The preferences of social tenants regarding the willingness to participate in the transition towards natural gas-free heating systems.

A Stated Choice Experiment into the "Programma Aardgasvrije Wijken"

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Preface

This research study serves as my graduation project and finalizes my master in Construction Management and Engineering at the Eindhoven University of Technology. The thesis was carried out in collaboration with Atriensis projecten. My student career has led my personal and professional development, which instigated my interest for sustainability in the built environment, coherent to my graduation project regarding the energy transition. The last months I had the opportunity to develop more knowledge concerning a topical problem which combines both the preferences and behavior of people with technical and complicated energy systems. This difficult contradiction is what really motivated me to conduct a research study in this field.

When I finished my Atheneum, I chose a hbo study in the built environment, which eventually resulted in my choice for the master Construction Management and Engineering. My interest in the heat and energy transition started with a more general interest in sustainability and the insulation of the housing stock in the Netherlands. My journeys to south-eastern Asia stoked up my interest in sustainability even further, as I personally experienced the consequences of unsustainable behavior in the form of pollution, breakdown of flora and fauna and the aggravation of natural disasters. Later I found out that the energy transition towards more sustainable energy sources can be a major contributor to the mitigation of climate change. In the Netherlands, the step towards non-natural gas-fired heating systems starts with the housing associations, who need the consent of 70% of their tenants before a project based energy transition can be executed. Hopefully, my research will contribute to the energy transition in Dutch social housing sector and the mitigation of climate change in the world.

Before the start of this master thesis I would loke to take this opportunity to express my thankfulness to everybody who contributed to the completion of my master thesis. First, I would like to thank my supervisors Dujuan Yang and Theo Arentze for their guidance, support and expertise. Despite only seeing my supervisor through video-conferences, due to the COVID-19 pandemic, they always found time to give me critical feedback. Especially, I would like to thank Dujuan Yang for her guidance and extensive feedback. Without the guidance of Dujuan Yang and Theo Arentze, this result would not have been possible.

Furthermore, I would like to acknowledge my gratitude to Atriensis projecten and particularly Linda Groenen, for their support during my research study. Linda Groenen enabled me to contact the housing associations whom I asked to distribute my questionnaire among their tenants. Linda and her colleagues at Atriensis projecten always made time to discuss my research and results. At last, I would like to thank my family for their support during my study and graduation, as they always motivated me to realize my ambitions. I am very happy and proud with the end result, which is the cornerstone of my student career. I am glad to finish my student career and am ready to start my professional career.

I hope my research will inspire you, enjoy.

Tom Wielders
Sittard, June 2021

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Summary

Climate change can be observed all around the world. In order to mitigate the effects of climate change, the United Nations have agreed on global climate goals, which were translated by the Dutch government into the Energy and Climate Agreement. Regarding the built environment, these agreements state an energy and heat transition from natural gas-fired heating systems to natural gas-free heating systems for the total housing stock of 7 million houses. The housing associations are assigned to be the starting engine of this transition, as they own one-third of the total housing stock in the Netherlands. In order to gather knowledge and experience regarding this transition, a subsidy program was introduced which uses a neighborhood oriented approach for the energy transition. This PAW program consists of 46 participating neighborhoods, which are called Proeftuinen. Dutch law states that 70% of all tenants have to give their consent before a (natural gas-free) renovation project can be executed. As a consequence, it is essential to create a support base among tenants of social housing. Consequently, it is necessary to identify the tenants' preferences regarding the motivators and barriers of this natural gas-free renovation. Currently, there is only literature which quantitatively studied the preference or motives of homeowners and tenants regarding energy efficiency renovations. Therefore, this research study aims to determine and value the motivators and barriers of tenants of social housing regarding the willingness to participate in natural gas-free renovation projects. Additionally, this research study intends to specify different groups of tenants which have different preference regarding the energy transition. Hence, the main research question is as follows:

How do tenants of social housing value their preferences for certain motivators and barriers (attributes) in the decision-making process, which influences their willingness to participate in natural gas-free renovation projects?

Answering the research questions started by conducting an extensive literature review. The literature review included the Goal-Framing Theory and the corresponding gain, hedonic and normative motives, which were studied in order to determine the tenants' motivators and barriers for engagement in pro-environmental behavior. The literature review provided evidence to concluded that there are six main motivators and barriers (attributes of SCE) which determine the tenant's decision-making process, specifically heating type, housing costs, comfort, nuisance and house and neighborhood improvement.

In order to measure the tenants' preferences for the attributes found in the literature review, a Stated Choice Experiment was conducted with the aid of an online questionnaire. The data collection resulted in a data sample which could not be checked for representativeness in comparison to the Dutch social housing sector, as there was no data available. Analyses of the results, by means of a Multinomial Logit model, indicated a general preference for the willingness to participate in natural gas-free renovation projects, no matter the levels of the attributes. This means that tenants have a positive general attitude towards the energy transition. Regarding the six attributes, only heating type was found to be insignificant, meaning tenants have no preference regarding their new heating type. Concerning the other five attributes, the housing costs, comfort and nuisance were respectively found to be most influential in the decision-making process of tenants, as they accounted for over three-

quarters of the relative importance. As housing costs contributed 49% to the relative importance, it can be concluded that the gain motive is the focal goal. The remaining two attributes, house and neighborhood improvements, had a minor influence on the tenant's decision-making process. Additionally, the results indicated that it is not worthwhile to improve the house or neighborhood, or to increase the comfort if this results in higher levels of nuisance, as the negative effect of higher degrees of nuisance will nullify the effect of the improvements. The socio-demographic variables which were included in the MNL model, only had minor influences on the willingness to participate in the natural gas-free renovation projects. The statement factors, specifically WTP and environmental attitude had mediocre parameters, yet they were influential on the tenant's willingness to participate in the natural gas-free renovation project. This can be explained by the fact that the statement factors were measured on a 5-point Likert scale, while the other variables were categorical. Higher degrees of WTP resulted in tenants being less influenced by housing cost increases and decreases. Similarly, higher degrees of environmental attitude resulted in tenants being less influence by housing costs increases, due to the significant parameter of the interaction term being opposite to that of the attribute housing costs.

The research question regarding the different groups of tenants was answered with the aid of a Latent Class model containing two classes. The first class showed a high general preference towards natural gas-free renovation projects, whereas the second class showed a negative association. This means that there is a major difference between the two classes of tenant in relation to their general preference of natural gas-free renovation projects. The probability to be a member of class one is highest with 77.1% in comparison to a probability of 22.9% for class two. The class characteristics were estimated with the socio-demographics and statement factors. Class one had a higher representation of tenants who did not receive rent allowance, lived in their house for less than one year and have a higher WTP. The tenants in class one were more influenced by comfort change and house improvements, whereas the tenants in class two were mainly influenced by changes in housing costs. All and all, the most important motivators and barriers regarding the willingness to participate in natural gas-free renovation projects by tenants of social housing are housing costs, comfort and nuisance, respectively. The largest difference between the two classes is their general preference, which is followed by their preferences for the different attributes.

For housing associations it is recommended not to increase the housing costs or decrease the comfort. Instead it is advised to decrease the housing cost and increase the comfort in order to persuade both classes of tenants to give their consent to the natural gas-free renovation project. Additionally, it is recommended to only implement house, neighborhood, or mediocre comfort improvements when they do not result in increased levels of nuisance, as this will eventually have negative effects on the participation and support base.

Samenvatting

Klimaatverandering is overal ter wereld waarneembaar. Om de effecten van klimaatverandering te reduceren hebben de Verenigde Naties mondiale klimaatdoelen opgesteld. Deze mondiale klimaatdoelen zijn door de Nederlandse overheid vastgelegd in het Energieakkoord en Klimaatakkoord. Aangaande de gebouwde omgeving staat in deze afspraken een energie- en warmtetransitie van aardgasgestookte verwarmingssystemen naar gasloze verwarmingssystemen betreffende de totale woningvoorraad van 7 miljoen woningen. De woningcorporaties zijn aangewezen als startmotor van deze transitie, aangezien zij een derde van de totale woningvoorraad in Nederland bezitten. Aangaande deze transitie is er een subsidieprogramma geïntroduceerd waarbij de energietransitie vanuit een wijkgerichte aanpak wordt benaderd. Met behulp van dit subsidieprogramma zal de benodigde kennis en ervaring worden vergaard. Dit PAW bestaat uit 46 deelnemende wijken, welke Proeftuinen worden genoemd. Volgens de Nederlandse wetgeving dient 70% van alle huurders toestemming te geven voordat een renovatieproject kan worden uitgevoerd. Dit betekent dat het essentieel is om draagvlak te creëren onder huurders van sociale huurwoningen. Derhalve is het noodzakelijk om de voorkeuren van de huurders met betrekking tot de motivatoren en barrières voor deze aardgasvrije renovaties te identificeren. Momenteel is er alleen kwantitatieve literatuur beschikbaar waarin onderzoek is gedaan naar de voorkeuren en motieven van huiseigenaren en huurders met betrekking tot renovaties op het gebied van energie-efficiëntie of verduurzaming. Zodoende is het doel van deze onderzoekstudie om de motivatoren en barrières met betrekking tot participatie van de huurders van sociale woningbouw in aardgasvrije renovatieprojecten te bepalen en waarderen. Daarnaast beoogt dit onderzoek verschillende groepen huurders te specificeren welke ieder verschillende voorkeuren hebben met betrekking tot deze energietransitie. Dit resulteert in de volgende onderzoeksvraag:

Hoe waarderen huurders van sociale huurwoningen hun voorkeuren voor bepaalde motivatoren en barrières (attributen) in het besluitvormingsproces dat van invloed is op hun bereidheid om deel te nemen aan aardgasvrije renovatieprojecten?

Alvorens het beantwoorden van de onderzoeksvragen werd een uitvoerige literatuurstudie uitgevoerd. Het literatuuronderzoek bevatte de Goal-Framing Theorie en de bijbehorende gain-, hedonistische en normatieve motieven, die werden bestudeerd om de motivatoren en barrières van huurders voor het aangaan van milieuvriendelijk gedrag vast te stellen. Het literatuuronderzoek leverde bewijs op om te concluderen dat er zes belangrijke motivatoren en barrières (attributen van het SCE) zijn die het besluitvormingsproces van de huurder bepalen, met name verwarmingstype, woonlasten, comfort, overlast en woning- en wijkverbetering.

Om de voorkeur van de huurders voor de in het literatuuronderzoek gevonden attributen te meten, is een Stated Choice Experiment uitgevoerd met behulp van een online vragenlijst. De dataverzameling heeft geresulteerd in een gegevenssteekproef die niet op representativiteit kon worden gecontroleerd in vergelijking met de Nederlandse sociale woningbouwsector, aangezien er geen gegevens beschikbaar waren. Met behulp van een Multinomial Logit-model is de data geanalyseerd. Onderzoek toonde een algemene voorkeur aan van huurders

voor deelname aan aardgasvrije renovatieprojecten, ongeacht de hoogte van de attributen. Dit toont aan dat huurders een positieve houding hebben ten opzichte van de energietransitie. Van de zes attributen werd alleen het verwarmingstype niet significant bevonden, hetgeen betekent dat huurders geen voorkeur hebben aangaande hun nieuwe aardgasvrij verwarmingstype. Van de overige vijf attributen bleken respectievelijk de woonlasten, het comfort en de overlast de meeste invloed te hebben op het besluitvormingsproces van de huurders. Deze drie attributen vertegenwoordigde ruim driekwart van het relatieve belang, waarbij de woonlasten voor 49% bijdroegen aan het relatieve belang. Dientengevolge kan worden geconcludeerd dat het gain motief het belangrijkste motief (focale doel) is. De overige twee kenmerken, woning- en wijkverbetering, hadden een kleine invloed op het besluitvormingsproces van de huurder. Daarnaast gaven de resultaten aan dat het niet loont om de woning of wijk te verbeteren, of het comfort te verhogen als dit leidt tot meer overlast, omdat het negatieve effect van een hogere mate van overlast het effect van de verbeteringen tenietdoet. De sociaal-demografische variabelen die in het MNL-model zijn meegenomen, hebben slechts een geringe invloed op de bereidheid tot deelname aan aardgasvrije renovatieprojecten. De factoren bereidheid om te betalen (WTP) en ecologische houding, hadden middelmatige parameters, maar waren invloedrijk op het besluitvormingsproces van de huurder, ten gevolge van het feit dat ze gemeten zijn op een 5-punts Likertschaal, terwijl de andere variabelen categorisch zijn. Door een hogere WTP werden huurders minder beïnvloed door stijgingen en dalingen van de woonlasten. Evenzo resulteerde een hogere mate van ecologische houding in het feit dat de huurder minder beïnvloed werd door stijgingen van de woonlasten, omdat de significante parameter van de interactieterm tegengesteld was aan die van de attribuut woonlasten.

De onderzoeksvraag met betrekking tot de verschillende groepen huurders werd beantwoord met behulp van een Latent Class-model met twee klassen. De eerste klasse vertoonde een hoge algemene voorkeur voor aardgasvrije renovatieprojecten, terwijl de tweede klasse een negatieve associatie vertoonde. Dit betekent dat er een groot verschil is tussen de twee klassen van huurders in relatie tot hun algemene voorkeur voor aardgasvrije renovatieprojecten. De kans dat men behoort tot de eerste klasse is het hoogst, namelijk 77,1%. Logischerwijs is er een kans van 22,9% dat men behoort tot klasse twee. De klassenkenmerken werden geschat met behulp van de sociaal-demografische gegevens en factoren. Klasse één had een hogere vertegenwoordiging van huurders die geen huurtoeslag ontvingen, korter dan één jaar in hun huis woonden en een hogere WTP hadden. De huurders in klasse één werden sterker beïnvloed door comfortverandering en woningverbeteringen, terwijl de huurders in klasse twee vooral beïnvloed werden door veranderingen in woonlasten. Al met al zijn de belangrijkste drijfveren en barrières voor huurders van sociale huurwoningen om deel te nemen aan aardgasvrije renovatieprojecten respectievelijk, woonlasten, comfort en overlast. Het grootste verschil tussen de twee klassen is hun algemene voorkeur, gevolgd door hun voorkeur voor de verschillende attributen.

Voor woningcorporaties is het aan te raden om de woonlasten niet te verhogen en het wooncomfort niet te verlagen. In plaats daarvan wordt geadviseerd om de woonlasten te verlagen en het comfort te verhogen om zo beide klassen huurders te overtuigen om in te stemmen met het aardgasvrije renovatieproject. Daarnaast is het aan te raden om alleen woning-, wijk- of comfortverbeteringen door te voeren als deze niet leiden tot meer overlast, omdat dit op den duur negatieve effecten heeft op de participatie en het draagvlak.

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Abstract

The energy transition towards non-natural gas-fired heating systems is part of the climate goals the Dutch government has stated in the Climate and Energy Agreement, in order to mitigate the effects of climate change. As the housing associations own one-third of the Dutch housing stock, they are assigned to kickstart this transition. This research study enriches already existing literature regarding the preferences of tenants of social housing in relation to the willingness to participate in natural gas-free renovation projects. These preferences can be used in order to increase the willingness to participate in natural gas-free renovation projects. To estimate the tenants' preferences regarding the motivators and barriers, a Stated Choice Experiment was conducted. The analyses were conducted with the aid of a Multinomial Logit model and a Latent Class model, whereby the first showed that housing costs, comfort and nuisance were the most important characteristics, related to the three goal-frames. A Latent Class model was conducted in order to relax the strong assumptions of the Multinomial Logit model. Additionally, the Latent Class model aimed to estimate a model with a better McFadden's Rho² adjusted in comparison to the Multinomial Logit model and to determine different classes of tenants with different preference regarding the natural gas-free decision-making process. The Latent Class model provided evidence that tenants with a higher willingness to pay, who receive no rent allowance and lived in their dwelling for longer than one year, more often belong to class one. This class had a more positive relation towards natural gas-free renovation projects in comparison to class two. Additionally, class one was more influenced by comfort, whereas class two was mainly influenced by housing costs. From the analyses it can be concluded that the renovation characteristics are more important in comparison to the socio-demographics of a tenant, as the attributes account for about three-quarters of the relative importance in all analyses. From these analyses it can be concluded that the gain goal is the focal goal, with the housing costs as the main attribute. This is closely followed by the hedonic goal, with the characteristics comfort and nuisance. For some tenants comfort can even be as important as the housing costs. As such, it is recommended for housing associations to create balanced renovation packages which increase the comfort and decrease the housing cost, without increased levels of nuisance, in order to motivate tenants to participate in the natural gas-free renovation project.

Keywords: energy transition, natural gas-free, willingness to participate, discrete choice experiment, tenants of social housing

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Glossary

A summary of the important definitions, notion, classifications, etc. related to the chosen problem.

Aedes	Aedes is the association for housing corporations in the Netherlands.
AHP	Analytical Hierarchy Process
Anthropocentrism	Regarding humankind as the central or most important element of existence, especially as opposed to God or animals.
Appropriate allocation	Renting a property with a rental price that matches the household size and household income. The Dutch government made specific rules for certain rental thresholds.
Attributes	Characteristics of an alternative in a stated choice experiment, where respondents derive their utility from.
BKT	Bathroom, kitchen and/or toilet
Buurkracht	An energy related neighborhood initiative in the Netherlands.
CBS	Centraal Bureau voor Statistiek (Dutch) Central Bureau for Statistics (translated in English)
Climate agreement	Also known as The Paris Agreements is an agreement aiming to reduce global greenhouse gas emissions in order to limit the global temperature increase to 2 degrees Celsius.
Behavioral motives	A person's inner drive for outward behavior.
Decision-making process	The cognitive process regarding several possible alternatives that result in a course of action or belief. The decision can both be rational or irrational. The decision-making process is based on the decision maker's values, preferences, motives and beliefs, which result in a final decision.
DCE	Discrete Choice Experiment
DoI	Diffusion of Innovation (Rogers, 2003)
Energy agreement	The Dutch Energy Agreement for sustainable growth is an agreement between the Dutch government and well over forty organizations, regarding energy saving, sustainable energy and climate measures.
Energy transition	A path toward the transformation of many sectors from fossil-based energy sources to zero-carbon energy sources.
Environmental behavior	Any behavior that has an impact on the environment (good or bad) (Steg, Van den Berg, & De Groot, 2019).
Exemptionalism	The belief that the relationship between humans and the natural environment is unimportant because humans are

	"exempt" from environmental forces and capable of adapting via cultural change.
Focal goal	There is always one goal (from the Goal-Framing Theory) that is dominant and as a consequence determines the information processing, also known as the focal goal.
Gain goal	The Goal-Framing Theory states that people's information processing and action is controlled by three goals: the gain, hedonic and normative goals (Lindenberg & Steg, 2007). The gain goal corresponds to the preservation or increase of personal resources, which can be monetary and non-monetary. This goal has a middle to long time horizon, wherefore people estimate the costs compared to the benefits to engage in the behavior.
GHG	Greenhouse gasses.
Heat transition	A path towards the transformation in many sectors from fossil-based heat sources to zero-carbon heat sources.
Hedonic goal	The Goal-Framing Theory states that people's information processing and action is controlled by three goals: the gain, hedonic and normative goals (Lindenberg & Steg, 2007). Hedonic goals aim at increasing one's feelings, mood, emotions, or pleasure.
LC / LCM	Latent Class model
ML	Mixed Logit model
MNL	Multinomial Logit model
Natural gas-free neighborhood	A neighborhood that does not used natural gas for heating and/or cooking.
Natural gas-free ready	Natural gas-free-ready means that, in terms of constructional and technical installations for heat supply, hot tap water and cooking, houses are ready for the disconnection of the natural gas network and connection to an alternative energy infrastructure.
NEP-scale	New Ecological Paradigm scale (R. E. Dunlap, Van Liere, Mertig, & Jones, 2000; R. Dunlap & Van Liere, 1978)
Normative goal	The Goal-Framing Theory states that people's information processing and action is controlled by three goals: the gain, hedonic and normative goals (Lindenberg & Steg, 2007). The hedonic goals' time horizon is short. The normative goal relates to behaving according to social norms and doing what is right.
Natural gas-free renovation	Renovation works where dwellings are transferred from natural gas to more sustainable heat and energy sources.
Natural gas-free transition	The energy transition towards natural gas-free neighborhoods.
PAW	Programma Aardgasvrije Wijken (Dutch) Natural gas-free neighborhood (translated in English)

PAW neighborhood	Neighborhoods that applied for one of the subsidy round of the Programma Aardgasvrije Wijken (PAW)
PBL	Planbureau voor de Leefomgeving (Dutch) Netherlands Environmental Assessment Agency (translated in English)
Pro-environmental behavior	Behavior which harms the environment as little as possible or even benefits it. This is behavior that is beneficial for the environment but is not necessarily (or exclusively) motivated by environmental goals. According to this definition people can act pro-environmentally without any intention to do so, for instance, because the behavior is habitual (e.g. you always turn the tap off when brushing your teeth) or because the behavior is motivated by other goals (e.g. not driving to work because cycling is cheaper and healthier). (Steg et al., 2019)
PV	Photovoltaic
RHS	Residential heating system
RPV	Residential photovoltaics
RVO	Rijksdienst voor Ondernemende Nederland (Dutch) Netherlands Enterprise Agency (translated in English)
SCE	Stated Choice Experiment
SEM	Structural Equation Modeling
SER	Social and Economic Council
Starting engine	Being designated as the initiator of a transition or the like
The Green Transition	A transition aiming for the decarbonization of all aspects of our economy (United Nations, 2016). The decarbonization means a reduction in the emission of greenhouse gasses to keep the increase of global temperature below 2 degrees Celsius (United Nations, 1998, 2015).
TPB	Theory of Planned Behavior (Ajzen, 1985)
WTP	Willingness to pay

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1. Introduction

The introduction chapter starts with background information and describes the context of the problem statement. This is followed by the problem statement, described in the second section, which consists of the neighborhood oriented approach, the problem definition and objectives. The third section contains the research questions, which are based on the problem definition from the previous chapter. This is followed by the fourth and final section that contains the research design and reading guide, which will be used to answer the research questions.

1.1 Background and context

For decennia the climate and nature have been fairly stable, now the climate has changed drastically in the past decades. As Sir David Attenborough (2018) stated, "The Garden of Eden is no more", urging the world to bring a stop to the rapid climate change, before the damage is irreversible. The current climate change already shows signs across the world, as there is more extreme weather, rising air and sea temperature, the melting of the sea and land ice on the poles resulting in the rising sea level while other areas face more droughts, species going extinct and sweet water becoming more scarce. This rapid climate change is caused by the increased emission of greenhouse gasses (GHG) by human activity during the last decades. The greenhouse gasses in the earth's atmosphere make life on earth possible, due to the stable temperature. By offsetting the balance of greenhouse gasses in the earth's atmosphere, the temperature on earth increases rapidly, resulting in climate change. To reset the balance of greenhouse gasses in the atmosphere, we need to adjust the way we live.

To guide the transition of our lifestyle, the United Nations have agreed on global climate goals. The main purpose of this agreement is the Green Transition, which is the decarbonization of all aspects of our economy (United Nations, 2016). The decarbonization means a reduction in the emission of greenhouse gasses to keep the increase of global temperature below 2 degrees Celsius (United Nations, 1998, 2015). Specifying these targets, the European Union has directed objectives for all Member States, in which it aims to reduce greenhouse gas emission by 40% in comparison to the year 1990 (European Commission, 2019; The European parliament and the council of the European Union, 2009). In relation to energy production and consumption, 32% of all produced energy has to be renewable and the energy efficiency has to increase by at least 32.5% by the year 2050. Consequently, the Green Transition involves the reduction of greenhouse gasses emission, but also a transition in the production and consumption of energy. The Green Transition is necessary to reset the balance of the world's climate.

