	18.8	56	18.8	61	22.4	100
17/10	0:08	8.4	21.3	55.2	18.3	59	18.6	61.5	21.9	100
17/10	8:03	9.4	20.7	58.7	18.4	61.6	18.7	63.2	21.4	92
17/10	14:03	14.9	20.5	55.8	18.1	57.4	18.6	58.6	21.7	70.5
17/10	20:58	13.6	20.9	55.1	18.7	56.7	18.5	58.7	21.9	49.5
18/10	0:08	13.2	21.2	53.1	19	56.4	18.4	59.8	22.2	49.5
18/10	8:03	15.3	20.7	55.2	19.4	58.4	18	60.8	21.7	50.5
18/10	14:03	17.7	20.8	57.3	19.6	57.9	18	62	22.2	52
18/10	20:58	13.3	21.4	55.5	19.8	57.5	17.8	61.1	22.4	50
	min	3.5	19	39.1	17.9	37.8	15.5	43.1	21.1	34
	max	17.7	22.3	67.2	21.9	68.9	20.3	71.9	23.2	100

Figure J-2: Monitoring data house E

	H										Ventilatie				aanwezigheid			
	Date	*Time*	*Buitentemp lelystad*	*T_woon*	*RV_woon*	*T_slaap(straat)*	*RV_slaap(straat)*	*T_slaap(tuin)*	*RV_slaap(tuin)*	*T_keuken*	*RV_keuken*	*ramen woonkamer*	*slaapkamerraam (tuin)*	*slaapkamerraam (straat)*	*keuken ventluik*	*woon*	*keuken*	*slaap(tuin)*	*slaap(straat)*
	5/10	0:08	10.4	22.4	56	22	59.9	20.6	100	22.4	56.1	0	0	0	0	25	0	25	25
	5/10	8:03	13.8	22.4	55.5	22.2	62	21.1	100	22.4	55.6	25	0	0	25	25	25	0	0
	5/10	14:03	15.4	22.4	58.1	22.1	62	21.1	100	22.5	58.2	25	25	25	25	25	0	0	0
	5/10	20:58	11	22.5	57.1	22	61.6	21.1	100	22.7	56.5	0	0	0	0	25	0	25	0
	6/10	0:08	9.8	22.4	56.4	22.1	62.4	21.1	100	22.4	56.5	0	0	0	0	25	0	25	25
	6/10	8:03	10	22.3	53.8	22.1	65.3	20.9	100	22.3	54.0	25	0	0	0	25	25	0	0
	6/10	14:03	13.8	22.3	52	21.9	63.1	21.1	100	22.4	51.3	0	25	0	25	25	0	0	0
	6/10	20:58	6.3	22.4	52.1	22	61.7	21.1	100	22.7	51.5	0	0	0	0	25	25	25	0
	7/10	0:08	5.2	22.3	51.1	22.1	62.6	20.9	100	22.4	51.1	0	0	0	0	25	0	25	25
	7/10	8:03	11.7	22.3	49.7	22.1	65.9	20.9	100	22.4	49.9	25	0	0	0	25	0	0	0
	7/10	14:03	13.8	22.1	51.6	21.7	61	21.1	100	22.3	51.4	0	25	25	0	25	25	0	0
	7/10	20:58	5.6	22.2	53	21.8	60.2	20.9	100	22.5	52.4	0	25	25	0	25	0	25	0
	8/10	0:08	4	22.3	53.7	21.8	61.6	20.9	100	22.5	53.7	0	0	0	25	25	0	25	25
	8/10	8:03	7.9	22.3	53.9	22.1	65.6	20.9	100	22.3	53.6	0	0	0	25	25	25	0	0
	8/10	14:03	13	22.5	58.4	22.1	65.6	20.9	100	22.5	57.9	0	0	0	0	25	0	0	0
	8/10	20:58	5.3	22.7	62.2	22.2	65.2	21.4	100	23.2	64.4	0	0	0	25	25	25	25	0
	9/10	0:08	3.5	22.6	60	22.2	65.4	21.1	100	22.7	60.2	0	0	0	0	25	0	25	25
	9/10	8:03	10	22.5	58.7	22.3	66.9	21.4	100	22.5	58.5	0	0	0	25	25	25	0	0
	9/10	14:03	12.9	22.2	50.7	22	62.5	21.1	100	22.2	52.8	0	25	0	25	0	0	0	0
	9/10	20:58	6	22.3	50.5	21.7	58.1	21.1	91.5	22.4	50.7	0	0	0	0	25	0	25	0
	10/10	0:08	6.1	22.3	49.7	21.8	58.1	20.9	92	22.3	50.5	0	0	0	0	25	0	25	25
	10/10	8:03	8.8	22.1	47.3	21.9	58.6	20.6	82.5	22.1	48.1	0	0	0	25	25	25	0	0
	10/10	14:03	12	22	44.1	21.8	57.1	20.6	76.5	22.1	45.4	0	0	0	25	0	0	0	0
	10/10	20:58	5.2	22.2	46	21.8	55.6	20.6	73.5	22.3	46.3	25	0	0	0	25	25	25	0
	11/10	0:08	3.8	21.9	45.2	21.8	58.1	20.6	80	22	46.0	0	0	0	0	25	0	25	25
	11/10	8:03	8.1	22	45.9	21.8	60.6	20.6	90.5	22	46.6	0	0	0	25	25	0	0	0
	11/10	14:03	13.8	21.7	46.5	21.5	58.2	20.1	74.5	22	46.5	25	25	25	25	25	0	0	0
	11/10	20:58	8.6	21.6	49.8	21.3	60.8	20.1	78	21.7	49.5	0	0	0	0	25	25	25	0
average			**9.14**	**22.26**		**21.94**		**20.89**		**22.36**									