Translating the European climate objectives into national climate policies, the Dutch government has created the Energy Agreement (Energieakkoord) and the Climate Agreement (Klimaatakkoord). The goal of the Energy and Climate Agreement is to reduce the emission of greenhouse gasses among all sectors, including the built environment (Dutch Government, 2019). The objectives for the built environment are to transition all 7 million houses in the Netherlands to alternative heating systems than the current gas-fired heating system (transition towards natural gas-free heating systems), renovate 1.5 million houses and make sure that houses make use of electricity from renewable sources. This transition is also known as the energy transition. To achieve these goals, a neighborhood-oriented approach will be applied in an increasing pace. Although the built environment only has the smallest contribution to the total reduction of greenhouse gasses (3.4 Mton) in the Netherlands, achieving the objectives before 2050 will require more knowledge and experience (Dutch Government, 2019).

In the past two centuries, multiple energy transitions have occurred due to different reasons, such as new technological possibilities, (geo)political shifts, or public opinion. The most recent energy transition is that towards gas-fired heating systems in the 1960's. In 1959 both Shell and Esso discovered natural gas in the province of Groningen in the Netherlands. The natural gas bubble in Slochteren turned out to be the largest natural gas field in Europe and the ninth largest in the world (Sawe, 2018). Both Shell and Esso, but also the Dutch government were involved in the exploitation of the natural gas in Groningen. This triggered the energy transition towards natural gas. The building code even stated an obligation to connect newly built houses to the gas network (Aansluitplicht in de Gaswet) (Dutch Government, 2020b). As a result, through 1960 to 1970 all Dutch houses were connected to the gas network. This transition to natural gas meant that since the 1970's natural gas became the dominant energy source in the Netherlands (Hölsgens, 2019).

The now forthcoming energy transition started in 2015 when the first earthquakes occurred in Groningen. The cause of the earthquakes was the extraction of natural gas, which caused prolapses in the earth's strata. The earthquakes caused extensive damage to houses in the province of Groningen for which the Dutch Government was partially responsible due to their involvement in the natural gas extraction. As a result, the cabinet of Rutte III reduced the natural gas extraction from the gas field in Slochteren and they abolished the obligation to connect new houses to the gas network (Aansluitplicht in de Gaswet) (M. Rutte (VVD), S. van Haersma Buma (CDA), A. Pechtold (D66), & G.J. Segers (ChristenUnie), 2017; RVO, 2018). The reduction of natural gas extraction appeared not to be enough as the earthquakes continued and became worse, turning public opinion against the extraction of natural gas from the gas field in Slochteren (Ekkers, 2016; RVO, 2018). Due to the increasing earthquakes and pressure from public opinion the Cabinet Rutte III decided on the 29th of march 2018 to scale down the extraction of natural gas in Groningen to zero in the year 2030-2031 (Dutch government, 2018; E. Wiebes, 2018). The gas extraction document for 2019-2020 even stated that the extraction will be zero in 2022, which goes according to plan, as the gas extraction document for 2020-2021 states that the phasing out of the natural gas extraction from the gas field in Groningen goes prosperously (E. Wiebes, 2019, 2020).

As the natural gas from Groningen is phased out, there is need for an alternative energy solution to heat all seven million houses and one million industrial buildings in the Netherlands. There are two main solutions for this dilemma. The first is to import gas from gas exporting countries. The benefit of this method is that all gas-fired heating system do not have to be replaced, as the natural gas from other countries can be used in the Netherlands with only minor chemical composition adjustments. The downside of importing gas is that the Netherlands will become dependent on other countries for their energy supply. Being dependent on other countries for the energy supply can have negative consequences, as countries can be unreliable (Hölsgens, 2019), which was previously shown in the oil crisis of 1973 and 1979. Another downside of importing gas is the fact that it does not mitigate climate change, as natural gas will still be the main heating source for houses. The second alternative energy solution is an alternative heat source for the gas-fired heating systems, which makes the Netherlands independent on natural gas and other countries. Alternative heating systems are not always applicable in industry, but for houses they are certainly a viable application. Currently, alternative heating systems for housing, like electrical heating, biomass, or city heating are applied on a small scale, as there is still a need for additional information and knowledge about the alternative heating systems before the application can be scaled up to a mass transition.

Both the problem of climate change and the earthquakes in Groningen are reasons for the upcoming energy transition. The upcoming transition is an opportunity to apply more sustainable alternative heating systems that comply to the goals of the Climate Agreement. In 2019, the total energy use in the Netherland consisted of 8.7% renewable energy, which was only 7.4% in 2018 (Central Bureau for Statistics, 2020). Only heating our houses in a more sustainable manner makes it possible to reduce the emission of greenhouse gasses and use our energy more efficiently as stated in the Climate Agreement (Dutch Government, 2019). The PAW's goal (Programma Aardgasvrije Wijken) in 2018 and 2019 was to transition 100 PAW neighborhoods (Proeftuinen), consisting of 500 dwellings each to alternative heat sources (natural gas-free), which should have resulted in 50,000 dwellings. The number of currently transitioned dwellings is less than 100 (Binnenlands Bestuur, 2020; NOS, 2020b). For the Netherlands to be natural gas-free by 2050, the energy transition's pace has to be increased to 200,000 dwellings per year by 2030 (Dutch Government, 2019; Ollongren, 2020).

1.2 Problem definition

1.2.1 Neighborhood oriented approach

The Dutch Climate Agreement describes the targets for the built environment to reduce the emission of greenhouse gasses, as described in the previous chapter. The Climate Agreement states that the energy transition for houses has to be scaled up, which means that by 2021 50,000 houses and by 2030 200,000 houses per year have to be transitioned to an alternative heat source. Accelerating the energy transition even further should result in a reduction of greenhouse gasses in the built environment of 3.4 Mton in 2050 in respect to 1990 (Dutch Government, 2019).

To achieve this goal of reducing 3.4 Mton of greenhouse gasses in the built environment, the Climate Agreement states that the main task is divided into five components, all represented by a different color, displayed in Figure 1. One of these approaches is the neighborhood-oriented approach which will be used for the energy transition, displayed in purple. The neighborhood-oriented approach is best for the sustainable natural gas-free renovation projects, as this is a new intervention in the built environment. As natural gas-free renovation projects are new, there is little participation, which should be increased. Additionally, there is the need for additional knowledge and knowledge sharing. The neighborhood-oriented approach means that many stakeholders like the municipality, housing associations, residents, etc., work together, neighborhood by neighborhood. The neighborhood-oriented approach attains to come to a realistic, but also financially feasible strategy to replace the current gas-fired heating systems with more sustainable and energy efficient natural gas-free alternatives.

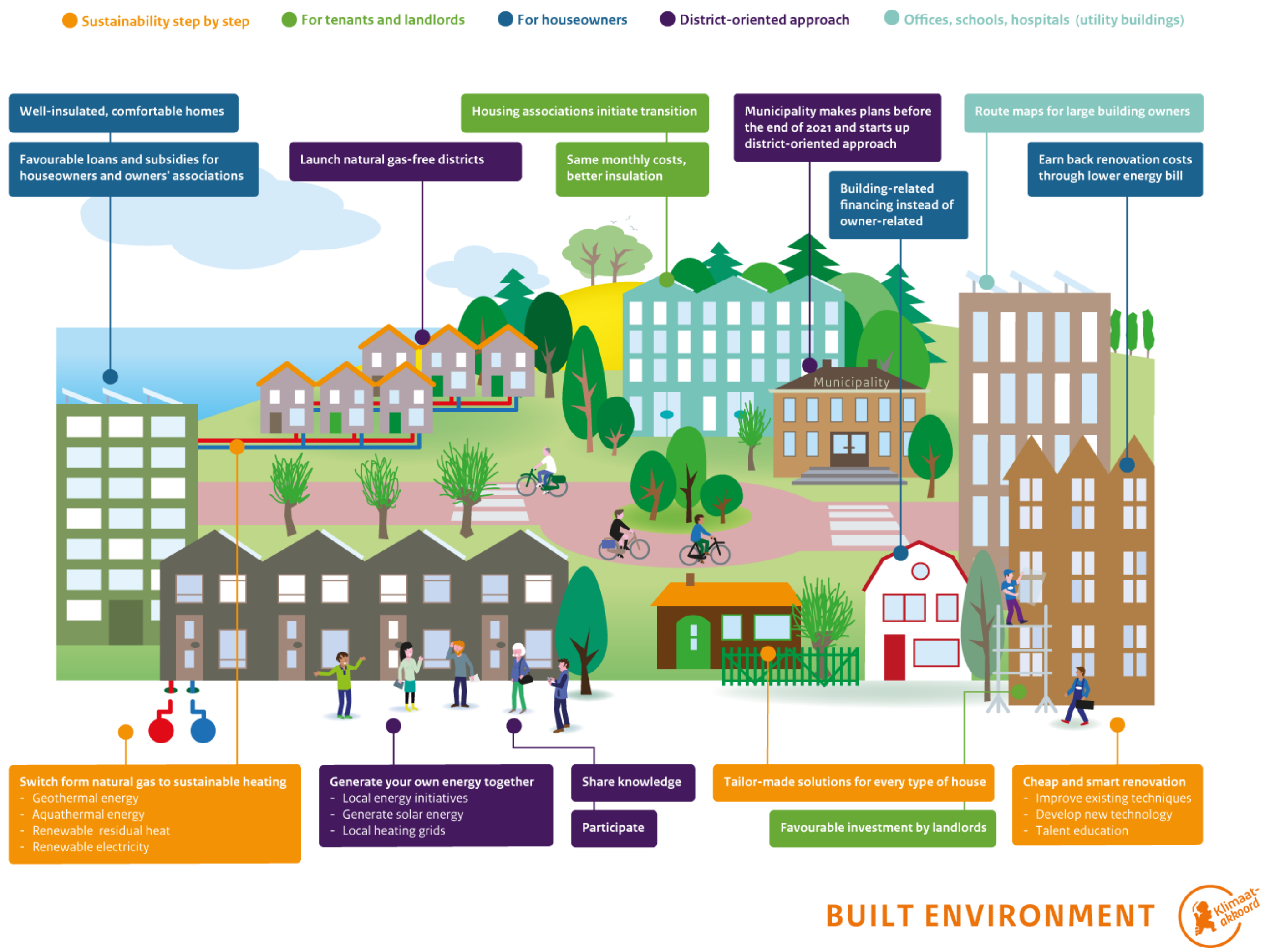

Figure 1 Infographics from the Climate Agreement regarding the built environment (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019)

The knowledge which is gained in every neighborhood should be shared, as it is necessary to increase participation and increase the scale of the energy transition to reach the goals of 200,000 transitioned houses per year by 2030 (Dutch Government, 2019). As it is hard for individual homeowners to gain and share knowledge about natural gas-free renovation projects, the housing associations are assigned to be the "starting engine" of the energy transition. The tasks of the housing associations are displayed in green in the infographic in Figure 1. The reason to assign the role of starting engine to the housing associations, is that they own one-third of the total housing stock in the Netherlands, which translates into 2.4 million houses (Ministry of the Interior and Kingdom Relations, 2019). As a stimulus and to gather knowledge, the Ministry of the Interior and Kingdom Relations created the Programma Aardgasvrije Wijken (PAW) (natural gas-free neighborhoods program), which is a cooperation between the Dutch government, the association of Dutch municipalities, provinces, the interprovincial consultation and the union of regional water authorities (Programma aardgasvrije wijken, 2019). PAW consists of KLP and Proeftuinen. KLP (Kennis- en Leerprogramma) is a knowledge and learning program that is "raising awareness about the energy transition. We (KLP) also identify and bring forward bottlenecks that municipalities and other stakeholders encounter" (Programma aardgasvrije wijken, 2019). The "Proeftuinen" are so called testing grounds, which is a subsidy program for 100 neighborhoods, as a learning experience to gather and share the hard needed knowledge about the energy transition for residential heating systems.

For municipalities and other stakeholders to learn and gather knowledge about the energy transition it is necessary to actually pass the transition from planning to development in the Proeftuinen and outside the testing grounds. The method proposed by the Ministry of the Interior and Kingdom Relations (2020) is "to learn by practice", which enables the stakeholders to learn an effective and scalable neighborhood-oriented approach. The first round of Proeftuinen received a total of 120 million euro's in subsidies, distributed over 27 neighborhoods (Ministry of the Interior and Kingdom Relations, 2018). After the first round in the PAW program, there was an evaluation which concluded that the program fulfils its purpose as a starting engine. The evaluation indicated that partly due to the PAW program, municipalities started with the energy transition of neighborhoods. Though not everything about the Proeftuinen is positive, as in October 2020 it was announced that the energy transition in one of the neighborhoods (Purmerend) was temporarily shut down as there were many issues, both technically and financially (NOS, 2020b). The news that the energy transition in Purmerend is going worse than expected, is a misfortune for the PAW program. Purmerend was perceived as a shining example, where some houses were already transitioned to a heat network. Despite the setbacks, there will be more rounds of Proeftuinen. The Proeftuin evaluation contained the details for the second round of subsidies, as there is a budget of about 4 million for 25 neighborhoods in total (Dutch government, 2020). In total 71 neighborhoods applied for the second round of subsidies from the PAW program, of which 19 neighborhoods were selected as Proeftuinen (Advisory committee Programma aardgasvrije wijken, 2020). In the first half of 2021 municipalities can apply for a third round of PAW subsidies.

1.2.2 Problem definition and objectives

The housing associations are responsible for the energy transition of one-third of the total housing stock, resulting in 2.4 million social rental properties. For the energy transition goal to succeed in the Netherlands, it is crucial that tenants participate in the energy transition and the related neighborhood-oriented approach. The energy transition in social housing has a major limitation, as a natural gas-free renovation project can only be developed when 70% of tenants agree with the renovation project. It is stated in the Civil Law that in case of complex wise renovation projects, a renter requires consent of 70% of the tenants (De Jonge, n.d.; Dutch Government, 2020a; Jager, 2018). Consequently, the participation of social tenants is a mayor interest in the energy transition. Additionally, the regulated participation can be a serious obstruction when the tenants do not agree to the energy transition, which can halter the transition and goals in the Climate Agreement (Jager, 2018). A sufficient support base among tenants is important to be able to execute the goals of the Climate Agreement (Dutch Government, 2019). The support for natural gas-free renovation projects is negatively influence by the social debate regarding the sustainability of biomass. Biomass is used to produce energy in biomass power plants. According to the Dutch central government, biomass is a renewable energy source, meaning it is sustainable (Dutch central government, n.d.). Experts and the SER (Social and Economic Council) challenge the assumptions that biomass is renewable (Milieu centraal, n.d.; NOS, 2020a). This social debate has a negative effect on the participation of tenants in relation to natural gas-free projects, as tenants are confused by the debate (Voesenek, 2020). The social debate puts more pressure on the limitation that housing associations need consent from 70% of their tenants for natural gas-free renovation projects to be executed.

The energy transition is mainly a transition which is occurring in the Netherlands. Unfortunately, there is limited research which identifies the motives (consisting of motivators and barriers) of tenants of social housing, or tenants in general to participate in energy or natural gas-free renovation projects. The researches that are most related to this subject mainly focus on homeowners performing energy improvements to their houses (Abreu, Oliveira, & Lopes, 2017; W. M. H. Broers, Vasseur, Kemp, Abujidi, & Vroon, 2019; Michelsen & Madlener, 2012; Mortensen, Heiselberg, & Knudstrup, 2016; Nair, Gustavsson, & Mahapatra, 2010; C. Wilson, Crane, & Chryssochoidis, 2015; C. Wilson, Pettifor, & Chryssochoidis, 2018). The results from these research studies cannot be generalized to tenants, as homeowners and tenants might share some motivators and barriers, but also have different motivators and barriers. Additionally, there is no evidence that tenants perceive any of the motivators or barriers with the same weight as homeowners. The limited research studies into the motives, values, motivators, barriers and considerations of tenants in sustainable renovation projects are mainly qualitative, or focus on energy renovations instead of natural gas-free renovations (DellaValle, Bisello, & Balest, 2018; Hoogenraad, 2019; Kerperien, 2019; Reuvekamp, 2013; Voesenek, 2020). The qualitative research study by Voesenek (2020) provides a framework consisting of motives, motivators, barriers and considerations of social tenants to participate in the energy transition. The framework is divided into three types of behavioral goals and corresponding motives which influence the decision-making process for the energy transition of tenants, specifically the gain, hedonic and normative motives (Steg, 2016; Steg, Perlaviciute, van der Werff, & Lurvink, 2014; Steg & Vlek, 2009). The framework and motives are not quantitatively tested, meaning they do not provide strengths for the motives and corresponding attributes. These three goals or motives consist of four value types, which are the hedonic, egoistic, altruistic and biospheric values. The motivators and barriers influencing a person's decision-making process can be divided along these values and thus also along the corresponding motives. This is displayed in Figure 2. The motive and value types are explained in section 2.1.8 Goal-Framing Theory.

For the energy transition to achieve its goals it is important to understand the decision-making process of social tenants for the willingness to participate in natural gas-free renovation projects. To understand the tenants' decision-making process regarding the willingness to participate in natural gas-free renovation projects, it is essential to value their preference for the different motivators and barriers, as these are determined by the consequences of the value types. Individuals find some values to be more important than others, which influences their preference for certain motivators and barriers. These value types are then influenced by the individual's goals, or motives. The theories involved, are described in the literature review. Understanding the individual's decision-making process can be done by studying and valuing the individuals' preferences of the motivators and barriers (for the analyses also known as attributes) of the decision-making process. The scientific research about the preferences of tenants in relation to the willingness to participate in natural gas-free renovation projects is mainly qualitative, meaning there is a lack of quantitative confirmation of the current (limited) knowledge. A quantitatively tested framework consisting of motives, values, motivators, barriers and consideration and can explain the tenants' willingness to participate in the energy transition. This knowledge is necessary in order to determine how tenants can be persuaded to support the energy transition of the social housing stock. This research study's main objective and contribution to the scientific field is to value the tenants' preferences for the motivators and barriers which influence the tenants' decision-making process in relation to the willingness to participate in natural gas-free renovation projects in social housing.

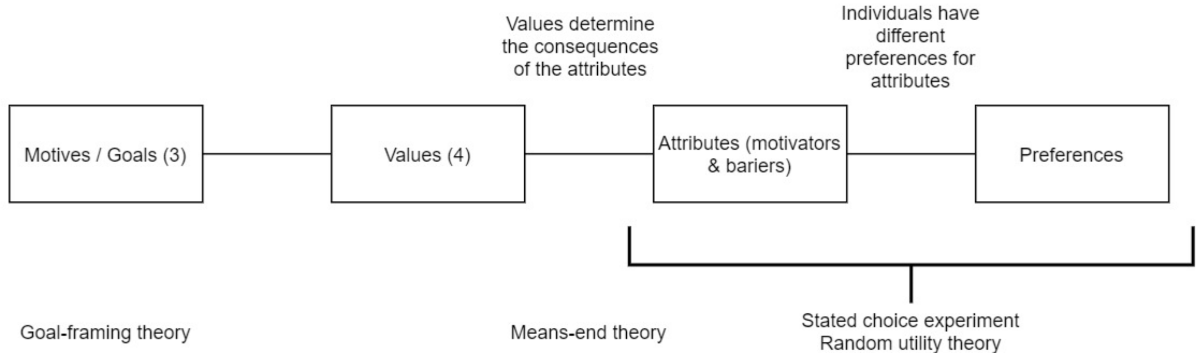

Figure 2 Overview of the relation between Motives / Goals, Values, Attributes and preferences

1.3 Research questions

To increase the willingness of social tenants to participate in natural gas-free renovation projects in social housing, it is important to determine the strength of the motivators and barriers which influence this decision-making process. In order to determine this, the first and second research questions are:

> *I) What are the motivators and barriers of residents (and tenants of social housing) in the decision-making process to engage in pro-environmental behavior?*
>
> *II) How do tenants of social housing value their preferences for certain motivators and barriers (attributes) in the decision-making process, which influences their willingness to participate in natural gas-free renovation projects?*

Governmental policies in the Netherlands have determined the target group for housing associations in the housing act, article 46 about appropriate assigning of tenants (Council of state, 2017). The target group consists of people from the lowest income classes, residential status holders, urgency placements, elderly, and other people with social problems (Leidelmeijer, van Iersel, & Frissen, 2018). Not all tenants of social housing are similar, as there are different types of tenants living in social housing. Each group has its' own views, motivations and preferred communication strategy. Different groups of tenants require personalized renovation and communication strategies, which can be used to convince tenants to participate in natural gas-free renovation projects. In order to determine whether there are differences in willingness to participate in natural gas-free renovation projects between different groups of tenants, the third research question is as follows:

> *III) What are the characteristics of different groups of tenants of social housing in relation to their preferences for the motivators and barriers (attributes) in the decision-making process, regarding the willingness to participate in natural gas-free renovation projects?*

According to Voesenek (2020), the natural-gas free transition strategies influences the decision-making process. Whether participants perceive the natural gas-free transition plan positively or negatively depends on the type of alternative heat source (all electric, heat network (high, mid, low temperature), hybrid, etc.) and the renovation plan (only natural gas-free vs natural gas-free combined with house and neighborhood improvements). In order to determine whether the alternative heating source and renovation plan are significant motivators or barriers in the decision-making process and what their strength is, two research questions will be answered:

> *IV) Is the alternative heating source a motivator or barrier in the decision-making process of social tenants for the energy transition and what are the strengths of its different levels?*

> *V) Is the renovation plan a motivator or barrier in the decision-making process of social tenants for the energy transition, what does it compose of and what are the strengths of the different levels?*

1.4 Research design and reading guide

This research study consists of quantitative research methods, which are used to quantitatively test the proposed conceptual model. It is an empirical research study in which preferences, factors, characteristics and variables are quantitatively tested. Consequently, the quantitative research study is an explanatory research study (Neuman, 2014). The goal of the research study is to value the tenants' preferences for the motivators and barriers of the decision-making process for natural gas-free renovation projects. The preferences of these motivators and barriers are consequences of individual's valuation of the four value types, which are related to the three pro-environmental behavior motives, specifically the gain, hedonic and normative motives. The conceptual model will be elaborated on in chapter 3.1. The decision-making process for tenants in relation to natural gas-free project is barely studied, which makes this the first research study with a quantitative approach to value characteristics of the decision-making process.

The remainder of this research study consist of a literature review which will provide an overview of the commonly used theories to study individual's behavior, followed by the factors underlying pro-environmental behavior. These factors are divided into knowledge, contextual factors and motives. Subsequently, an overview of the motivators and barriers of individuals, residents and tenants to exhibit pro-environmental behavior, structured along the three behavioral motives will be provided. As the literature on the decision-making process of natural gas-free renovation projects is limited, there is also literature included which focusses on pro-environmental behavior in general and the decision-making process of energy efficiency renovations for both tenants and homeowners. Third, multiple approaches to model and study the tenant's decision-making process regarding the willingness to participate in natural gas-free projects will be discussed. The end of the literature chapter is marked with a conclusion.

Above mentioned conceptual model forms the basis of the methodology of this research study and will be elaborated on in chapter 3. In order to answer the research questions a research study will be conducted with the aid of a questionnaire. The questionnaire will consist of three parts; general questions about demographics; statements regarding ecological attitude, housing association trust, housing association communication and willingness to pay and a Stated Choice Experiment in order to study the conceptual model. Furthermore, the methodology describes the chosen modeling approach (DCE), how the questionnaire is constructed and it will justify the choices made in this process. The questionnaire will be sent to tenants in PAW neighborhoods (Proeftuinen) and tenants of other neighborhoods.

The results obtained from the research study will be statistically tested and analyzed. These analyses include descriptive analyses and statistical tests to determine the representativeness of the sample. Proceeding from these analyses, a discussion of the results of this research study is elaborated on, specifically by means of Multinomial Logit models and Latent Class models.

Finally, various conclusions can be drawn from this research study. This research study ends with some theoretical, societal and managerial contributions, limitations and a future outlook for further research purposes.

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2. Literature review

This chapter starts with the most researched behavioral theories regarding pro-environmental behavior. The behavioral theories will be described with their common features, differences and (dis)advantages. The second section contains an overview of the factors underlying pro-environmental behavior, which are knowledge, motivation and contextual factors. This will be followed by a section that extensively discusses the motivators and barriers divided along the behavioral motives for pro-environmental behavior, based on the most relevant theories. This section will contain both motivators and barriers for individuals to exhibit pro-environmental behavior. There will be special attention for the differences between the motivators, barriers and motives for pro-environmental behavior which relate to residents in comparison to those which relate to tenants of social housing. Subsequently, the modeling approach will be consisting of different modeling types which can be used to explain the tenants' decision-making process. The literature review is marked with a conclusion which provides an answer to the first research question, behavioral theories and a model which will be used to explain the tenants' decision-making process.

This research study focusses on the motivators, barriers and motives of tenants of social housing regarding the willingness to participate in natural gas-free renovation projects. In these natural gas-free renovation projects, there is limited freedom of choice for the tenants, as the homeowner decides on the renovation project. As described in the introduction, 70% of tenants have to agree to a renovation project for it to continue. This gives tenants some influence on the renovation projects. Consequently, it is important for housing associations to know what their tenants think of a natural gas-free renovation project, its benefits and downsides and how they trade-off these factors.

The literature which is discussed in this literature review is gathered from the TU/e library and Google Scholar and consists of articles published in journals and books. Studying the reference lists of these research studies and articles provides additional literature. The literature is added with graduation theses published by the study association of Construction Management and Engineering. The quality of the literature is ensured with a number of criteria which are used for the selection of the literature. Behavioral theories and models are selected on their relation to energy, or pro-environmental behavior. The literature which discusses behavioral motives relates to pro-environmental behavior. There is limited research regarding the motivators, barriers and motives of tenants to exhibit pro-environmental behavior. Consequently, not only research studies into tenants of social housing will be studied. Literature regarding the motivators, barriers and motives of pro-environmental behavior are selected based on the type of respondents (residents, homeowners, or tenants).

2.1 Energy behavioral theories

The drivers of individual behavior have been studied across all fields of social sciences. Gaining a thorough understanding of the human behavior and its motivators and barriers have inspired researchers to create many different decision models. These different theories explain the same behavior, yet they are based on different assumptions. The quantitative research methods statistically analyze large amounts of data to study or measure facts. Quantitative research methods are good at predicting and explaining the relations between variables and the strength of these relations. An effective way of gathering large amounts of data for quantitative research is with the aid of questionnaires. Questionnaires combined with quantitative research methods are a solid method to study people's preferences, opinions and perceptions. The disadvantage of these research methods is that an unobserved lurking variable possibly influences the relationships between the researched variables.

Wilson et al. (2007) stated that decision models are created to understand human behavior and to identify the motivators and barriers which motivate this behavior. These decision models are based on behavioral theories. This section has the intention to provide an overview of the most researched behavioral theories which can be used to measure the willingness to behave pro-environmentally.

2.1.1 Energy ladder

According to Toole (2015) the concept of the energy ladder first started to appear around the fuel-wood crisis in the 1970s-1980s. The energy ladder is a hierarchical relationship between fuel types used for heating and cooking and households' rise in economic status (Toole, 2015). Consumer Economic Theory states that consumers choose more superior goods over the inferior goods when their income increases. This Consumer Economic Theory has been linked to the Energy Theory, which has shown that households act similarly to consumers, as according to their economic status, they try to maximize their energy utilities (Toole, 2015; Van Der Kroon, Brouwer, & Van Beukering, 2013). This means that as household income rises, they start to consume different fuel types, which are higher on the energy ladder.

Nansairo, Patanothai, Rambo, & Simaraks (2011) and Toole (2015) provided five characteristics which determine the fuel types, namely cost of the fuel, cleanliness of the fuel, energy efficiency of fuel, greater convenience and costs of higher lifecycle. There are multiple versions of the energy ladder with five or six rungs. Hosier & Dowd (1987) introduced a five rung ladder, while Reddy (1995) came up with a six rung ladder. Paunio (2018) on the other hand used nine energy types, as displayed in Figure 3. Paunio (2018) also divided the fuel types in solid and non-solid fuels.

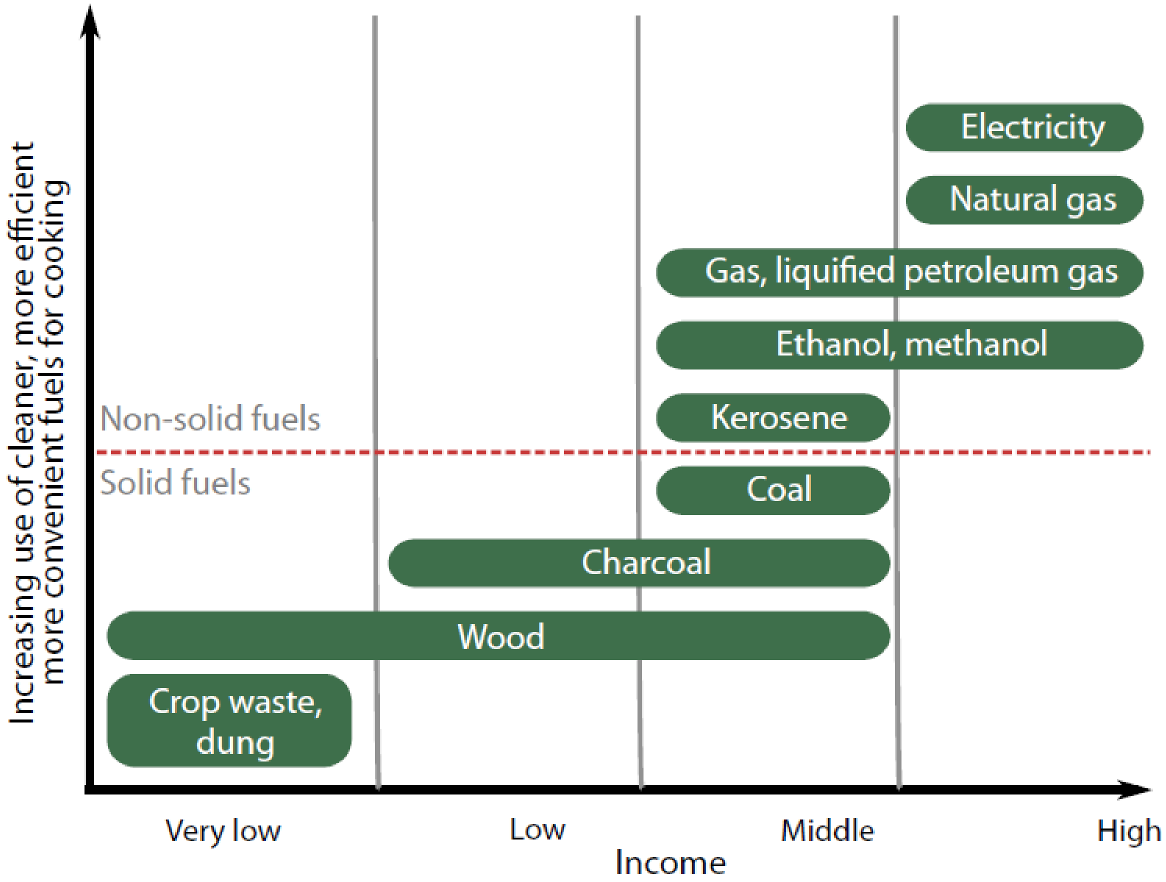

Figure 3 The energy ladder (Paunio, 2018)

The energy ladder is related to the current energy transition, as the energy ladder shows the change in energy use and demand in relation to the households' economic status (Erdmann & Haigh, 2013; Van Der Kroon et al., 2013). Consequently, rising household incomes mean that there will be a move to more expensive, yet cleaner fuel types (Mekonnen, GebreEgziabher, Kassie, & Kölin, 2009; Nansaior et al., 2011). As a result, a more expensive and cleaner fuel type leads to a climb on the energy ladder . There are three phases of moving on the energy ladder. The first is the change away from inefficient, polluting and cheap fuels, which happens when households' socio-economic status increases. The second phase consist of a transition towards transition fuels, when households move away from the reliance of traditional fuels. The third phase presents the adoption of the highest fuel types on the energy ladder, which are LPG and electricity (Van Der Kroon et al., 2013). The three phases are displayed in Figure 5. The phases of switching to more superior fuel types is known as an energy transition.

Aside from the economic growth of households, there are other motivators in relation to changing energy behavior. Mekonnen et al. (2009) and Toole (2015) have found that not only financial factors influence the change of energy resources, as they have determined multiple factors for this change. They have introduced various factors which influence the change in energy resources, specifically technologies, price changes, availability and reliability of resources, urbanization, environmental pressure, living standards, cooking and consumption habits, preferences, education, household composition and people's decision-making behavior. This has resulted in a complex combination of factors which influence the household decision to switch fuel type. Kroon et al. (2013) have created a framework which represents people's decision-making behavior regarding their energy choices, displayed in Figure 4.

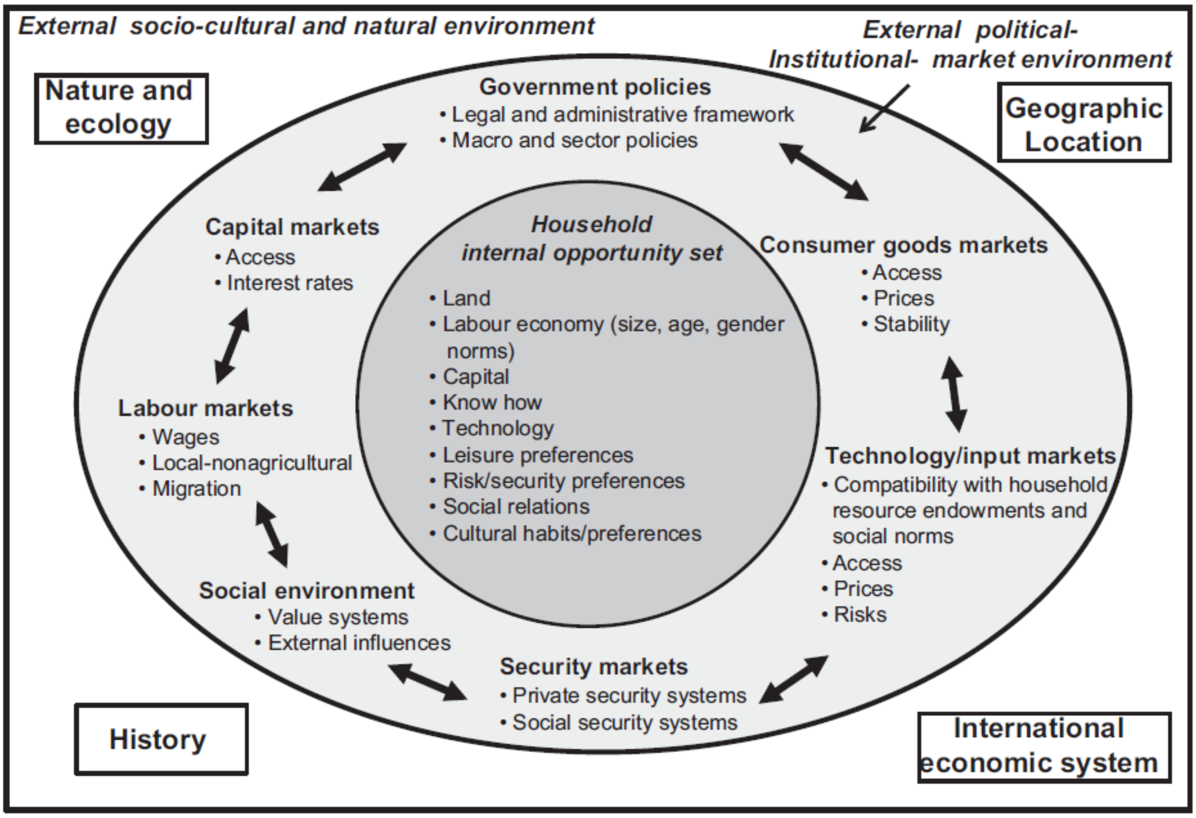

Figure 4 Conceptual model for explaining household energy choices (Van Der Kroon et al., 2013) *adapted from* (Heidhues & Brüntrup, 2003)

The fuel switching, or energy transition is not a matter of only using one fuel type. Households can combine multiple fuel types of different levels of advancement. This creates a new concept, which is called fuel stacking, also known as the multiple fuel model (Van Der Kroon et al., 2013). The Fuel Stacking Theory states that if the household income increases, people do not switch fuel type, but use multiple fuels consisting of an energy mix (Mekonnen et al., 2009; Van Der Kroon et al., 2013). Both approaches which explain households' energy use behavior, the energy ladder and energy stack are displayed in Figure 5. Despite the different approaches the two concepts follow, they both rely on a hierarchical relation between fuel type and household income. The hierarchy in both concepts ranges from biomass, to kerosene, to LPG, to electricity, which implies that the energy transition from LPG to electricity is the final step on the energy ladder.

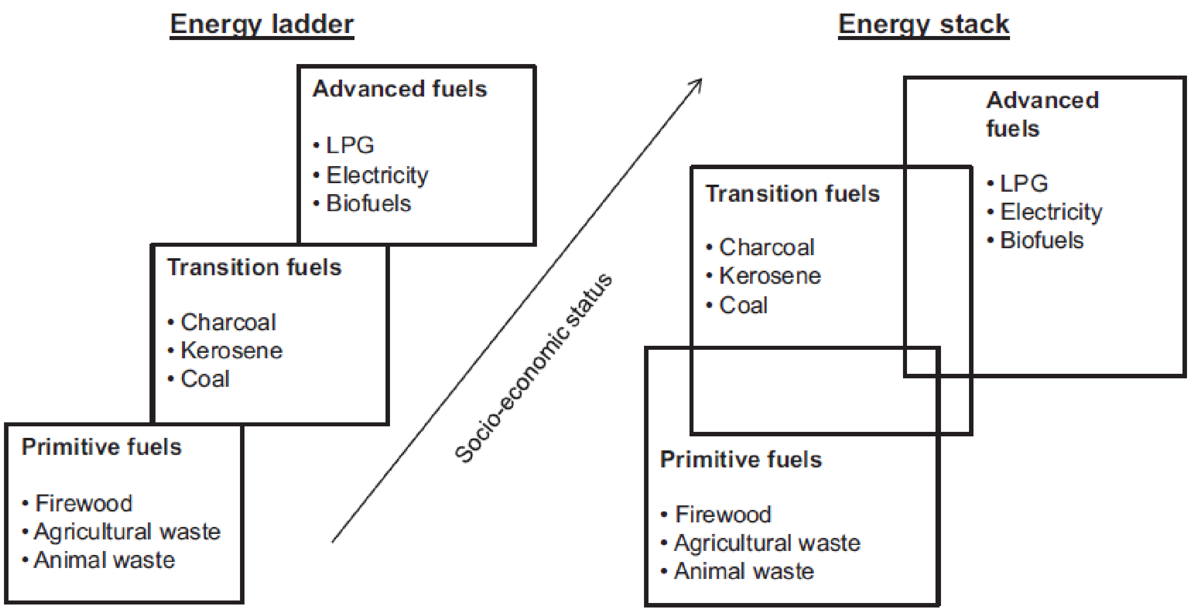

Figure 5 The energy transition process (Van Der Kroon et al., 2013) *adapted from* (Schlag & Zuzarte, 2008)

Biomass is the lowest step in the energy ladder, but can still serve as a very clean energy sources, dependent on the way it is used to produce energy. This has to do with the technological improvements that have occurred. The energy ladder has been used intensively to explain energy behavior of households. Yet, from the beginning of the 21st century, the energy ladder has become outdated and is being replaced with the fuel stacking concept.

2.1.2 Diffusion of Innovation Theory

The Diffusion of Innovation (DoI) Theory by Rogers (2003) assumes innovation as an agent of behavioral change. The innovation's attributes determine the adoption rate, while the adopter's characteristics are of less influence. Nowadays the theory has been widely applied in the fields of marketing, health and development (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). Rogers (2003) has distinguished five stages related to five groups, which accept the adoption process. The groups consists of the innovators, early adopters, early majority, late majority and laggards. The visual representation of the Diffusion of Innovation Theory and the five corresponding groups is displayed in Figure 6.

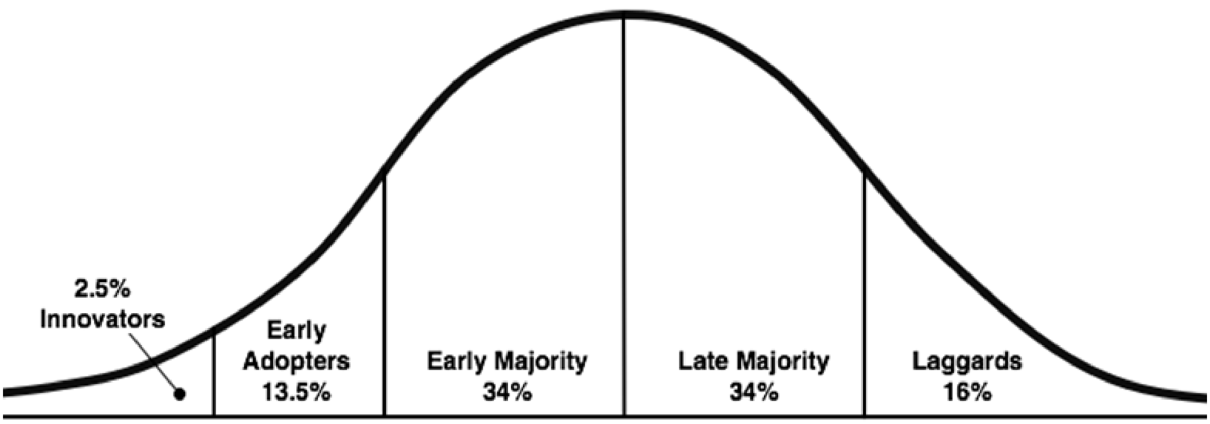

Figure 6 Adopter categorization on the basis of innovativeness. (Rogers, 2003)

There are four main factors which influence behavioral change according to DoI, specifically innovation, communication channels, time and social systems (Rogers, 2003). Rogers (2003) has stated the process as follows:

Diffusion is a process in which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication in that the messages are concerned with new ideas.

The DoI Theory states that there are a number of factors which influence the speed of the innovation adoption, namely the relative advantage, compatibility, complexity, trialability, observability and communication channels. Relative advantage means that the innovation is perceived by the adopters as better than the competition, or alternatives. The innovation also needs to be compatible to the adopters values, experiences and needs. For adoption purposes, the understandability of the product (complexity) is an important factor, as well as the fact whether it can be tested easily (trialability) in order for the functioning and results to be observed (observability). The different communication channels have an influence on the information exchange with the adopters. The different groups of adopters are influenced and persuaded by different information, communicated through different communication channels. Besides the different communication channels, the Diffusion of Innovation requires time.

The Diffusion of Innovation Theory has been used very often in the academic field of innovation. Most of its studies were conducted in a context of economics, which focused on innovations as an economic driver. There are fewer studies that focused on the non-economic outcomes and problems regarding the Diffusion of Innovation. Macovei (2015) has created an integrated model for determinants of consumers' pro-environmental behavior, in which components of Roger's (1995) Diffusion of Innovation Theory were used. The compatibility is used to represent the compatibility between pro-environmental behavior and the consumers' needs, values and lifestyle.

Cognitive dissonance is a limitation to DoI, which means that an individual has inconsistent attitudes, beliefs, or thoughts in relation to behavioral decisions and attitude change. This can be caused by the incorrect assumption in DoI which states that there is a linear representation of knowledge, awareness, intention and behavior. This results in weak explanatory power for adoption when there are situational constraints (T.W. Valente & Schuster, 2002). An example can be lack of resources. Another suggestion which is stated in DoI Theory, is the fact that a barrier is the inverse of a motivator. This suggestion has not been confirmed (Gardner & Stern, 1996). The Cognitive Dissonance Theory states that individuals make decisions to reduce the cognitive dissonance to experience consistency between their attitudes, knowledge and actions, as inconsistency will generally result in discomfort (Festinger, 1957).

2.1.3 Theory of Planned Behavior

One of the most widely cited and applied behavior theories is the Theory of Planned Behavior (TPB) (Ajzen, 1985). The Theory of Planned Behavior is an individual behavior theory which focusses on individual behavioral change. TPB has an emphasis on attitudes and outcomes, which links the TPB to the DoI. TPB belongs to a family of theories which embrace a cognitive approach to explain behavior. The TPB (Ajzen, 1985, 1991; Ajzen & Madden, 1986) has evolved from another theory, the Theory of Reasoned Action (Fishbein & Ajzen, 1975). The Theory of Reasoned Action states intention to be the best predictor of behavior. The TPB follows the assumption that behavior is a result of behavioral intention, which centers on individuals' attitudes and beliefs. Besides attitudes, intention is also influenced by subjective norms, which leads to social pressure on an individual. The final factor influencing behavioral intention according to the TPB, is perceived behavioral control, which is the perceived ease with which an individual is able to perform the behavior. The three main components of TPB are displayed in Figure 7.

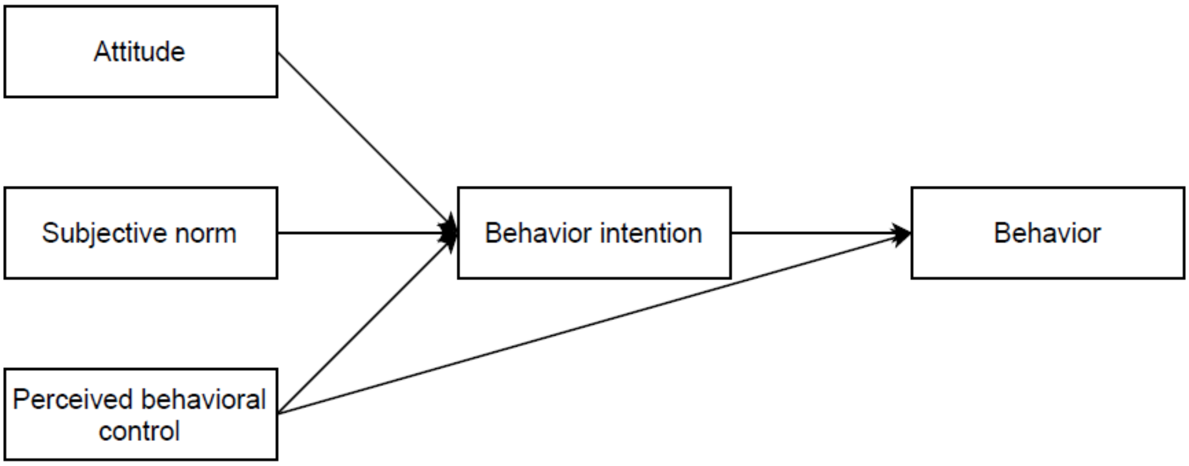

Figure 7 TPB in scheme (Ajzen, 1985)

The TPB is suited to predict behavior and retrospective analysis of behavior based on the intention of behavior. The intention is based on three components, which means that the stronger the intention to behave, the stronger the actual behavior. The attitude towards behavior and the perceived behavioral control have been reported to have strong correlations with actual behavior (Morris, Marzano, Dandy, & O'Brien., 2012). Only the subjective norms' correlation to behavior has been reported to be weak. However, Armitage and Conner (2001) have found that a few researches which studied the correlation between behavior and subjective norm appropriately have found strong correlations. As such, they state that the weak correlation is probably due to the used methodology.