Figure J-3: Monitoring data house H during longitudinal questionnaire

	E											Ventilatie				aanwezigheid			
	Date	*Time*	*Buitentemp lelystad*	*T_woon*	*RV_woon*	*T_slaap(straat)*	*RV_slaap(straat)*	*T_slaap(tuin)*	*RV_slaap(tuin)*	*T_keuken*	*RV_keuken*	*ramen woonkamer*	*slaapkamerraam (tuin)*	*slaapkamerraam (straat)*	*keuken ventluik*	*woon*	*keuken*	*slaap(tuin)*	*slaap(straat)*
	5/10	0:08	10.4	22.2	63.4	21	64	19.7	71.2			0	25	25	0	25	0	25	25
	5/10	8:03	13.8	21.5	61.8	21	63.8	19.4	71			25	25	25	0	25	25	0	0
	5/10	14:03	15.4	20.6	66.3	21.1	65.4	19.6	71.9			25	25	25	25	25	25	0	0
	5/10	20:58	11	21.9	63.9	21.3	62.5	20.3	70.4			0	25	25	0	25	0	0	0
	6/10	0:08	9.8	21.9	61.5	21.4	62.1	20.2	68.2			0	25	25	0	25	0	25	25
	6/10	8:03	10	20.8	56.2	21.1	59.7	19.2	62.9			25	25	25	0	25	25	0	0
	6/10	14:03	13.8	20.6	51.4	21.7	53.1	20	60.7			25	25	25	0	25	0	0	0
	6/10	20:58	6.3	21.3	54.5	21.6	55.9	19.3	63.9			0	25	25	0	25	25	0	0
	7/10	0:08	5.2	21.7	52.7	21.5	57.6	18.9	61.9			0	25	25	0	25	0	25	25
	7/10	8:03	11.7	21.3	52.2	21.2	53.9	18.6	59.4			0	25	25	0	25	25	0	0
	7/10	14:03	13.8	20.9	57.3	21.1	55.1	19.2	62.5	22.2	66	25	25	25	0	25	0	0	0
	7/10	20:58	5.6	21.6	59.4	21.7	56.9	19.4	63.7	22.9	100	0	25	25	0	25	25	0	0
	8/10	0:08	4	21.2	57.6	21.6	58.8	19.3	62.8	22.7	76	0	25	25	25	25	0	25	25
	8/10	8:03	7.9	21.3	59.2	21	57.5	19.5	64.9	22.4	74	25	25	25	25	25	25	0	0
	8/10	14:03	13	21.1	65	21	63.6	19.9	67.4	22.4	100	0	25	25	25	25	0	0	0
	8/10	20:58	5.3	21.8	64.8	20.8	62.7	19.9	67.3	22.7	100	0	25	25	25	25	25	0	0
	9/10	0:08	3.5	22	63.7	20.8	63	19.9	67.7	22.9	100	0	25	25	0	25	0	25	25
	9/10	8:03	10	21.6	62.5	21	63	20.3	68.6	22.4	100	25	25	25	0	25	25	0	0
	9/10	14:03	12.9	19.4	54.1	20	53.1	19.9	59.5	21.7	46	25	25	25	25	25	0	0	0
	9/10	20:58	6	22	54.6	19.6	52.2	19.9	56.1	22.7	61.5	0	25	25	0	25	25	0	0
	10/10	0:08	6.1	21.6	50.8	20.2	50.2	19.4	54	22.9	52	25	25	25	0	25	0	25	25
	10/10	8:03	8.8	21.4	48.6	20.1	49.5	18.5	51.6	22.2	44.5	25	25	25	0	25	25	0	0
	10/10	14:03	12	20.7	46.3	20.4	47.4	19.3	51.7	21.9	34	25	25	25	0	25	0	0	0
	10/10	20:58	5.2	20.9	48.3	20.5	48.2	19.6	51.8	21.9	39.5	0	25	25	0	25	25	0	0
	11/10	0:08	3.8	21.2	49.6	21	49.4	19.2	53.1	22.2	43.5	0	25	25	0	25	0	25	25
	11/10	8:03	8.1	21.1	46.5	20.3	50.3	17.9	52.4	22.2	37	25	25	25	0	25	25	0	0
	11/10	14:03	13.8	21.1	48.7	19.3	51.1	18.8	55.1	21.9	43.5	25	25	25	25	25	0	0	0
	11/10	20:58	8.6	21.9	58.4	18.6	52	18.3	57	23.2	100	0	25	25	0	25	25	0	0
average			**9.14**	**21.31**		**20.78**		**19.41**		**22.41**									

Figure J-4: Monitoring data house E during longitudinal questionnaire

	Totaal vergelijk							
	aanwezig	douche	woon vent	woon ramen	slaapkamer ramen (tuin)	slaapkamer ramen (straat)	electriciteits verbruik	warmte gebruik
		min	*hrs*	*hrs*	*hrs*	*hrs*	*kWh*	*GJ*
H	2.21	34	22	3	30	48	59	0.225
E	2.21	24	53	23	168	168	88.3	0.09

Figure J-5: Comparison longitudinal questionnaire house E and H

APPENDIX K Measured appliances Plugwise

House H

1 DVD player
2 Laptop
3 Second laptop
4 Fridge
5 Microwave
6 Mobile telephone charger
7 Television
8 Washing machine
9 Kettle

House E

1 Extractor fan
2 DVD player
3 Coffee machine
4 Laptop
5 Modem/Router
6 Mobile telephone charger
7 Television
8 Dishwasher
9 Washing machine