The TPB is best at predicting likely behavior, besides the fact that it can also be a method to identify influences on behavior, which in turn could be targeted for change. On the contrary, the TPB is not considered to be useful in relation to interventions to change behavior (Hardeman et al., 2002; Taylor et al., 2007; Webb, Sniehotta, & Michie, 2010). Yuriez et al. (2020) has found that the TPB is regularly used to study pro-environmental behavior and behavior adoption intention. Consequently, this means that the stronger the intention to behave pro-environmentally, the stronger the actual pro-environmental behavior.

2.1.4 Social Practice Theory

A theory which is more and more used to analyze human behavior in relation to energy use and consumption is the Social Practice Theory (SPT). Social Practice Theory does not approach behavioral change based on rational choices. Instead, Social Practice Theory looks at practices (habits, routinized behavior, ways of doing) as an explanation for human behavior (Reckwitz, 2002). The human practices in Social Practice Theory are arrangements of inter-connected elements. Reckwitz (2002) has described these elements as norms, meanings, knowledge, technology use and physical and mental activities. These elements form the basis of human behavior. The Social Practice Theory occurs in situ, which means that it brings a more holistic and grounded perspective on human behavioral processes. For this reason the Social Practice Theory can be an addition to the more traditional behavioral methods (Hargreaves, 2011; E. Shove, Pantzar, & Watson, 2012; Elizabeth Shove, 2010). There is not one Social Practice Theory, as it is more an umbrella which includes various aspects of theory.

Shove et al. (2012) have developed a three elements model which consists of materials, meanings and procedures/competences. The materials are physical objects, infrastructure, tools and the human body which facilitate the performance of activities. Meanings are images, ideas and aspirations which determine how and when activities are performed. Procedures or competences are skills, know-how and practical knowledge of the practice which are necessary to execute the activities. According to Social Practice Theory, the contextual factors are more important than the individuals choices and attributes. This results in people not being autonomous, but becoming carriers of routines and practices (Reckwitz, 2002). The three elements model is visually displayed in Figure 8.

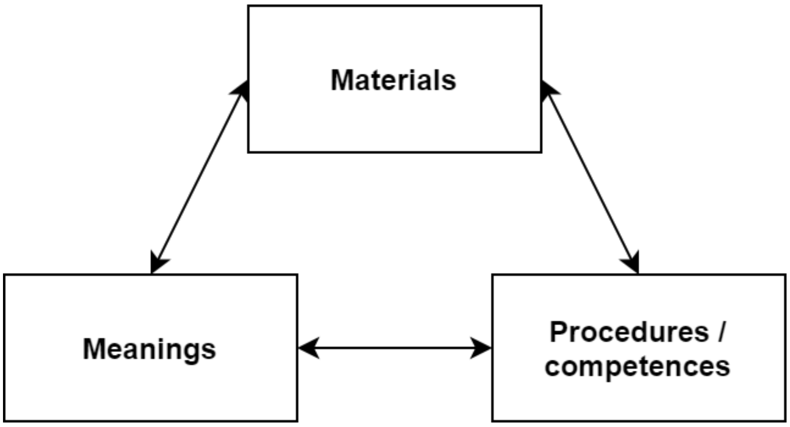

Figure 8 Conceptual framework for social practices (E. Shove et al., 2012)

Social Practice Theory has increasingly been used to understand sustainable behavior, energy behavior and energy use. For example, Hargreaves (2011) has applied Social Practice Theory to pro-environmental behavioral change with the use of case studies. According to this theory, there are a large number of new possibilities to understand and explain behavior. The main assumption is to focus on the social practice and the interaction between material context and the people's practice, not on the individual behavior. This diverts from people's choices and behavioral intervention. The focus of Social Practice Theory is on studying the reasons for certain practices and how and why others are not carried out. The role of technology and its evolvement should be considered. Shove (2010) has stated that it is impossible to merge the contrasting paradigms of individual behavior and Social Practice Theory. Consequently, it has been suggested that an integration of them would not work.

2.1.5 Self-Perception Theory

Bem (1967, 1972) has developed the Self-Perception Theory which is an account of attitude formation. It states that people develop their attitudes when they observe their behavior. On the basis of the behavior, the attitudes which caused them can be determined. Bem (1967) has argued that people can both analyze their own as someone else's behavior. A person can make both inferences about attitudes by analyzing their own as well as by analyzing someone else's behavior. Figuered, & Tsarenko (2013) have used self-perception to determine whether "being green" is a determinant to participate in sustainable initiatives at a University.

It is a counterintuitive theory, as other theories argue that attitudes determine behavior. Bem (1967) on the other hand has stated that people only understand their attitudes and interests because they can conclude them from their actual behavior. This means that people like football because they watch matches and play football. The Self-Perception Theory is also applicable for emotions, as people derive their emotions from their behavior (such as facial expressions, level of enthusiasm and posture). As such, feelings are consequences of behavior. This means that someone can conclude that he is happy, because he laughed.

Several research studies have tried to distinguish the Cognitive Dissonance Theory from the Self-Perception Theory. The Cognitive Dissonance Theory states that believing one thing and doing another creates an inconsistency which results in emotional discomfort. This discomfort steers behavior to reduce the inconsistency or dissonance. The Cognitive Dissonance Theory focusses on a dissonance between behavior and attitude, or belief. In order to confirm this theory, the attitudes, beliefs and behavior need to be known. This is not the case in the Self-Perception Theory, as attitudes are not known and can be derived from behavior. As a consequence, it can be concluded that there are different applications for both theories. The Self-Perception Theory can best be applied when people's attitudes are weak, vague or ambiguous.

2.1.6 Means-End Theory

The Means-End Theory has been used to uncover individuals' underlying emotions, consequences and personal values which drive choice behavior. As it uses laddering interview techniques, it consists of both qualitative and quantitative research methods. The Means-End Theory of decision-making incorporates two aspects of persuasion (Costa, Dekker, & Jongen, 2004). The first aspect is about understanding the target group's personal values. The second aspect reflects the understanding of the emotional link which connect the values to the individual's specific decision. An individual's decision-making is found in four elements, according to the Means-End Theory. The elements are attributes, benefits (or functional consequences), emotions (or psychological consequences) and personal values. The personal values and emotions belong to the individual, while the benefits and attributes belong to the product or service. The Means-End Theory assumes that the attributes of the product or service are associated with the personal values via the products consequences. The Means-End Theory in turn results in a means-end value chain which links these elements, as is displayed in Figure 9. Consequently, the motives, motivators, or barriers for decision-making are based on both rational and emotional elements. For individuals, a decision becomes more relevant and likely when it is perceived as to help them realize their values. The Means-End

Theory has also been used to study pro-environmental behavior, as Bagozzi, & Dabholkar (1994) have used it to study consumer recycling goals and their effect on decisions to recycle.

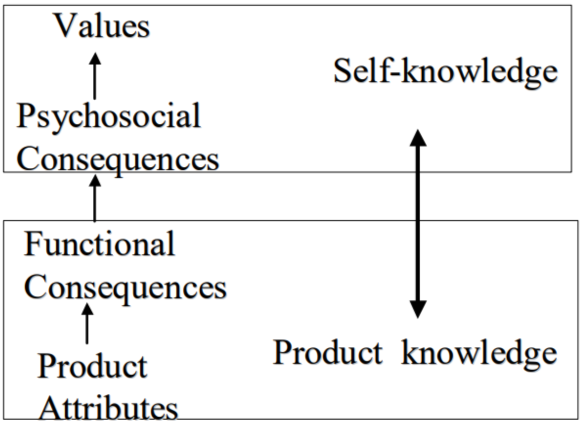

Figure 9 Means-end chain model (Raffaele Zanoli & Simona Naspetti, 2002)

2.1.7 Random Utility Theory

Random Utility Theory is based on the assumption that individuals seek to get the highest satisfaction (maximum utility) from their (economic) decision, given a number of constraints. A decision alternative with a higher utility will be preferred over an alternative with a lower utility. Hence, the utility is a measurement of the preference for different alternatives. The main assumption in the Random Utility Theory is based on the fact that individuals make rational decisions, in order to maximize their utility (Borgers, 2019; Karatasou, Laskari, & Santamouris, 2014; C. Wilson et al., 2018). The preferences are assumed to be ordered, known, invariant and consistent.

A limitations to the Random Utility Theory is the irrational behavior which can occur in the real world. There can be factors which influence a choice resulting in irrational behavior, like impulsive behavior, loyalty and sense of morality. Another limitation is the ordinal utility, which states that it is hard for individuals to give an exact value of utility (Hicks & Allen, 1934). For an individual it is easier to give an order based on preference. As an example, a person might have a preference to travel by car, over travelling by train. This is called the ordinal utility, which is less precise, but is a rough guide to utility.

2.1.8 Goal-Framing Theory

The Goal-Framing Theory is an increasingly used theory in the research field of environmental psychology. Lindenberg & Steg (2007) have developed a Goal-Framing Theory by integrating various theoretical frameworks into one integrated framework. The theory intends to understand environmental behavior. Identifying the optimal way of changing this environmental behavior is also the aim of the theory (Steg et al., 2019). The environmental behavior is based on four value types, specifically the hedonic, egoistic, altruistic and biospheric values (G. Perlaviciute & Steg, 2015). The hedonic values relate to people's comfort and pleasure. The egoistic values relate to people's personal resources (monetary and non-monetary) and safeguarding. The altruistic values refer to the way in which people value the well-being of society and others. Lastly, the biospheric values relate to the environment.

People have a personal preference for these values, which influences their environmental behavior (Steg, Bolderdijk, Keizer, & Perlaviciute, 2014; Steg, Perlaviciute, et al., 2014).

The Goal-Framing Theory states that people's information processing and action is controlled by three goals, in specific the gain, hedonic and normative goals (Lindenberg & Steg, 2007). The gain goal corresponds to the preservation or increase of personal resources, which can be monetary and non-monetary. This goal has a middle to long time horizon, wherefore people estimate the costs compared to the benefits to engage in the behavior. The personal resources can be time, money, relations, or other personal resources. Hedonic goals aim at increasing one's feelings, mood, emotions, or pleasure. Pro-environmental behavior is in most cases less comfortable or unpleasant. The hedonic goal's time horizon is short. The normative goal relates to behaving according to social norms and doing what is right. These norms do not easily or often change. Hence, the normative goal has a long time horizon. These three goal frames are related to the four values types, which define what is important to people and what they seek in their life (Rokeach, 1973; Schwartz, 1992). Steg et al. (2014) found that the hedonic (and to a lesser extent the egoistic) values predicted attitudes, preferences and behavior in the opposite direction to the altruistic and biospheric values. As altruistic and biospheric attitudes exhibited pro-environmental behavior, they were related to the normative goal frame. The hedonic value is most related to the hedonic goal frame. The egoistic value is mainly related to the gain goal frame, as they both aim for the preservation, or expansion of personal resources.

The three goals influence a person's behavior, but each one to a different degree as every person has a different personal preference. There is always one goal which is dominant and as a consequence determines the information processing, also known as the focal goal. The two goals which are not dominant, influence the strength of the focal goal. Additionally, the goals can influence each other, wherefore the gain and hedonic goal have a more similar focus on personal benefits. Acting based on the gain and normative goal is more short-term and beneficial for the individual itself. The normative goal on the other hand aligns with doing the right thing for the environment, which implies pro-environmental behavior. People's actual behavior arises from a combination of the influences from the three goals.

2.2 Factors underlying pro-environmental behavior

As natural gas-free renovation projects have been considered to be pro-environmental behavior, this first section determines the factors which underly to pro-environmental behavior and thus to natural gas-free renovation projects. Many individual decision-making models and theories differ axiomatically. Wilson & Dowlatabadi (2007) have stated that some of them are based on emphasized physical or contextual factors from individual to social scales, while others have been based on informed rationality or psychological variables. What all decision theories agree on, is that there are multiple factors influencing a decision-making process. Wilson et al. (2007) have stated that these factors for decision-making can be divided in two groups, in specific the psychological, or personal and the contextual factors. Steg et al. (2015) have described three main factors underlying to energy behavior (pro-environmental behavior), which have been widely explored in the literature. The three factors are knowledge, motivation and the ability to do so (contextual factors). Motivation and knowledge by Steg et al. (2015) can be described as the psychological factors by Wilson et al. (2007), as these are both included in the psychological factors. This section is structured based on the three factors for energy behavior by Steg et al. (2015).

2.2.1 Knowledge

People are not always aware of the causes and consequences of their behavior on climate change, as people who are not exposed to interventions have less knowledge of energy conservation (Abrahamse, 2007). This has indicated that there is a lack of knowledge. People with a higher education have more knowledge about climate change, but the correlation is weak (Tobler, Visschers, & Siegrist, 2012). People's limited understanding of their human behavior on climate change means that they misrepresent the contributions of certain activities and behavior to global warming. People perceive the causes of global warming to be activities such as industry, not their own actions (Whitmarsh, Seyfang, & O'Neill, 2011). As people misrepresent the energy use of their behavior, this means that they do not know what changes effectively reduce their energy consumption. For example, people are not aware of the amount of energy which is needed to heat water, as such they are not aware of the amount of energy they can save by showering less (Schuitema & Steg, n.d.). Another misrepresentation is related to the characteristics of energy sources, as some people categorize natural gas as renewable energy, while only 55% categorize biomass as a renewable energy source (Devine-Wright, 2003).

There is a relation between knowledge and concern about climate change and environmental problems. Additionally, more knowledge has a positive effect on a person's attitude towards the environment (O'Connor, Bord, & Fisher, 1999). If a person has more knowledge about climate change and its causes, the person is generally more concerned about the climate change (Guy, Kashima, Walker, & O'Neill, 2014; Sunblad, Biel, & Gärling, 2009; Tobler et al., 2012). A study by Kahan, Peters, Wittlin, Slovic, Larrimore, & Mandel (2012) has stated that there is no relation between higher degrees of science literary, technical reasoning capacity and concern about climate change. This has indicated that there is no direct relationship between knowledge of climate change, knowledge of science literacy and technical reasoning. Consequently, a lower concern about climate change cannot be explained by a lack of understanding the science behind climate change. Scientists disagreeing about the seriousness of climate change may contribute to the confusion, which according to McCright, Dunlap, & Xiao (2013) lowers the public's concern about climate change.

There is no strong relation between knowledge and environmental behavior (energy behavior). Some studies have stated that environmental knowledge somewhat increased the pro-environmental behavior likelihood (Frick, Kaiser, & Wilson, 2004; Hines, Hungerford, & Tomera, 1987). Contrarily, there are other studies which have stated that pro-environmental behavior is not increased by knowledge (Kollmuss & Agyeman, 2002; Meinhold & Malkus, 2005; Vicente-Molina, Fernández-Sáinz, & Izagirre-Olaizola, 2013). According to research, there are different types of knowledge which can influence pro-environmental behavior differently. There are two types of knowledge which can predict environmental behavior, specifically the action-related knowledge and the effectiveness knowledge (Frick et al., 2004). The action-related knowledge translates to what can be done in relation to the environment.

The effectiveness knowledge translates to knowledge about the effectiveness and benefits of pro-environmental behavior. An additional knowledge type, system knowledge only affected environmental behavior indirectly. System knowledge translates to a person's understanding of the environment and the ecosystems, which in turn influences pro-environmental behavior indirectly through the other two knowledge types. As a consequence, knowledge promotion is not sufficient to encourage pro-environmental behavior. Knowledge is a precondition for pro-environmental behavior. Knowledge alone will not result in pro-environmental behavior when people are not motivated (Steg et al., 2015).

2.2.2 Contextual factors

Even though most people care about the environment, not all their behavior is pro-environmental. Besides the lack of knowledge and motivation, there is the influence of the contextual factors. The contextual factors are the advantages and disadvantages of different (pro-)environmental behavior, which influence individual behavior (Lindenberg & Steg, 2007; Ölander & Thøgersen, 1995; Steg & Vlek, 2009; Stern, 1999; Thøgersen, 2005). Wilson et al. (2007) have stated that these contextual factors include technologies, economic incentives, available choices, infrastructure and social norms. Some of these contextual factors can hinder the pro-environmental behavior, like in the case of renovations in social housing, as there is limited freedom of choice for the tenants. This phenomenon is caused by the fact that the housing associations make the decisions regarding (energy efficiency) renovation projects. The tenants can only make suggestions and communicate their concerns. Consequently, contextual factors can prevent people from acting on their biospheric values (Abrahamse & Steg, 2009, 2011; Diekmann & Preisendörfer, 2003; Harland, Staats, & Wilke, 1999; Steg, de Groot, Dreijerink, Abrahamse, & Siero, 2011). In some situations, the contextual factors make (pro-) environmental behavior impossible (Corraliza & Berenguer, 2000; Guagnano, Stern, & Dietz, 1995). Contextual factors can also motivate (pro-) environmental behavior by supporting people's biospheric values. Nonetheless, when the contextual factors support the behavior, these biospheric values are less predictive of the behavior (Guagnano et al., 1995). This suggests that low behavioral barriers results in pro-environmental behavior, no matter someone's biospheric values.

The contextual factors influence the consequences (motivators and barriers) of (pro-) environmental behavior, but they can also trigger certain values. This can increase the effect of these values in certain situations (Steg, Bolderdijk, et al., 2014). For example, hedonic and egoistic values can be triggered by high behavioral costs. Due to the high behavioral costs it is less likely that the biospheric values play a large role in people's behavior.

2.2.3 Motivation

The motivation to engage in pro-environmental behavior is influenced by the consequences of such behavior. The more favorable the relative advantages, (i.e. motivators vs barrier), the more likely a person is to engage in pro-environmental behavior. There are many individual consequences (motivators and barriers) to environmental actions, such as the instrumental, which can consist of time, comfort and price. This might result in the fact that consequences motivate individuals to exhibit pro-environmental behavior, based on the relative advantage of the consequences. Wilson et al. (2007) have classified the motivations which have been described by Steg et al. (2015) as the psychological factors, which include values, attitudes and personal norms. These instrumental consequences of pro-environmental behavior are normally barriers, as pro-environmental behavior is often costly and requires extra effort. Besides the individual consequences, there are also collective consequences of environmental behavior, namely the consequences to the environment (Steg, Perlaviciute, et al., 2014). Doing what is the right thing to do, motivates people to engage in pro-environmental behavior (Bolderdijk, Steg, Geller, Lehman, & Postmes, 2013). As a result, there are also moral considerations for environmental behavior, as people can derive pleasure from the social and affective motivators, because it makes them feel good to do the right thing (Carrus, Passafaro, & Bonnes, 2008; Pelletier, Tuson, Green-Demers, Noels, & Beaton, 1998; Schuitema & Steg, n.d.; Smith, Haugtvedt, & Petty, 1994) and they can get the approvement of others (Harland et al., 1999; Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008). Additionally, the symbolic aspect has a positive influence on behavior in relation to renewable energy systems, as this means that the innovation gives a positive signal about the owner (Noppers, Keizer, Bolderdijk, & Steg, 2014). Despite the instrumental barriers, it can still be favorable for people to engage in pro-environmental behavior due to the positive symbolic of the innovation.

The likelihood that an individual will consider the individual and collective consequences of pro-environmental behavior (motivators and barriers) are enhanced by certain factors which influence their choice behavior. These factors are values, which define what is important to people and what they seek in their life (Rokeach, 1973; Schwartz, 1992). These values affect beliefs, evaluations and actions (Steg, Perlaviciute, et al., 2014). The four values are relevant for people's evaluation of (pro-)environmental behavior (de Groot & Steg, 2008; Steg, Perlaviciute, et al., 2014), as they determine how important people value certain consequences of (pro-)environmental behavior. People's values influences their preferences, beliefs and choices, as these value the goals people strive for. Hence, the values are a person's preference for the goals they strives for in (pro-)environmental behavior, as the goal-frames capture the way people process information and act upon it. The relation between these values and motives/goal-frames is displayed in Figure 10. Steg et al. (2014) have found that people prioritize values differently, which results in different goals. Specifically, this means that strong gain goals result in a person focusing on gain aspects of an alternative. The normative goal frame is related to the altruistic and biospheric attitudes as they exhibited pro-environmental behavior. The hedonic value is most related to the hedonic goal frame and the egoistic value is mainly related to the gain goal frame, as they both aim for the preservation, or expansion of personal resources. At any given time these multiple goals are active, which may or may not be compatible. This means that goals in the background may influence the focal goal.

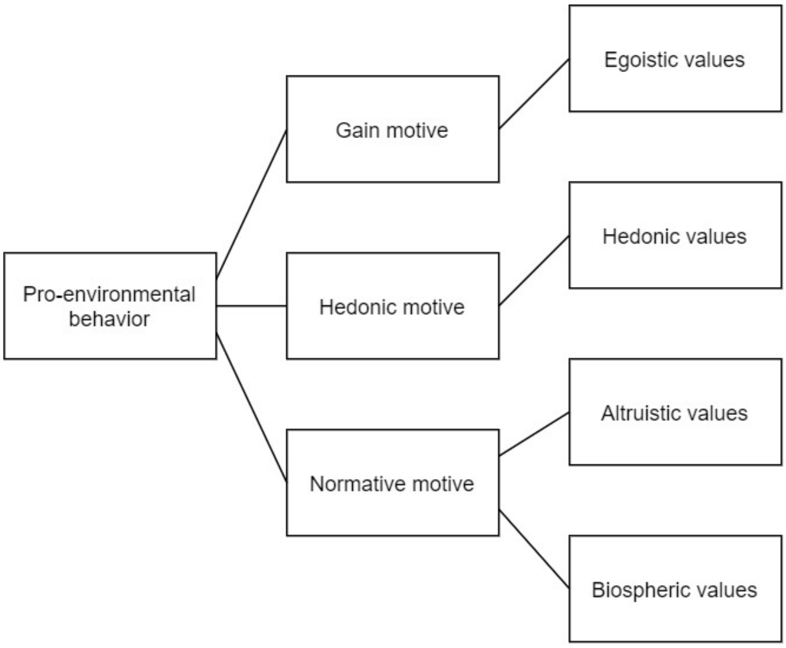

Figure 10 Graphical representation of the relation between pro-environmental behavior, motives/goal-frames and values.

Consumer profiles in motivation

Motivation created different consumer profiles, as individuals have different values, goals and motives. Motivaction's five consumer profiles explain pro-environmental behavior of Dutch people (Motivaction, 2020). The whitepaper by Motivaction is called "Vijf tinten groener", which translates into "Five shades of greener". The five shades of green are the five consumer profiles which can be used to explain sustainability and pro-environmental behavior. The five consumer profiles are dutiful, structure seekers, status conscious, responsible ones and developers. The five detailed profiles are explained in Appendix 1. The whitepaper by Motivaction (2020) is not a scientific research study, as the methodology, calculations and results are not published. This means that it not peer reviewed, which makes it risky to base assumptions on.

A scientific research study regarding homeowners profiles is that by Broers, Vasseur, Kemp, Abujidi, & Vroon (2021). They have conducted a study among Dutch adopters of RPV and created a segmentation model. With the aid of the model, five homeowner profiles were created, based on their level of environmental concern and educational background, or profession (technical, financial-economic or other). These five homeowner profiles all require a different approach with different information provision (with different levels of technicality and complexity) and different communication and promotion strategies (based on different benefits such as environmental, financial/economic and aesthetic). These five profiles can be used to explain pro-environmental behavior and increase its adoption.

The following three sections will discuss research studies which explain the motives, values, motivators and barriers influencing people's (pro-environmental) behavior and focal goal (G. Perlaviciute & Steg, 2015; Goda Perlaviciute, Steg, Contzen, Roeser, & Huijts, 2018; Steg, Perlaviciute, et al., 2014). There is limited research regarding the motives of tenants to exhibit pro-environmental behavior. As tenants and homeowners can have similar values and motives, studies focusing on the motives for pro-environmental behavior of homeowners are described as well. The following section elaborates on the three different motives.

2.2.4 Gain motives

The gain goal is one of the three motives to exhibit behavior. The gain motive has as goal to preserve or improve a person's personal resources, which can both be monetary and non-monetary. The non-monetary motives can be time, relations, comfort, effort, status, etc. (Lindenberg & Steg, 2007).

Steg et al. (2015) have conducted a research study into the influence of values on people's perception and adoption of energy alternatives. They have distributed two questionnaires among Dutch people in order to determine their perception of values related to nuclear (study 1, n=279) and renewable energy (study 2, n=143). To test the hypotheses, Pearson's correlation was used. The study has concluded that people who value the individual consequences of energy alternatives as more important, have stronger egoistic values and thus gain motives. As a consequence, this has an influence on people's attitude towards energy resources and how they perceive the consequences of behavior adoption. Additionally, the study has determined that stronger egoistic values positively relate to valuation of individual and environmental consequences of nuclear energy. Nonetheless, innovations with less complexity and higher relative advantages, were related to actual adoption. As a result, actual adoption behavior is more influenced by the gain motive than the adoption intention. Abrahamse & Steg (2013) have found similar results in their meta-analysis, which studied the results of 29 other research studies.

McMakin & Malone (2002) have conducted an experiment at a military base where they studied engagement in energy efficient behavior. They have found evidence to conclude that gain motives are the main motivator for energy efficient behavior, as people focus on their own benefits. When the monetary incentive is not applicable, the comfort and health incentives are the main drivers to engage in energy efficient behavior. However, Abreu et al. (2017) have described that homeowners consider adjustment of their house mainly when there is a need for it. Reasons can be maintenance that is due, reparations, renovations, etc.. For these house adjustments, the financial resources are the most important parameter in the decision-making process. However, some homeowners indicated that energy efficiency improvements are also important. Similar results have been found by Mortensen et al. (Mortensen et al., 2016) and Wilson et al. (2015), who have studied the parameters of homeowners' willingness to participate in energy efficiency renovations. They have determined that the financial and economic benefits, as well as the size of the investment were the main determinants in the decision-making process. The project will only be carried out if it is financially feasible. Additionally, Mortensen et al. (2014) have concluded that homeowners experience multiple factors which have influence on the motivation to conduct energy saving retrofits, but the financial factor remain the final determinative. Similar results have been found by Lappegard Hauge, Thomsen, & Löfström (2013), who have conducted a research study into the factors which influence the chance that resident or homeowners in a housing cooperative agree on a sustainable renovation. A multitude of factors have been studied, namely economic factors, the information provision, the time frame and process, attention of the residents' needs and availability of exemplary projects and role models. The research study has concluded that the economic factors were the main influence in the decision-making process and that the sustainable renovation and pro-environmental behavior were a bonus. To study the adoption in community PV projects Koch & Christ (2018) have conducted 18 interviews among (non-) participants of the projects. For the non-participants, the lack of financial resources were the main barrier for participation. On the other hand, the use of regionally generated energy was the main driver for participation. Dóci & Vasileiadou (2015) have conducted a quantitative research study into the motivations for investment in renewables in community projects. They have concluded that the gain motive is often the focal goal in the decision-making process. As a consequence, the reduction of energy cost is the main driver, while the normative motives are less important. Studying the purchase process of solar PV, Sommerfeld, Buys, & Vine (2017) have conducted 22 semi-structured interviews. They have found evidence to conclude that the financial factors are the main factor in comparison to the pro-environmental factors. Broers, Vasseur, Kemp, Abujidi, & Vroon (2019) have studied the motives of Dutch homeowners in the decision-making process of energy renovations. These motives vary in the several stages of the decision-making process. Environmental concern and knowledge recognition are most important in the first stage of the decision-making process. Financial and economic motives on the other hand are the most important factors in the final stage of the decision-making process.

For a tenant the financial factors are relatively simple, as there are no investment costs, also known as ROI (return on investment) and no capital needed. An energy efficiency or natural gas-free renovation project will never impact a social tenant negatively in the Netherlands, as there is the split incentive which indicates the fact that the housing costs should always decline, or remain the same (Ministry of the Interior and Kingdom Relations, 2012; Monteiro, Causone, Cunha, Pina, & Erba, 2017). The housing costs are composed of rent and energy costs. If the energy costs decrease due to the renovation, a part of this saving can be charged as a rent increase for the tenant. Combined, the rent and energy costs should never increase after a sustainability renovation. Van der Spank (2013) has found that the decrease of living-costs is the most important factor (33.5%) for the participation of tenants in sustainability renovations. The reason for the relative high importance of decreasing housing costs is the tenants' generally low household income. Quirijns (2011) and Werf (2011) have both confirmed the findings by Van der Spank that financial aspects are important for tenant participation.

Grient & Vos (2019) have conducted a public monitor for climate and energy among Dutch homeowners and tenants regarding their knowledge, attitude and behavior in relation to climate change and the energy transition. It appears that the costs of measures are more important than the climate, as most Dutch people find it important that the measures deliver them a benefit. The main barrier of adopting pro-environmental behavior is the lack of knowledge about the benefits and costs of the measures, as most people cannot determine whether the measures comply with their house or situation.

All the studies have found comparable results which show the given that financial and economic factors are the main drivers of pro-environmental behavior for both homeowners and tenants. This applies to different kind of measures such as energy efficiency renovations, solar PV, both individually and in community projects, but also to more general home adjustments. In this decision-making process the gain motive is the most important factor (focal goal) which determines the (pro-environmental) behavior of the person.

2.2.5 Hedonic motives

The hedonic motives can be described as follows: 'because it is enjoyable and easier'. Hedonic motives are experienced by people as feelings like excitement, pleasure or the willingness to avoid effort, as it focusses on their feelings and mood (Lindenberg & Steg, 2007). The assumption that people make rational choices, is not always true, as people also make choices which are highly influenced by the fact that it makes them feel good. It can be concluded that emotions are motives of human behavior (Steg et al., 2019). Hence, behavioral change will not be effective if the new behavior requires more time or effort, or leads to less comfort. Usually, people choose the easiest way with the largest benefits (Delmas & Lessem, 2013; Steg, 2008).

Van der Spank (2013) has conducted a research study into sustainable renovations among tenants and has concluded that there are two major concerns which negatively affect pro-environmental behavior. The first concern is regarding their house and rent, which not only means that the tenants are concerned about their rental change, but even more about the change that occurs in their house. This has to do with the enjoyability of the current state of their house, which can be higher than the wish for change. The second concern is related to nuisance, caused by the renovation. The degree of nuisance depends on the extent of the renovation and whether the bathroom, kitchen, toilet and/or heating are also renovated. Most (natural gas-free) renovation projects are executed in occupied houses. This can cause serious inconvenience for the residents. Too much inconvenience or nuisance could serve as a barrier, which impedes their willingness to participate in such a renovation project. Schillemans, Rooijers, & Benner (2006) have confirmed there is a negative relation between the nuisance of a renovation project and the willingness to participate. Other research studies have stated similar results which have indicated that nuisance is an influential factor for participation, but not a crucial factor (Quirijns, 2011; Werf, 2011). Nuisance can be caused by various reasons, like the fact that preparatory measures or – work, temporary decrease the tenant's living comfort. It is important to take into account that this experience of discomfort is highly influenced by the duration of the renovation project. Taking care of temporary accommodation as an encounter of the experienced discomfort could be a way to increase the hedonic motivation of tenants to cooperate with the renovations works. Another disadvantage of acting pro-environmentally is the fact that it usually requires extra effort, such as time consuming efforts or an increase in monetary costs. This given is underlined by the findings of Hage et al. (2008) and Barr et al. (2013) who have concluded that in order to achieve high participation for waste separation, high accessibility is essential in order to reduce the extra effort. Without high accessibility, the participation will be low, despite high awareness and a positive attitude towards waste recycling. Bernstad (2014) has conducted a study which focused on the repeated treatment of waste separation behavior with two different strategies. The first treatment focused on information provision about environmental gains and the second intervention provided the kitchen equipment for the waste separation, which results in extra convenience. The first treatment has presented a 12% increase in collected food waste in the first 10 weeks, but the number decreased to 10% and 7% in the following 10 and 20 weeks. The second treatment has showed a 49% increase in the first 20 weeks and a more stable 44% increase after 30 weeks. This has indicated that convenience makes it easier to change behavior and thus leads to better pro-environmental behavior.

Besides multiple research studies showing a positive relation between convenience and pro-environmental behavior, there is also a negative relation between negative feelings and pro-environmental behavior. This has showed that people do not like negative feelings, which can be caused by various reasons, such as the extra effort needed in order to engage in pro-environmental behavior. Steg et al. (2014) have proved the negative relation between hedonic motives and pro-environmental behavior in an extensive research, which has included four studies and questionnaires. The research has stated positive correlations between hedonic values and egoistic values ($r = 0.39$, $p < 0.001$), and lower correlations with biospheric ($r = 0.25$, $p < 0.001$) and altruistic values ($r = 0.20$, $p < 0.001$). The correlation between altruistic and biospheric values was higher ($r = 0.68$, $p < 0.001$). Consequently, this proves that hedonic values result in an opposite effect than altruistic and biospheric values in relation to pro-environmental behavior. People with strong hedonic values associate less with pro-environmental behavior and associate more with higher energy consumption, as they are less likely to sacrifice their comfort or pleasure to reduce energy consumption. People’s unwillingness to reduce their personal pleasure results in a negative relation between personal sacrifice and the willingness to engage in pro-environmental behavior. This given can be underlined by Werff and Steg (2016), as they have found similar results which concluded that strong hedonic values decrease the likelihood of participation in smart energy system projects. The results are most likely applicable to other pro-environmental behavior, like natural gas-free renovation projects. The hedonic values and their relation to pro-environmental behavior could impede behavioral change, which illustrates the importance to include the hedonic values in environmental studies. Besides the already discussed increase in effort which is required by most pro-environmental behavior, there is also the factor of risk perception which is linked to a person’s emotions, mood, comfort and pleasure. Perlaviciute, Steg, Hoekstra, & Vrieling (2017) have conducted a research study into the risk perception and negative emotions among citizens in the province of Groningen in relation to natural gas-fired energy production. This research study has confirmed the preference of risk reduction (of earthquakes) and the improvement of quality of life. These findings resemble the hedonic motives which seek to reduce negative feelings (like risk) and aim for pleasure and an increased quality of life.

Abreu et al. (2017) have conducted 18 in-depth interviews, which have indicated that the intrinsic value motivating the energy efficiency of a person’s home is not the reason for homeowners’ renovation decisions. The main reason to renovate is aesthetically, motivated by issues in a person’s lifestyle, or due to the need for repair. The financial motives are critical when the financial resources are limited. Van der Spank (2013) has concluded that besides nuisance and living-cost savings, the technical factors of dwelling expansion (16.5%), living space renovation (16%) and sustainable solutions (13%) are influential on tenants' participation in sustainable renovations. Additionally, an alternative heat source qualifies as a technical factor, as it is a technical installation which serves as a sustainable solution. Nonetheless, many tenants do not value technical solutions, but the comfort which is related to these solutions. This has been confirmed by a study among Danish homeowners by Mortensen et al. (2014), who have found similar results, indicating the most important reasons for renovation. The top motivators are the indoor climate (4.9), the interior lay-out/functionality indoor environment (4.4) and the operating costs (4.4), which are the costs for maintenance and water, electricity and heating. Abreu et al. (2017), Van der Spank (2013) and Mortensen et al. (2014) have concluded that energy efficiency is an extra advantage of renovations, but not a motivation, as the main reasons are comfort, aesthetical and lay-out improvements. Wilson et al. (2015) have found evidence to conclude that homeowners value the importance of finances and appearance more compared to the extent to which they value the importance of energy savings. To increase the motivation of homeowners to conduct energy efficiency renovations, Wilson et al. (2015) have suggested to couple the motivating factors to the societal benefits. This means coupling motivators like comfort improvements to the decrease of energy consumption. Mortensen et al. (2016) have used the questionnaire data from Mortensen et al. (2014) to study the key parameters determining the willingness and motivation of Danish homeowners for energy renovations. They have found that the homeowners place in life is important for their interest and willingness to participate in an energy renovation. Homeowners over 60 years old are mainly motivated by comfort improvements, as they value the condition of their property as good. An analysis of the WOON questionnaire confirmed the importance of the hedonic motives in relation to the decision-making process for home renovations (Ebrahimigharehbaghi, Qian, Meijer, & Visscher, 2019). Convenience and hassle have been found to be co-determinants in the decision-making process in the consumer questionnaire by Motivaction (Van der Grient et al., 2019). A measure with a low degree of hassle combined with comfort improvement has a higher likelihood to be adopted.

All the research studies have indicated that the reduction of energy consumption is not a motivator for energy efficiency measures. The willingness to adopt pro-environmental behavior is mainly influenced by people's place in life and household characteristics, combined with hedonic motives such as comfort improvements and limited nuisance, hassle or risk perception.

2.2.6 Normative motives

The normative motive to engage in pro-environmental behavior has been described by Steg et al. (2014) as behaving in a certain way, because it is 'the right thing to do'. Normative motives correspond with altruistic and biospheric values (G. Perlaviciute & Steg, 2015). The normative goal focusses on both the social norms and the urge to behave appropriately according to this social norm and the ideological belief in the necessity to save the environment.

Voesenek (2020) has qualitatively investigated the participation of social tenants in natural gas-free renovation projects. Two case studies and semi-structured interviews have been used to determine the motives of tenants in order to accept a natural gas-free renovation project. The motives and goals named by the participants of the semi-structured interviews were coded based on the conceptual model. The results have showed that a majority of participants indicated to (highly) value biospheric values and personally feel responsible for the mitigation of climate change. This means that (social) tenants have strong normative motives. On the other hand, biospheric values serving as a determinant in their decision-making process, were only indicated by a small group of participants. Consequently, tenants indicated that their strong normative motives do not influence their decision-making process. However, Kochen & Moore (2007) have found other striking results. They have investigated the participation in green-electricity programs in the US. There are two mechanisms that both have a 10 to 30 percent higher electricity price than conventional electricity, which means that participants are participating due to normative motives. A questionnaire has been spread among participants and non-participants which served as the control group. This research study has measured the extent of the altruistic attitudes with the aid of the Schwartz model for activation of altruistic behavior. The New Ecological Paradigm (NEP) scale has been used to measure the environmental concern of the participant. The results have showed that participation in green-electricity programs is influenced by altruistic and environmental concerns. Household income on the other hand does not influence the participation, only the amount of donation to the program. Hence, the persons attitude influences their willingness to pay. This research study has proven that environmental concerns and consequently normative motives are a motivation to engage in pro-environmental behavior. This given has been confirmed by the research study conducted by Nguyen et al. (2017) which have focused on the personal characteristics and their relation to pro-environmental behavior. They have provided evidence to conclude that strong personal altruistic preferences result in a positive relation towards environmental protection.

The given that communal motives are an important motivation of pro-environmental behavior has been supported by Sloot, Jans, & Steg (2019). In their research study they have distributed questionnaires in 29 Dutch neighborhoods involved in an energy related neighborhood initiative (Buurkracht). The communal (altruistic) motives are positively related to the participation in these energy related neighborhood initiatives. The respondents do not indicate the communal motives as important motivations for participation themselves. As a consequence, the communal motives have been underrated by the participants. Financial motives on the other hand have been overrated, as they have been indicated as important motivators for participation, while they actually have been less influential. Environmental (biospheric) motives have been found to be both influential and perceived as influential regarding the participant’s willingness to participate in these initiatives. Consequently, the research study has concluded that normative values, being both biospheric and altruistic values, are motivators for participation in pro-environmental initiatives. Steg et al. (2015) have found similar results which have indicated that stronger biospheric values have a positive relation to a person valuing environmental consequences of behavior.

Allcott (2011) has conducted a research study in which participating households compared their energy use with the average of similar households. This has resulted in a conservation of energy, which means that social pressure comes from surroundings to do the right thing.

Delmas & Lessem (2013) have used a similar approach in student dorms with three different groups. One group received no information about their energy-use. One group got private information about their energy use and the energy use of other students. The final group received the same private information, but also public information which stated a ranking of the students' energy-use. The public information moved participants to reduce their energy-use by 20 percent, which means that the social pressure, which is a normative motive, leads to energy conservation. Similar results have been found by Morrison & Lawell (2016). They have studied the mode of transport of military personnel and have found that the amount of carpoolers with peers who carpool is higher. As a consequence, social pressure, which is classified as a normative motive is positively related to pro-environmental behavior.

The Ministry of Economic Affairs and Climate has conducted a public opinion monitor which provides insight in the development of climate awareness and sustainable behavior among Dutch people (Van der Grient et al., 2019). Most Dutch people worry about the climate, as 72% recognize the existence of climate change. 7% of Dutch people deny the existence of climate change. The majority of the Dutch people think that it is the responsibility of large companies (71%) and the government (65%) to take measures against climate change. However, 35% of Dutch people believe they are also responsible themselves, while 50% of Dutch people believe they are partially responsible. It can be concluded that Dutch people are generally aware of climate change and that they feel (partially) responsible. All research studies have indicated that there is an intention to behave pro-environmentally. However, this does not always result in actual pro-environmental behavior. Behavior consists of multiple factors, motivations and barriers. The combination between gain, hedonic and normative motives results in actual (pro-environmental) behavior.

2.2.7 Overview of motives

Figure 11 contains the motivators and barriers to exhibit pro-environmental behavior, which have been concluded form chapter 2.2 Factors underlying pro-environmental behavior.

Gain motives	**Hedonic motives**	**Normative motives**
Individual consequences	Feelings and mood	Social norms
Personal image	Comfort	Responsibility for climate change
Monetary resources	Nuisance	Conservation of energy
Time frame	Accessibility / ease of use	Social pressure
Adjustment of house	Risk perception	
	Aesthetics	
	Effort / convenience	
	Interior or layout improvements	

Figure 11 Overview of motivators and barriers for pro-environmental behavior as provided by literature

2.3 Modeling approach

As explained by Wilson & Dowlatabadi (2007) decision models are created by researchers in order to understand human behavior and to identify behavioral motivators and barriers, also known as attributes. The following section discusses the most used and researched behavioral and decision models regarding (pro-) environmental behavior, which can be used to identify and value those motivators and barriers.

Table 14 in Appendix 2 displays an overview of researches into pro-environmental behavior, tenants' preference and the used modeling approach. As represented in

Table 14, the most used modeling approaches for explaining pro-environmental behavior in relation to energy efficiency measures are Discrete Choice Modeling, Structural Equation Modeling and Analytical Hierarchy Process. The following sections elaborate on these modeling approaches.

2.3.1 Discrete Choice Modeling

The discrete or qualitative choice models describe the choices individuals make based on alternatives, which are characterized by a number of attributes. These attributes can have different levels, which results in different alternatives. The Discrete Choice Models are utility-based decision models, which aim for utility maximization, based on the Random Utility Theory, as described in 2.1.7 Random Utility Theory. The Random Utility Theory states that people normally choose what they prefer, but when they do not, this can be explained by a random factor. Consequently, the variations in behavior are not explainable, otherwise it is not a random phenomenon. Hence, in a random utility model, the utility consists of a structural and a random utility. This translates into McFadden's (1986) formula:

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$

$$V_{iq} = \sum_n \beta_{in} * X_{inq}$$

A utility-based model describes the distribution of preferences in a population, or population group. The main assumption for utility-based decision models is the fact that individuals make rational decisions, based on a maximalization of the utility (Borgers, 2019; Karatasou et al., 2014; C. Wilson et al., 2018). Based on this theory, the Discrete Choice Models can be used to explain the preference of all kind of activities, services, facilities and products, which can be decomposed in different attributes. The values of these attributes are perceived differently by every individual, as the individuals have certain preferences for the values of these attributes. The preferences are integrated in an overall utility for every alternative.

There are two types of preferences which can be used in utility-based models, namely revealed and stated preferences, as is displayed in Figure 12 (Kemperman, 2000, 2017). Revealed preferences are observed or reported and can be explained as actual behavior which display real world choices. Stated preferences are observed, or expressed preferences, or choices which are hypothetical and therefore can consist of hypothetical alternatives. Preference modeling can either be compositional or decompositional, where in the first, the respondent is asked to rate the attributes based on importance. Identification of preferences is harder to be estimated in compositional models (Kemperman, 2000). The other stated preference is decompositional, which is based on trade-offs between variables. This entails that it is possible to estimate the relative importance of variables. Stated choice modeling uses hypothetical situations or choices where the respondent has to choose the preferred choice (Kemperman, 2000). When the respondents are presented with new phenomena, Stated Choice modeling is only particularly useful (Haegeli, Haider, Longland, & Beardmore, 2010).

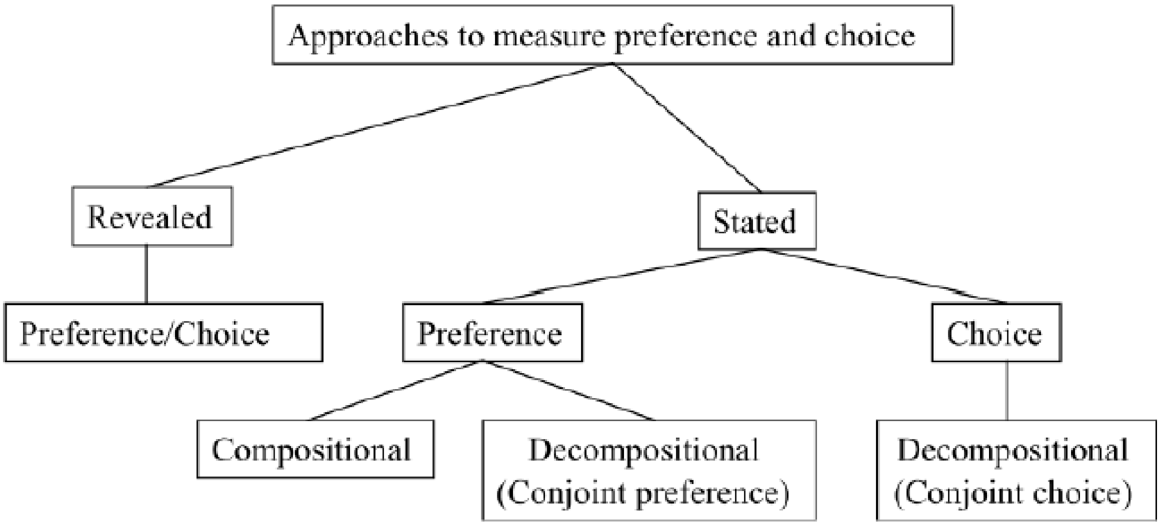

Figure 12 Measurement of preference (Kemperman, 2000)

Michelsen et al. (2012) and Kerperien (2019) have investigated the preference of social tenants in relation to energy efficiency investment with the aid of Discrete Choice Modeling with stated preferences in relation to pro-environmental behavior. In the research study by Kerperien (2019) the respondent accepts the renovation when choosing option A or B and declines an energy efficiency renovation when choosing C. This is also known as an unlabeled design. Choosing option A and B is both considered as acceptance of the energy efficiency renovation, while the attributes are different. Kerperien (2019) has conducted two choice experiments with different information treatments, one gain treatment and one hedonic treatment. The gain treatment focused on the benefits in comfort and ease, while the hedonic treatment focused on monetary benefits. The results from the choice experiment have been used to predict whether information treatment based on hedonic or gain motives is more successful in persuading tenants to accept an energy efficiency renovation. Additionally, the results from the choice model have been used to predict the acceptance of four renovation packages by Aedes (2017). Michelsen et al. (2012) have studied homeowners preference in relation to the adoption of innovative residential heating systems with the aid of the Discrete Choice Modeling method. Michelsen et al. (2012) have used the residential heating system (or RHS) as a dependent variable, for which the other attributes are explanatory variables. The different RHS's all have their own degree of acceptance, as the type of RHS is an attribute. Consequently, the adoption of every RHS can be calculated. The explanatory variables are socio-demographics, home characteristics, spatial characteristics and RHS-specific attributes. These explanatory variables can be studied for every RHS. It has to be taken into account that the research study by Michelsen et al. (2012) has focused on homeowners, and not on (social) tenants, which have different motives and barriers to adopt a RHS. Another difference between the research study by Kerperien (2019) and Michelsen et al. (2012) is that Michelsen (2012) has chosen to study every RHS separately, wherefore every RHS has an a different adoption and different values for the explanatory variables. Kerperien (2019) on the other hand has not used different systems, renovations, etc.. This means that all the choice alternatives which consist of attributes are perceived as adoption (unlabeled), while the choice alternative “none of the two” is perceives as no adoption. Hence, Kerperien (2019) has studied which factors influence the adoption of energy efficiency measures in general, while Michelsen et al. (2012) have studied which factors influence the adoption of different RHS’s. In relation to new technologies, Discrete Choice Modeling can also be used in combination with the Diffusion of Innovations Theory, as proven by Wilson et al. (2018). Wilson et al. (2018) have studied why homeowners decide to renovate energy efficiently. Both Van der Spank (2013) and Banfi, Farsi, Filippini, & Jakob (2008) have utilized Discrete Choice Modeling to study the willingness to pay of residents for energy-saving measures, related to residential buildings. Specifically the choice behavior of tenants is widely studied with Discrete Choice Modeling, as it has been used by other research studies, such as the research studies of Van der Spank (2013) and Walker, Marsh, Wardman, & Niner (2002). Choice behavior in relation to residential buildings has been studied by Nijënstein (2012), Van der Spank (2013) and Walker et al. (2002). These studies have focused on building characteristics, financial characteristics, energy components and sustainable improvements. Additionally, there have been studies which focused on pro-environmental behavior which was unrelated to the built environment, like on consumer preferences for pro-environmental behavior (Ewing & Sarigöllü, 2000).

2.3.2 Structure equation modeling

Structural Equation Modeling (SEM) is a multivariate statistical analysis technique, which is incorporated in behavioral studies and based on the Theory of Planned Behavior. The power of Structural Equation Modeling lies in the ability to estimate and analyze structural relationships between measured (observed) and unobservable (latent) variables. SEM consists of a combination between multiple regression analysis and factor analysis, which can estimate the multiple (interrelated) dependencies in one analysis. The unobservable constructs (latent variables) can be ascribed to the observable variables, which is why SEM is widely used in social sciences (Hancock, 2003). A Structural Equation Model consists of a measurement model and a structural model (Kaplan, 2008; Kline, 2011). The measurement model describes latent variables with (one or more) observed variables. The structural model ascribes relations between latent variables. The relationships between the variables of the Structural Equation Model can be estimated with the aid of independent regression equations (Kline, 2011).

The relations between the unobserved and observed variables are displayed in an SEM diagram, which normally shows the latent variables as ovals and the observed variables as rectangles, as is displayed in the example in Figure 13. In SER, error does not influence the latent variables, as every observed variables has an error value. The Structural Equation Model values every relationship between the observed and unobserved variables and between the unobserved variables themselves. This enables the estimation of latent variables, with a number of observed variables (MacCallum & Austin, 2000).

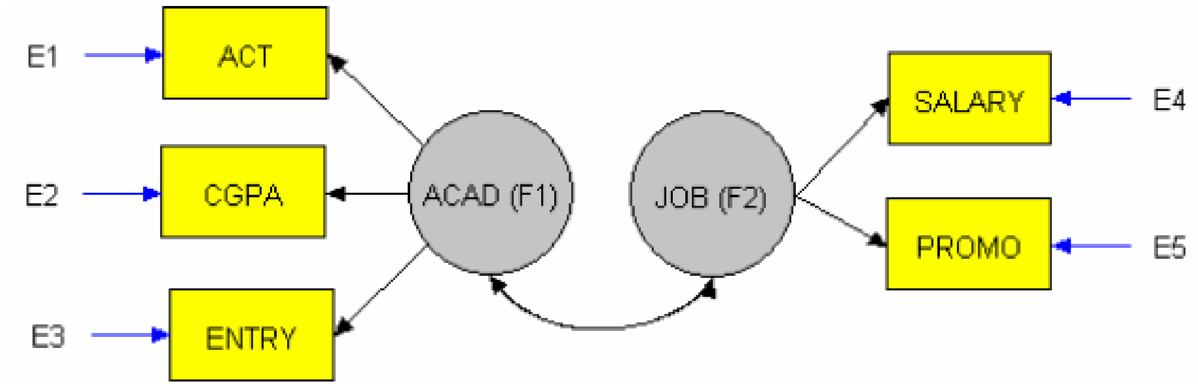

Figure 13 Structural Equation Model – Relationship between academic and job constructs (Suhr, 2006)

As stated before, there are two model parts, consisting of the structural and measurement part. The structural model part describes the causal relations between endogenous (dependent variables) and exogenous (independent variable) variables. The measurement model part in turn describes the relationships between the latent variables and the corresponding indicators. There are analytical models which only use the measurement or the structural part of SEM. In order to determine which model is the best, a number of theoretically plausible models are tested. Based on the set of models, the best fitting model is chosen based on the model interpretations, which provides claims about the included variables.

Structural Equation Modeling has been used in a number of studies in the built environment and in relation to pro-environmental behavior. In relation to the built environment, SEM has been used by Hoogenraad (2019) to explore the effects of an energy renovation on tenant's satisfaction and their energy consumption, while Fornara, Pattitoni, Mura, & Strazzera (2016) have used SEM to predict the intention to improve household energy efficiency. In relation to pro-environmental behavior intention, Fujii (2006) has used SEM to find determinants of pro-environmental behavior intention, while Waris, & Hameed (2020) have used SEM to evaluate environmentally sustainable consumption intention.

A limitation to SEM is the sometimes weak external validity of accepted models and the philosophical bias fundamental to the standard procedures (Tarka, 2017). Another possible limitation are claims about causality. A causal model conveys causal assumptions, which is not similar to a model that produces validated causal conclusions. Experimentation and time-ordered studies can help to rule out rivalling hypotheses, but it is impossible to rule out all causal inferences, even with a randomized experiment. A good model fit surrounding a casual hypothesis does not necessarily mean that another model with a different causal hypothesis invariably entails a bad model fit. It is impossible to differentiate these conflicting hypotheses with a research design. The only possibility to differentiate these conflicting hypotheses is with an interventional experiment (Judea, 2000).

2.3.3 Analytic Hierarchy Process

The analytic hierarchy process (AHP) is an multiple-criteria analysis (MCA), or multiple-criteria decision analysis (MCDA). MCA is an analysis which evaluates multiple conflicting criteria in relation to decision-making, by structuring decisions. A simple example of conflicting criteria are quality and price, as people strive for a high quality and low costs, while high quality normally costs more and lower quality normally costs less. There are many different schools, theories and methods for solving MCA problems, one of them is the AHP.

The analytic hierarchy process (AHP), is a structured technique used to organize and analyze complex decisions. The process is based on mathematics and psychology. Saaty & Wind (1980) have developed the Analytic Hierarchy Process (AHP), which became a prominent decision support tool due to its simplicity and power. In addition, the AHP has the potential to be used for group decision processes, which include multiple actors, decision elements and scenarios. The decision elements consist of criteria, sub-criteria and alternatives. The AHP works with a well-structured problem, displayed as a hierarchy. The goal is at the top, the levels below consists of criteria and sub-criteria, with the alternatives on the lowest level of the hierarchy. The relative importance of these sets of (sub-) criteria is studied by pair-wise comparing the hierarchical elements on all levels. Saaty et al. (1980) have proposed a scale of importance for the elements of the hierarchy. The outcome of the AHP is a ranking of the alternatives, based on their priority in relation to the goals. The best ranked alternative is indicated by the highest valued normalized weight (Srdjevic & Srdjevic, 2013).

The AHP has been used in the research field of built environment in different ways. One of the researches closest to this research study is the research study by Reuvekamp (2013). Reuvekamp (2013) has used the AHP to analyze project aspects which influence tenant participation in sustainable renovation projects. Case studies have been used to determine the tenant participation based on the four criteria dwelling renovation, financial aspects, tenant approach and nuisance. The complete hierarchical model is displayed in Figure 14. Reuvekamp (2013) has found that only the level of rent increase, duration, decrease in living convenience and preparatory activities have negative effects on tenant participation in relation to sustainable renovation projects. All other criteria have a positive effect. Additionally, the AHP has been used to determine stakeholder, or tenant preferences regarding pro-environmental behavior and “green” building features (Adnan, Daud, Aini, Yassin, & Razali, 2013; Contreras, Hanaki, Aramaki, & Connors, 2008).

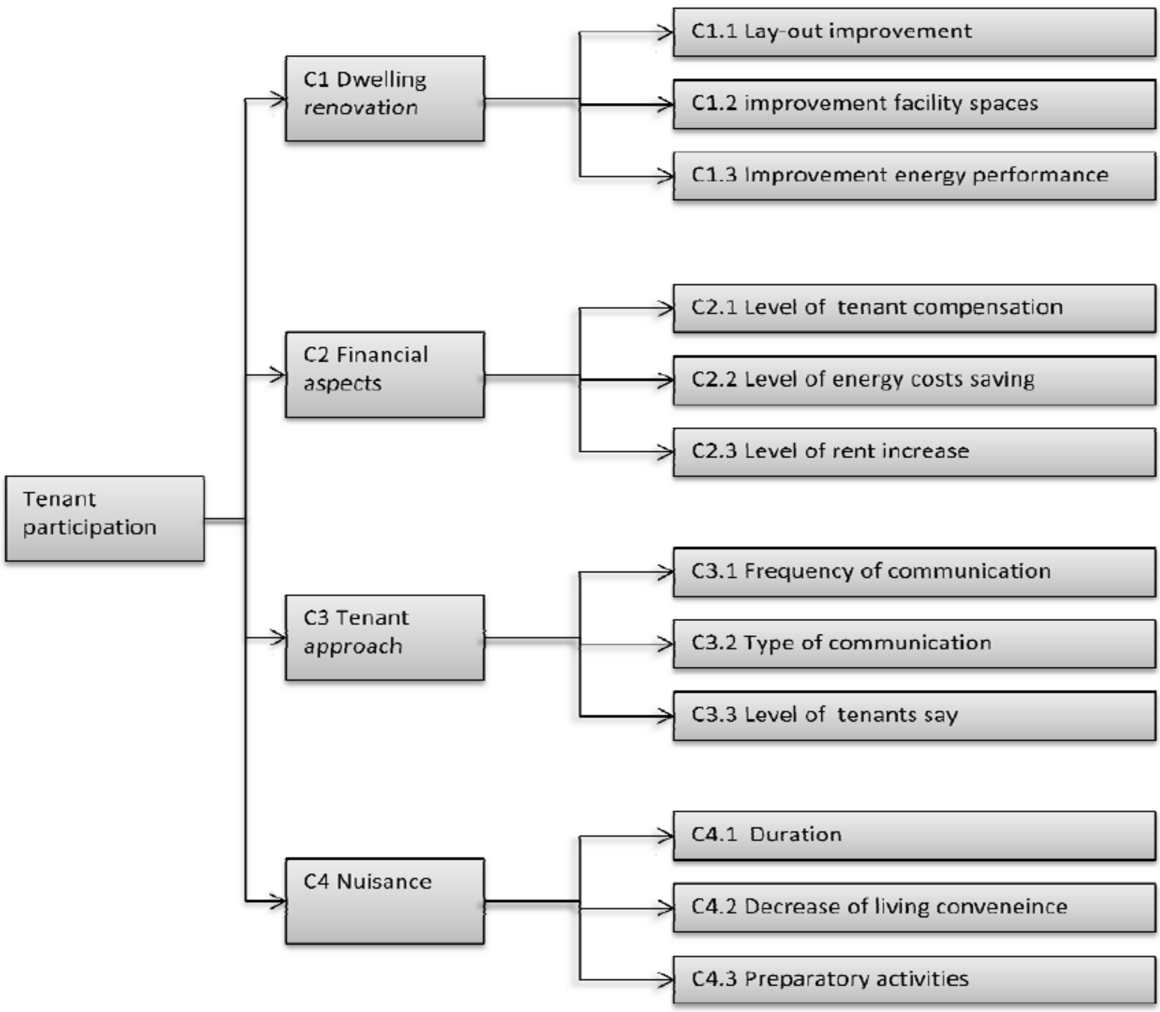

Figure 14 Hierarchical model (Reuvekamp, 2013)

2.4 Conclusion

The introduction of this literature review describes the starting engine role of the housing associations in relation to the energy transition in the Netherlands. The reason for this energy and heat transition is the contribution to the climate goals and the earthquakes in the northern province Groningen due to the natural gas extraction. Unfortunately, there are some limiting factors which can reduce the pace of the energy transition for housing associations. Besides the limited resources, there is the limitation that the 70% participation rate has to be reached before a renovation can be realized. This implies that 70% of all tenants in a renovation project have to be willing to participate. Despite this participation rate, the literature review focused on the motives of both homeowners and tenants in the willingness to exhibit pro-environmental behavior. This given is due to the fact that homeowners and tenants share a large number of motives to exhibit pro-environmental behavior. As the energy transition contributes to the goals of the climate agreement, giving consent to a natural gas-free renovation project is seen as pro-environmental behavior.

The first chapter is dedicated to the relevant theories in the field of human behavior and behavioral modeling. A number of important theories are elaborated on, specifically the energy ladder/energy stacking, Theory of Planned Behavior, Social Practice Theory, Diffusion of Innovation, Self-Perception Theory, Random Utility Theory and the Goal-Framing Theory. The Goal-Framing Theory is extensively discussed as this is one of the dominant theories which will be used in this research study. According to the Goal-Framing Theory there are three goals, the gain, hedonic and normative goal.

The second part of the literature review zooms into the factors underlying pro-environmental behavior, which are knowledge, contextual factors and motivation. Knowledge promotion is not sufficient to encourage pro-environmental behavior, as knowledge is a precondition for pro-environmental behavior. As a consequence, knowledge alone will not result in pro-environmental behavior when people are not motivated and the contextual factors limit pro-environmental behavior. The contextual factors are known as the advantages and disadvantages of different (pro-) environmental behavior, which in turn influences individual behavior. Contextual factors include technologies, economic incentives, available choices, infrastructure and social norms. The contextual factors influence the consequences (motivators and barriers) of (pro-) environmental behavior, but they can also trigger certain values. This can increase the effect of these values in certain situations. The motivation to engage in pro-environmental behavior is influenced by the consequences of such behavior. The more favorable the relative advantages (i.e. motivator vs barrier), the more likely a person is to participate in pro-environmental behavior. The three previously described goals for pro-environmental behavior are influenced by these three motives for (pro-) environmental behavior, specifically the gain (resources both monetary and non-monetary), hedonic (emotions, avoiding effort and pleasure) and normative motives (behaving conform social norms). These motives consist of motivators and barriers, which are the answers to the first research question:

> *I) What are the motivators and barriers of residents (and tenants of social housing) in the decision-making process to engage in pro-environmental behavior?*

The gain motives focusses on acquiring or preserving personal resources, both monetary and non-monetary, such as time. The research studies discussed in the literature review have stated that the economic or financial motives are the main determinative in the decision-making process to engage in pro-environmental behavior. The main determinative of the gain motives for the decision-making process of social tenants for the willingness to participate in natural gas-free renovation projects is the housing costs, consisting of rent and energy costs. The investment costs are not applicable to the tenants, as the renovation is at the expense of the housing association. Hedonic motives are mainly based on the enjoyment of certain behavior, the comfort and pleasure one feels, the disturbance, or nuisance one experiences and the personal sacrifice which is required. The literature review has discussed that strong hedonic motives will most likely result in less pro-environmental behavior. The research studies in the literature review have stated that regarding hedonic motives, comfort and nuisance are the main important motivators and barriers for pro-environmental behavior. Normative motives explain motives to behave in a certain way based on social norms, because ‘it is the right thing to do’. This relates to the long-term consequences of behavior and feeling personally responsible to reduce climate change. As the literature has stated, there are conflicts between the different motives, as pro-environmental behavior is costly. As a result, hedonic and gain motives are not compatible with the normative motives in relation to pro-environmental behavior. A tenant's environmental attitude can be determined by the 'willingness to pay' for sustainable measures or with the NEP-scale.

The third part of the literature review has discussed the modeling approaches which are relevant to model the willingness of tenants to participate in pro-environmental behavior. The discussed modeling approaches are Discrete Choice Modeling, Structural Equation Modeling and Analytical Hierarchy Process. The modeling approach of choice for this research study will be Discrete Choice Modeling, as this is the most dominant approach for above mentioned research problems. In conclusion, Discrete Choice Models is the most relevant approach in order to determine and value the motivators and barriers which influence the willingness of social tenants to participate in natural gas-free renovation projects.

The literature has dived into extensive studies regarding the motivators and barriers for pro-environmental behavior. There are many studies which have not distinguished resident into tenants and homeowners and there are studies which have only focused on homeowners. The motives of tenants in relation to energy efficiency renovations are a less researched topic. The few studies which have focused on tenants in relation to energy efficiency have provided similar results as the other studies into homeowners, or more generally into residents. Thus far, there is only the qualitative research study by Voesenek (2020) which has studied tenant participation in relation to natural gas-free renovation projects. Therefore, this study will contribute to the identification and valuation of the motivators and barriers (motives) of social tenants regarding the willingness to participate in natural gas-free renovation projects.

3. Methodology

This chapter elaborates on the used statistical methods in this research study. First, the conceptual model is discussed, which serves as the basis of this research study. Second, the design of the questionnaire is discussed. The third section consists of the choice modeling which is used for the analyses. Subsequently, the methodology was analyzed and justified. The fifth and final section is the conclusion of this chapter.

3.1 Conceptual model

The conceptual model was developed based on the literature review and forms the backbone of this research study. The conceptual model served to analyze the motivators and barriers of tenants of social housing regarding the willingness to participate (acceptance) in natural gas-free renovation projects. It can be concluded from the literature review that motives to behave in a certain (pro-environmental) manner originate from gain, hedonic and normative goals. In conclusions, this means that the motives of tenants of social housing to give consent for a natural gas-free renovation project can be divided according to these three categories. One of these three motives is decisive, which is the focal goal. As there is no framework for the Goal-Framing Theory, a framework for the Goal-Framing Theory was assumed, which is displayed in Figure 15. Voesenek (2020) has used a similar conceptual model for the Goal-Framing Theory in her qualitative study and has concluded that it worked accordingly.

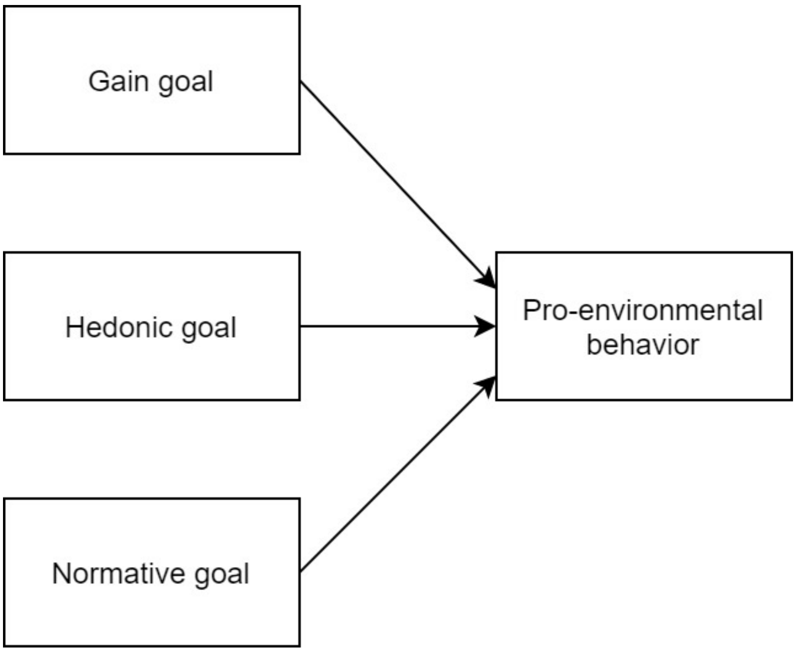

Figure 15 Conceptual model of the Goal-Framing Theory

Various motivators and barriers influencing the willingness to participate in natural gas-free renovation projects have been extensively studied and quantified in this research study. They are all divided along the framework of the Goal-Framing Theory, as described above. This means that all motivators and barriers are related to one of the three motives, either gain, hedonic, or normative. The heating type is considered to be a normative motive, as this is related to the biospheric and altruistic value types, which represent doing what is desirable (or the norm) for society and for the environment. Natural gas-free heating systems are in general considered to be good for the environment, but it is not yet clear whether some are considered to be the norm more than others. This could indicate whether some natural gas-free heating types are more desirable in relation to what is good for society and the environment. In the conceptual model of the Goal-Framing Theory, the end node is displayed as pro-environmental behavior. The willingness to participate in natural gas-free renovation projects is considered to be pro-environmental behavior. Hence, the end node of this research study's conceptual model is replaced with the willingness to participate in a natural gas-free renovation project. The conceptual model of the project dependent motivators and barriers (attributes), used in the experiment is displayed in Figure 16. In the experiment, the preferences for these attributes (motivators and barriers) were measured.

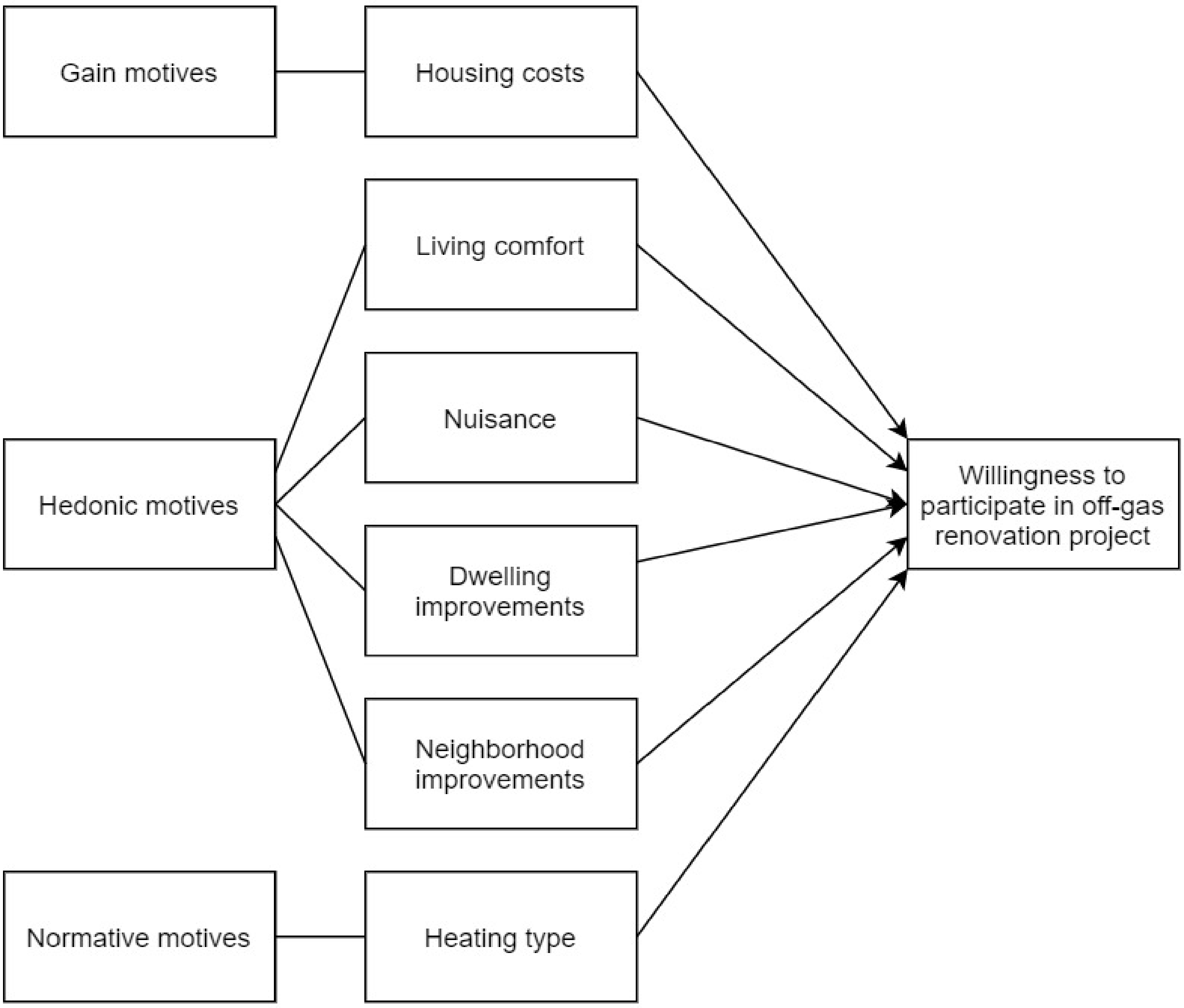

Figure 16 Conceptual model which combines the Goal-Framing Theory and the motivators and barriers (attributes) from the experiment.

In addition, the willingness to participate in a natural gas-free renovation projects is influenced by various factors which were not included in the Stated Choice Experiment. These factors were determined by answering statements on a 5-point Likert scale. Some of these factors can be related to the gain, hedonic, or normative motives. The environmental attitude was expected to be an important normative motive, while willingness to pay was expected to be an important gain motive. The tenant’s satisfaction with the housing association was expected to correspond with the trust in the housing association and the satisfaction with the housing association’s communication. These factors and their relations to the willingness to participate in natural gas-free renovation projects are displayed in Figure 17.

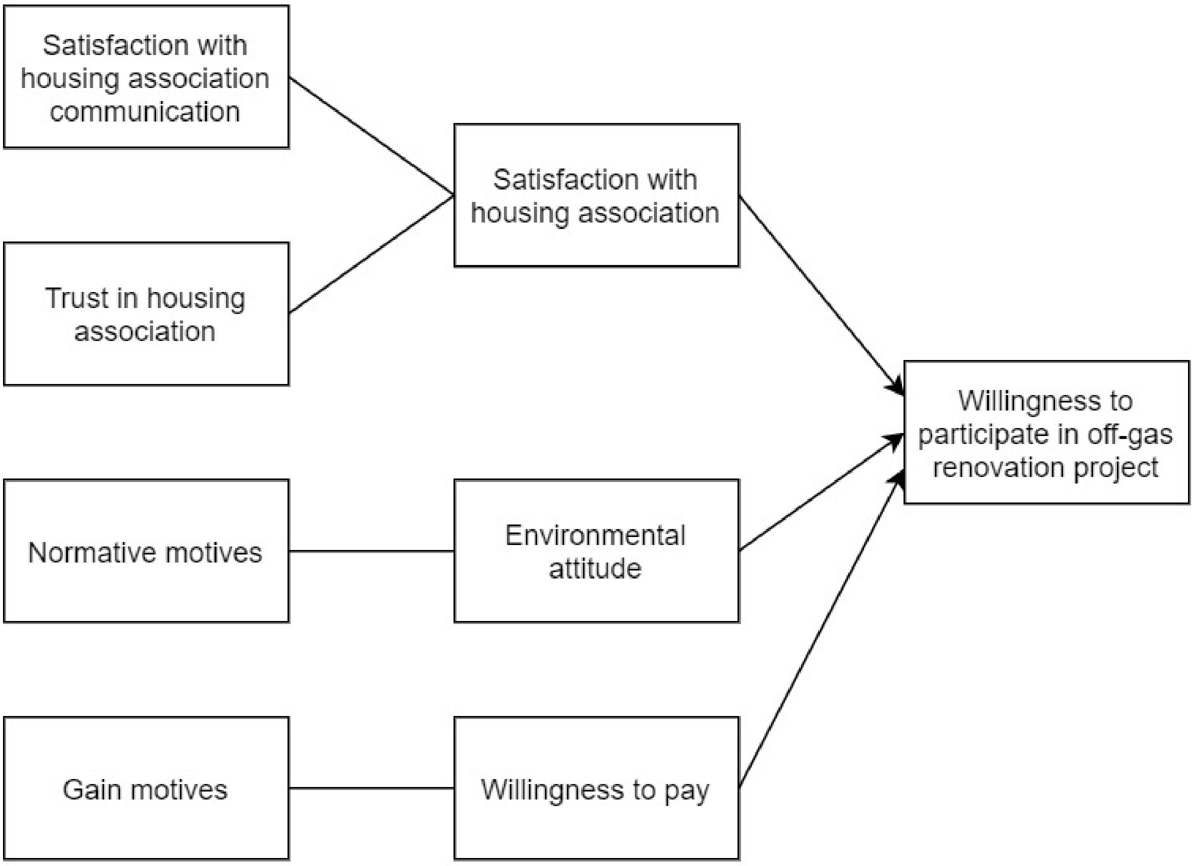

Figure 17 Conceptual model of the factors that influence the willingness to participate in natural gas-free renovation projects that are not part of the experiment.

There are also certain characteristics which are expected to influence the willingness to participate in natural gas-free renovation projects. These characteristics correspond to personal, household, neighborhood and dwelling characteristics. Figure 18 exhibits all characteristics, which potentially influence the willingness to participate in natural gas-free renovation projects.

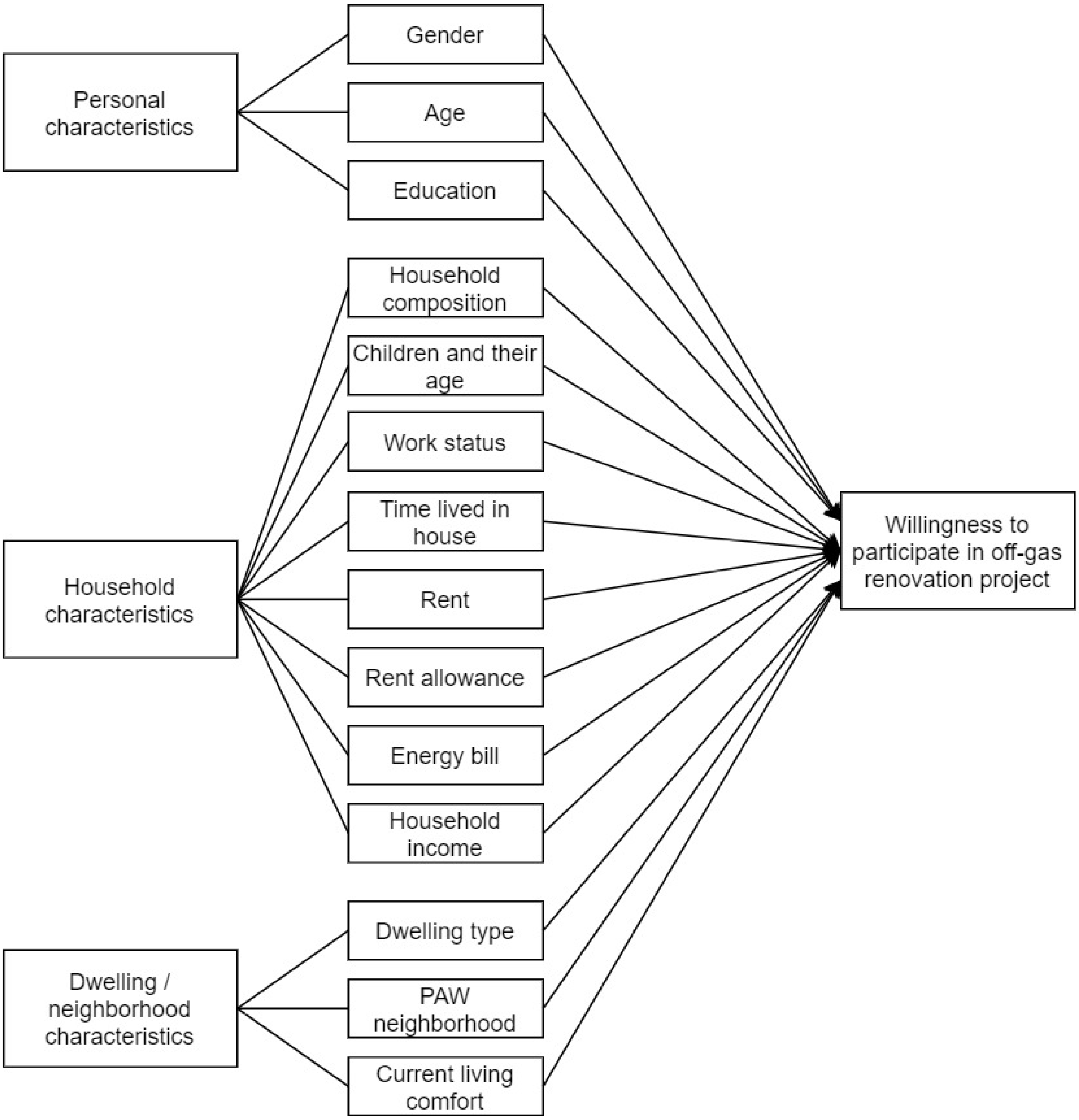

Figure 18 Conceptual model that display the relation between personal, household and dwelling / neighborhood characteristics and the willingness to participate in natural gas-free renovation projects.

The four above mentioned conceptual models were combined into the research model discussed in this research study. The research model served as the cornerstone of this research study and formed the basis of the statistical analyses conducted in this research study. The research model is illustrated in Figure 19 below.

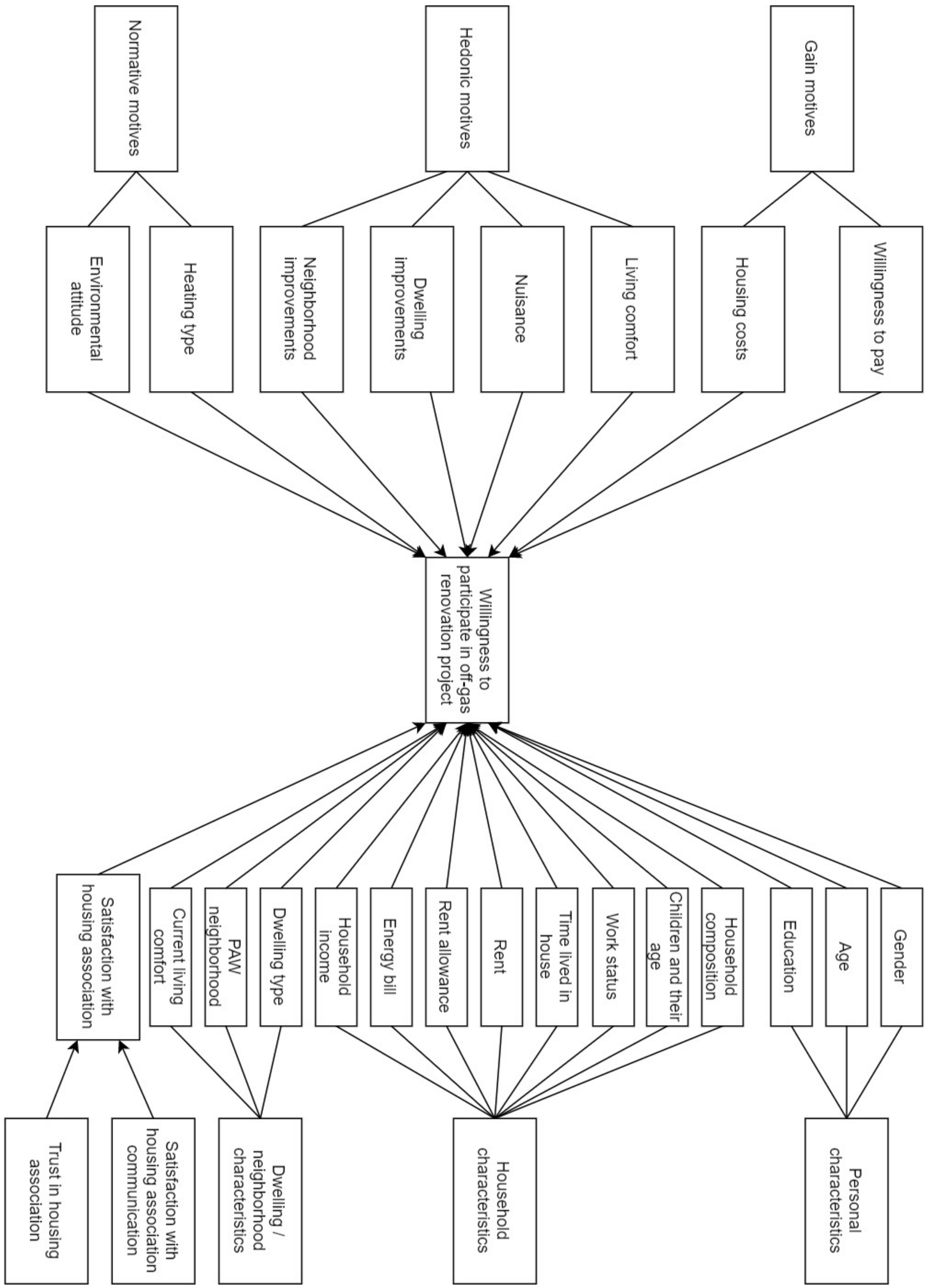

Figure 19 Complete conceptual model of this study

3.2 Experimental design

To determine the willingness of tenants of social housing to participate in natural gas-free renovation projects, it is important to zoom into the tenants' motivators and barriers. To determine these motivators and barriers, the preferences for the different attributes of a natural gas-free renovation project were analyzed with a Stated Choice Experiment. These preferences indicated whether certain attributes are motivators, or barriers and to what extent they influenced the willingness to participate in natural gas-free renovation projects. The first part of the questionnaire was devoted to the Stated Choice Experiment and was distributed among tenants of social housing either living in PAW-neighborhoods or in other neighborhoods. Hensher, Rose, & Greene (2015) have made an overview of the process to develop a Stated Choice Experiment, which is displayed in Figure 20. Stage one is defined as the problem definition, followed by stage two, the refinement of the alternatives, attributes and the corresponding values. Stage three represents the experimental design consideration. This stage elaborated on the consideration and determination of the experimental design. This consideration is based on the SCE's principle of repeated choices, which means that a respondent is presented with multiple choice sets representing multiple attributes which consist of different values. Stage four represents the experimental design, based on the considerations of stage three. The attributes were allocated to the experiment design in stage five. Subsequently, stage six determined the combinations of the choice sets by randomizing the choice sets in stage seven. Finally, stage eight marked the final step of the process which is devoted to the construction of the questionnaire. The questionnaire included the SCE, statements and socio-demographic questions. The answers to the questions as stated in the questionnaire provided data which was used to statistically test and subsequently analyze the research questions as described in chapter 1.3. Based on extensive statistical tests and subsequential analyses of these results, answers to the research questions were provided. These answers served as scientific evidence which enriched already existing literature studies, since it shed a new light on the field of the energy transition and environmental behavior.

In order to come to a decent SCE, the following stages were applied in this research study.

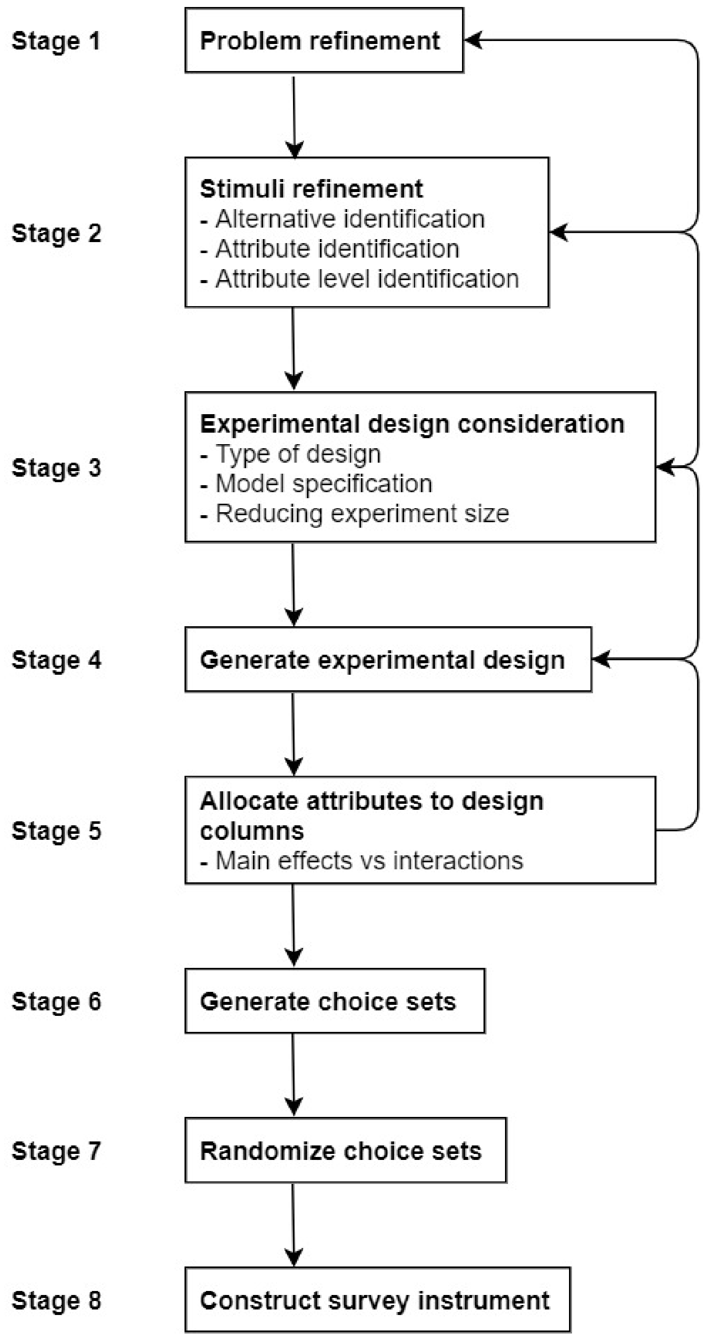

Figure 20 Stated Choice Experiment stages (Hensher et al., 2015)

3.2.1 Problem refinement

The problem definition is described in chapter 1.2 Problem definition. This research study was conducted in order to study the willingness to participate in natural gas-free renovation projects, specifically aimed at tenants of social housing. The willingness to participate in natural gas-free renovation projects is influenced by three goals which influence pro-environmental behavior, specifically, the gain, hedonic and normative goals. The motivators and barriers which influence the tenants' behavior to give consent for a natural gas-free renovation project can all correspond to one of these three goals. However, it was unclear to what extent these attitudes influenced the preferences of tenants of social housing regarding the willingness to participate in natural gas-free renovation projects.

3.2.2 Stimuli refinement

In this section, the alternatives, attributes and corresponding attribute levels were determined. Every choice set in the Stated Choice Experiment consisted of three alternatives. The first two alternatives were new natural gas-free heating propositions, which consisted of six attributes. The third alternative corresponded to "Keep my current heating system". In the third alternative there was no change in the respondent's current situation and heating system.

In chapter 2.2 Factors underlying pro-environmental behavior, all the motives (motivators and barriers) for pro-environmental behavior were discussed extensively. The main motives which were used as attributes in the Stated Choice Experiment are discussed in this section. An overview of all attributes and values in the stated choice experiment is displayed in Figure 21 Overview of attributes and values in the Stated Choice Experiment.

New heating system

The first attribute is the new (natural gas-free) heating system which replaces the (normally gas-fired) heating system. The new natural gas-free heating is a normative motive, as it provides little to no benefits to the respondent in terms of personal benefits, comfort, finances, or pleasure. A new natural gas-free heating system is the right thing to do in order to comply with social norms as it reduces the use of natural gas and can consequently be classified as pro-environmental behavior. Nevertheless, the new natural gas-free heating system is good for the environment, as it replaces a gas-fired heating system. The new heating system consists out of four values, in specific, heat network with new radiators, heat network without new radiators, heat pump on electricity and heat pump on electricity and green gas. The heat network is split between two different levels, with and without new radiators, as these heat networks have different operating temperatures, based on the type of heat source. It is possible that due to the lower temperature of the heating water (low temperature heat network), the old radiators are unable to provide the heat demand which is necessary to heat the dwelling in winter. When the heat supply is too low, the radiators have to be replaced, in order for the heat supply to be matched. When higher temperature heat sources are used for a heat network, it is not necessary to replace the radiators. The heat pump is also split between heat pump on electricity and heat pumps on electricity and green gas. This split is made due to the fact that they both have different applications. The electric heat pump can only be applied in combination with very good insulation, as the electric heat pump on its own cannot heat a dwelling in winter which is not insulated very well. When a dwelling is not sufficiently insulated for the application of an electrical heat pump, it is combined with green gas. This means that most of the year, the electrical heat pump can heat the dwelling, but during winter, when the electrical heat pump cannot deliver the heat demand entirely, the green gas fired heating jumps in.

Housing costs

The second attribute is the monthly housing costs increase or decrease for the tenant. The housing costs consists of a change in rent, combined with a change in energy costs. In terms of monetary costs and benefits, a tenant is not faced with investment costs, as the renovation is funded by the housing association. The tenant only pays rent. Due to the split incentive, a tenant's housing costs are not allowed to increase due to sustainable renovation measures (Ministry of the Interior and Kingdom Relations, 2012). This means that the increase in rent should always be less than the decrease in energy costs due to the sustainability measures. When a renovation includes aesthetical, or dwelling improvements, it is allowed for a housing association to increase the rent, which could result in an increase in housing costs. The housing cost attribute is a gain motive, as it is a monetary motive. The values for this attribute are €10,- per month less, €5,- per month less, €0,- per month and €10 per month more, as stated in the questionnaire. Most housing associations seek ways in order to avoid an increase of the housing costs, as it is in most renovation projects not possible to increase the housing costs due to the split incentive and it would drastically influence the participation rate. Due to this reason there are two values which decrease the housing costs and one value where the housing costs remain the same as the tenant's current situation. Additionally, there is one value which increases the housing costs, as this is allowed in combination with dwelling improvements.

Living comfort

The living comfort attribute is described as draft and temperature change in the dwelling in relation to the current situation of the tenant. There are various heating systems which all have a different functionality. Hence, they influence the amount of time needed to heat a dwelling, which leads to a higher or lower maximum heat supply. It might be necessary to apply ventilation grilles, which can result in different airflow and the experience of draft. These changes in temperature and air flow work on the hedonic goal, as it increases/decreases the living comfort. Increasing the comfort is enjoyable and makes people feel good, while avoiding effort, whereas decreasing the comfort can result in negative feelings. The values for living comfort are as follows: better, a little better, remains the same and a little worse. In general, the living comfort will not change drastically due to the transition from a gas-fired heating system to a natural gas-free heating system. The renovation works which are combined with the natural gas-free renovation, are the ones which normally result in higher or lower living comfort. In most cases housing associations will aim for a higher living comfort, as this is one of the main motivators for pro-environmental behavior and is therefore important for the tenant's willingness to participate. It is never the intention to decrease the comfort, but it can be an additional drawback. Consequently, there are two values which increase the living comfort and only one which decreases the living comfort. In the fourth value the living comfort remains similar to the tenant's current situation.

Nuisance

The attribute nuisance is described in the Stated Choice Experiment with the aid of a number of examples. First, the fact whether the tenants will be disturbed during their daily routine, as there will be installers and construction workers in their dwelling during the renovation works. Due to the renovation works it is also very likely that there will be clutter in the dwelling, left behind by the installers and construction workers. They will try to limit the clutter, dust, etc., but it is almost impossible to prevent any form of clutter. Due to the clutter and the accessibility of radiators, heating systems, etc., it will be necessary that the tenant tidies up the dwelling to make all the designated area's in the dwelling accessible for the installers. As most (natural gas-free) renovation projects are executed in occupied houses, this can cause serious inconvenience for the tenants. Too much inconvenience or nuisance can be a barrier for the willingness to participate in natural gas-free renovation projects. The research study of Schillemans, Rooijers, & Benner (2006) has underlined the fact that there is a negative relation between the nuisance of a renovation project and the participation. Other research studies have stated similar results which have indicated that nuisance is an influential factor for participation, but not a crucial factor (Quirijns, 2011; Werf, 2011). Nuisance is a hedonic motive for pro-environmental behavior, as it describes the comfort the tenants experience in their house, as they try to avoid additional effort. The experienced nuisance is an important barrier for tenants according to the literature (Quirijns, 2011; Schillemans et al., 2006; Werf, 2011), as such it was described extensively in the questionnaire, in order to provide the respondents with a clear view of what this attribute means. There are two values corresponding to this attribute, specifically, a lot of nuisance and little nuisance. The reason that only two values were chosen, is due to the fact that a respondent is able to understand the difference between a lot and little nuisance, according to the examples given. Including more values like, moderate, or limited nuisance make it harder for respondents to discriminate between the values, as it will be hard to determine the difference between the values, based on the examples.

House improvements

The attribute of house improvements describes the renovation of the bathroom, kitchen, and/or toilet. Usually, a housing association has norms which state that bathrooms, kitchens and toilets (in short BKT) are renovated after a specified number of years. Nonetheless, it can be interesting for a housing association to entice the tenant to participate in a natural gas-free renovation project with a renovation of the BKT in case they are not yet due to be replaced. In this way, the tenants will receive a new BKT sooner in case they choose to participate in a natural gas-free renovation project. House renovations are hard to assign to one motive, as it relates to both the gain and hedonic motives. House improvements relate to the gain motive, as it provides tenants with personal resources. Usually, tenants have to pay an extra amount of rent when they want their house to be renovated in some way, which relates to the monetary gain motive. When no rental increase is asked for these improvements, this means tenants experience an indirect gain motive. Additionally, house improvements relate to the hedonic motive, as people enjoy their improved house, which provides them with feelings of pleasure. As the house improvement mostly relates to the hedonic motive, it was classified as such. The literature review has indicated that indoor renovations, like BKT renovations can be the second most important reason for sustainable renovations. The values for the attribute house improvement are that the tenant receives a new bathroom, kitchen and/or toilet, or that the tenant will receive none of the above. The reason that dwelling expansion, or layout improvements were not included in the house improvement is that these values are very hard to specify, as they are dwelling specific. Another reason is that every respondent will have a different perception of a layout improvement or dwelling expansion, as they all have different preferences and wishes for their dwelling. BKT renovation can be described and interpreted more easily and specifically. For this reason only the renovation of the BKT was included as a level in the house improvement attribute.

Neighborhood improvement

The attribute neighborhood improvement describes the change in neighborhood quality. Neighborhood improvement in the Stated Choice Experiment consists of improvement of green, landscaping and water drainage. Neighborhood improvement might also consist of the reduction of nuisance, litter, the social isolation of elderly, or fixing parking problems by adjustment of the public space. Neighborhood improvement might serve as a way for housing associations to entice tenants to participate in natural gas-free renovation projects without doing too much renovation works inside the house, which in turn, can reduce nuisance inside the house. This can be especially interesting in neighborhoods where the number of houses which belong to housing associations is relatively high in comparison to privately owned houses. Neighborhood improvement can be related to all three behavioral motives, as it provides tenants with gain and hedonic motives in a similar manner to the house improvement attribute. Additionally, neighborhood improvement relates to the normative motive, as neighborhood improvement can be good for the environment as well. The neighborhood improvement mainly relate to the hedonic motive, as it will provide tenants with feelings of joy and pleasure to see their neighborhood improved and the (social) problems fixed. As such, the neighborhood improvement was classified as a hedonic motive. The values for the attribute neighborhood improvement were either one of the following, the neighborhood of the tenant will be improved and the (social) problems will be fixed, or there will be no neighborhood improvement.

Overview of attributes and values

	Attribute	*Values*	*Additional information*
1	New (natural gas-free) heating	Heat network WITH new radiators, heat network WITHOUT new radiators, heat pump on electricity, heat pump on electricity and green gas	
2	Housing cost	€10 p/m LESS, €5 p/m LESS, €0 p/m, €10 p/m MORE	This is the rent increase minus the saving on energy costs.
3	Living comfort	Better, a little better, remains the same, a little worse	Consists of draft and temperature change.
4	Nuisance	A lot of nuisance, little nuisance	You will be disturbed, you have to tidy up your house, there will be clutter.
5	House improvement	New bathroom, kitchen and/or toilet, none	
6	Neighborhood improvement	Your neighborhood will get better and the (social) problems will be fixed, none	

Figure 21 Overview of attributes and values in the Stated Choice Experiment

3.2.3 Designing the Stated Choice Experiment

The attributes and corresponding values were constructed as such that, the experimental design could be determined. The determination of the experimental design consists of stage three, four and five as described in the Stated Choice Experiment stages by Hensher et al. (2015). To determine the experimental design, the statistical program SAS was used. Appendix 3 displays the experimental design used for the Stated Choice Experiment. The design consisted of six attributes with either two or four values, as described in section 3.2.2 Stimuli refinement. This Stated Choice Experiment consisted of two alternatives (and a null alternative) per choice set, which resulted in a full factorial design with 512 profiles. To reduce the number of choice sets, an orthogonal subset of attribute level combinations was created, called a fractional factorial design. This fractional factorial design which was constructed with a MktEx Macro, resulted in the most optimal combination of 32 profiles (alternatives) into 16 choice sets. This design resulted in a 100% efficiency. Every respondent was presented with eight out of the 16 choice sets, so there were two versions of the Stated Choice Experiment. A randomization effect was utilized to determine which version of the Stated Choice Experiment was presented to the respondent. As a consequence, one respondent which filled in questionnaire one and one respondent which filled in questionnaire two, together completed the design 16 choice sets.

3.2.4 Choice sets and randomization

This section zooms into stage six and seven which elaborated on the Stated Choice Experiment stages which have been constructed by Hensher et al. (2015). Stage six described the identification of the choice sets, which is conducted in LimeSurvey, a tool which was provided by the TU Eindhoven. LimeSurvey is a tool which is used to create questionnaires. In LimeSurvey it is technically impossible to randomize the choice sets which are presented to a respondent. To provide a workaround for this setback, a random number was used to select which Stated Choice Experiment was presented to the respondent. This meant that two Stated Choice Experiments were created which consisted of eight fixed choice sets, resulting in a total of 16 fixed choice sets with 32 choice alternative. Figure 22 displays an example of a choice set from the Stated Choice Experiment.

Features of the renovation	Choice A	Choice B	Choice C -Current heating
New heating	Heat network WITH new radiators	Heat network WITHOUT new radiators	
Housing costs	€10 p/m LESS	€10 p/m MORE	
Living comfort	Remains the same	Better	
Nuisance	A lot of nuisance	Little nuisance	
Dwelling improvement	New bathroom, kitchen and/or toilet	None	
Neighborhood improvement	Your neighborhood will get better and the (social) problems will be fixed	None	

Choose one of the following answers

Choice A | Choice B | Choice C

Figure 22 Example of a choice set from the Stated Choice Experiment

3.2.5 Questionnaire design

The questionnaire consisted out of three parts. The first part of the questionnaire consisted of the Stated Choice Experiment. In the second part of the questionnaire, several questions were asked. The answer possibilities were based in a 5-points Likert scale ranging from Strongly disagree (1) to Strongly agree (5). These questions were incorporated in the questionnaire in order to gather information about the current living comfort, willingness to pay, satisfaction with housing association's communication, trust in housing association and environmental attitude. The third part of the questionnaire consisted out of personal, household, neighborhood and dwelling characteristics. The complete questionnaire is displayed in Appendix 4.

The questionnaire was designed with the aid of the survey program LimeSurvey. The questionnaire was conducted in two languages, namely in English and Dutch. The choice to construct the questionnaire in two languages was based on the fact that a large number of tenants living in social housing are not capable to read English and some suffer from low literacy as there is a large group of immigrants who do not speak Dutch. By distributing the questionnaire in two languages it was possible to reach the non-Dutch speaking tenants as well, which enhanced the representation of the target group, consisting of tenants of social housing. Respondents could change the language of the questionnaire at the start of the questionnaire, up to their choice of preference. This option was clarified at the beginning of the questionnaire. The questionnaire started with an introduction and privacy statement, followed by a selection question which asked whether the respondent was a tenant of social housing. If this was not the case, the respondent was not part of the target group and could not participate in the research study. Subsequently, the respondent was presented with an introduction video which described the different natural gas-free heating systems, the Stated Choice Experiment and the different attributes variables and levels of the experiment.

The first part of the questionnaire consisted of the Stated Choice Experiment, which is described in the previous section. The following two sections describe the second and third part of the questionnaire, consisting of the questions regarding statements and socio-demographics, respectively.

Statements

The second part of the questionnaire consisted of statements which were expected to influence pro-environmental behavior, according to the literature review. The statements were asked with the aid of a 5-point Likert scale, ranging from Strongly disagree (1) to Strongly agree (5). The first statement referred to the respondent's current living comfort. The current living comfort is compared to the importance of comfort improvements in the stated choice model, in order to see whether respondents with a currently higher or lower comfort level are more or less susceptible to comfort improvements regarding the natural gas-free renovation projects.

The second statements referred to the willingness to pay for certain house adjustments. As displayed in the Stated Choice model, the willingness to pay is compared to the change in housing costs in order to determine whether respondents with a high gain goal, are more or less willing to pay for certain things. The statements concerned willingness to pay for BKT, comfort improvements, the environment and a reduced energy bill.

The third section of statements is related to the satisfaction regarding the housing association's communication, also known as tenant approach. According to Reuvekamp (2013), tenant approach can be divided into three categories, the type of communication, frequency of communication and level of tenant say. The type of communication determines whether communication with tenants goes by e-mail, post, newsletter, etc.. Communication frequency goes without the need of any further explanation and tenant say implies that the tenants have influence on the decisions made by the housing association regarding their house. Werf (2011) has found statistical evidence to conclude that the extent to which tenants could influence the decision-making process, is a high influential factor regarding their willingness to participate in renovation projects. In general, the way of and frequency of communication is an important factor in relation to participation, as it is one of the main ways of information provision from the housing association to the tenants. Additionally, the extent to which information was provided regarding the renovation projects is an important factor for participation, according to the literature review. The satisfaction concerning the housing association's communication is used to see whether respondents which value the housing association's communication as higher or lower, display different choices in the Stated Choice Experiment and as a consequence, value different goals. Additionally, the satisfaction regarding the housing association's communication was used to determine whether tenants which value the communication lower tend to choose the alternative to keep their own heating more often in relation to the tenants which value the communication higher. This was used to determine whether a lower degree in satisfaction regarding the housing association's communication resulted in resistance towards participation in natural gas-free renovation projects. The section started with questions whether and how the respondents were informed by the housing association regarding natural gas-free renovation projects. These questions were followed by four statements regarding the respondents' satisfaction about the housing association communication. The statements referred to the satisfaction of communication in relation to natural gas-free renovation projects, the housing associations communication type, the frequency of communication and the degree of participation in the decision-making process.

The fourth section of statements elaborated on the respondents' trust in the housing association. Trust is a fundamental aspect for a tenant to participate in natural gas-free renovation projects. Seen from the tenant's point of view, it is very hard to believe the claimed reduction in energy costs and thus the financial feasibility of the renovation. Consequently, trust is used to determine whether respondents with a lower degree of trust tend to answer the Stated Choice Experiment different from respondents with a higher degree of trust. Additionally, trust in the housing association was used to determine whether respondents with a lower degree of trust tend to choose the alternative C (keeping their own heating system), more often compared to respondents with a higher degree of trust. This determined whether a lower degree of trust in the housing association resulted in resistance towards the willingness to participate in natural gas-free renovation projects. The statements regarding trust in the housing association were described as general trust in the housing association, whether the housing association upholds its agreements and whether the respondent would recommend the housing association to family and friends.

The fifth and final section contained statements referred to the respondents environmental attitude. Environmental attitude serves as an important aspect in behavioral models. As a consequence, it is assumed that there is a relation between the willingness to participate in natural gas-free renovation project and the environmental attitude. To test the relationship, the NEP-scale was used in order to determine the environmental attitude (R. E. Dunlap et al., 2000). The environmental attitude was calculated based on five questions, selected from the NEP-scale (R. E. Dunlap et al., 2000; R. Dunlap & Van Liere, 1978). The NEP-scale consists of 15 questions representing the hypothesized facets of the ecological worldview of a person. The questions can be answered based on a 5-point Likert scale and are distributed across five groups. These five groups are as follows: the reality of limits to growth, anti-anthropocentrism, the fragility of nature's balance, rejection of exemptionalism and the possibility of an eco-crisis. These five facets represent the endorsement of an ecological worldview. Incorporating all 15 questions in the questionnaire would lead to a very long questionnaire. This would have impeded the likelihood of gathering a large sample size, since respondents tend to dislike long questionnaires, which usually results in a lower response rate. This in turn would hinder the representativeness of our research sample and as such, the choice was made to select five questions. There is a dominant factor (group) in the NEP-scale, but the choice was made to select one question (the most item-related) from every group instead of focusing on the dominant factor. So the most item-related question is selected from every group, which resulted in the five questions which represent the environmental attitude. Some questions were constructed in such a way that agreement indicated a pro-ecological worldview, while others were worded the other way around. The five questions had to be combined in order to create one variable representing the tenant's average environmental attitude, where Strongly Agree (5) meant the highest possible pro-ecological worldview. The questions which were constructed in such a way that agreement indicated a non-pro-ecological worldview, were transferred in order to enable the combination of the five questions into one average. For this average, Strongly agreeing (5) represented the highest possible pro-ecological worldview.

Personal, household and dwelling characteristic

The third part of the questionnaire consisted of personal, household (socio-demographics), neighborhood and dwelling characteristics. The main socio-demographics are gender, age, educational background, household composition and the presence and age of children. Both Werf (2011) and Mortensen et al. (2016) have concluded that some of these socio-demographics have an influence on the participation in renovation projects. Where Werf (2011) has focused on social tenants, Mortensen et al. (2016) on the other hand, have focused on homeowners. The resident's current life phase determines their willingness to participate, as there are differences between elderly and families with young children, since their motives and reasons to participate are different (Mortensen et al., 2016). The tenant's participation in renovation projects is also influenced by the financial situation, which mainly consists of household income, housing costs (rent and energy costs) and rent allowance. As explained above, these socio-demographics might influence the behavior and choices of tenants. Additionally, they can be used to create tenant groups which exhibit different behavior. In order to determine these influences and create these tenant groups, multiple choice questions on these subjects were included in the questionnaire. The questions as elaborated on earlier, were constructed with the aid of the energy saving covenant in the rental sector and CBS standards (CBS, 2019, 2020b, 2020a, 2021; Ministry of the Interior and Kingdom Relations, 2012). These standards were also used for descriptive statistics, to check the representative of the data sample. The following socio-demographics were gathered:

- Gender
- Year of birth
- Highest education
- Household composition
- Work status
- Number of children'
- Age of youngest child
- Zip code
- Dwelling type
- Time lived in dwelling
- Rent
- Rent allowance
- Energy bill
- Household income

3.2.6 Questionnaire testing

Tenants of social housing are considered to be an increasingly challenging group, as it consists of people from the lowest income groups, residential status holders, urgency placements, elderly, or other people with social problems (Leidelmeijer et al., 2018). As a large part consists of elderly, the communication has to be simple and clear. A more general problem which should be taken into account is related to all social tenants' lack of knowledge regarding sustainable dwelling solutions (like natural gas-free renovation projects) and energy usage (Schillemans et al., 2006). Besides the lack of knowledge, tenants do not understand the technical terms which are used surrounding energy efficiency and natural gas-free renovation projects. Tenants think in terms of ease of use, nuisance and comfort. A tenant does not think of EPC or R-value when the temperature is to low, but in terms of draft or cold feet. In order to gather decent data, it was required to construct questions which were understandable without further knowledge and do not contain any technical information. Solely intuitive information should be incorporated in the questionnaire.

To determine whether the questionnaire was understandable, readable and provided the required results, the questionnaire was tested in two phases. In the first test phase, students, friends, supervisors and colleagues from Atriensis projecten were asked to fill in the questionnaire and provided feedback in order to enhance the comprehensibility of the questionnaire. Respondents with different ages, educations and backgrounds were chosen to test the questionnaire in order to make sure that is was readable and understandable for everyone. The questionnaire was enhanced with the feedback provided by the test panel, which indicated minor presentation issues in the introduction video and the Stated Choice Experiment. Experience from the test panel pointed out that it is highly recommendable to fill in the questionnaire on a pc or laptop and not a mobile device. This instruction was incorporated in the beginning of the questionnaire.

The second test phase was devoted to 15 tenants of social housing, as this was the actual target group of this research study. This test round did not come up with major inconsistencies, nor any presentation issues. There were only some textual clarifications necessary according to the second round of testing. The second round indicated that the respondents valued the introduction video, as it provided them with some of the lacking knowledge about sustainable dwelling solutions. Additionally, after the second test phase, the data export was checked to be sure that the desired data was correct, which was the case. Based on the feedback received during the second testing phase, the questionnaire was optimized and could be distributed among the target group.

3.2.7 Privacy

The data collection was done fully anonymous and the gathered data was treated confidentially, as there was no possibility to trace back the answers provided by the respondents. To clarify this to the respondents, the questionnaire contained a privacy statement in the beginning of the questionnaire. The privacy statement had to be accepted by checking a box to agree with the stated terms, otherwise it was not possible to continue with the questionnaire. The terms in the privacy statement correspond with the terms and conditions of the Ethics Committee of the TU/e regarding privacy and ethics. The privacy statement explained that the data would be treated completely confidential and that only grouped data would be presented in the research study, no individual data. The only "personal" data which was requested, was the zip code, which was necessary to determine whether a respondent lived in a PAW neighborhood. Nonetheless, this zip code could not be used to identify a respondent, as there are many people with the same zip code. As the amount of personal data asked in the questionnaire was limited, there were no further procedures necessary to gain the approval of the ethics committee.

3.2.8 Sample size

In order to ensure a large enough sample size, a rule of thumb was applied. The rule of thumb determined that a minimum sample size of 20 respondents per variable was necessary in order to comply to the sample size standards. This is a relatively high number, which ensured that the results were stable and significant. The Stated Choice Experiment contained six attribute variables, which were added with an estimated 6 to 7 socio-demographic and statement variables. Based on the totally estimated 12 to 13 variables which would be included in the analyses of the Stated Choice Experiment and each variable requiring 20 respondents, it was concluded that the minimal size of a decent sample size consisted of 250 respondents.

3.2.9 Reduction of missing values

To prevent missing values in the data, acquired from the questionnaire, all the questions in the questionnaire were mandatory. This implied that a respondent had to fill in an answer to be able to continue to the next question and complete the questionnaire. As some questions could be perceived as personal (household income, etc.) and respondents could feel obliged to fill in these questions, they were provided with an “I do not know” or an “I do not want to answer” option to prevent respondents from ending to questionnaire without entirely finishing the questionnaire.

3.3 Choice modeling

To analyze the data, several statistical methods and scientific models were utilized and analyzed. The two models used were the Multinomial Logit model and the Latent class model. Both two models are extensively elaborated on in the next sections.

3.3.1 Multinomial Logit model

In the Stated Choice Experiment the respondent had to choose between two alternatives, either one of the natural gas-free renovation strategies, or the choice not to cooperate with the renovation project, which meant they kept their current heating system. The choices made by the respondents were analyzed with the Random Utility Theory, explained in chapter 2.1.7 Random Utility Theory. In the Random Utility Theory, it is assumed that an individual chooses the alternative with the highest random utility U_{iq}, for which *i* denotes the alternative and *q* the respondent. A respondent’s utility is composed of two components, the observable(*V)* and unobservable (Ɛ) component. The unobserved part, also known as the error term (Ɛ), is assumed to have a standard Gumbel distribution (double exponential distribution) (Kemperman, 2017). Hence, Ɛ follows an identical and independent distribution. Consequently, it is assumed that the respondent acts, or chooses according to the utility they perceive, known as the maximum utility (Hensher et al., 2015). The random utility formula is constructed as follows:

U_{iq} = $V_{iq} + \varepsilon_{iq}$

U_{iq} = Utility individual *q* for alternative *i*

V_{iq} = Observed component of individual *q* for alternative *i*

ε_{iq} = Unobserved error component of individual *q* for alternative *i*

The structural utility V_{iq} can be calculated with another formula:

V_{iq} = $\sum_n \beta_n * X_{inq}$

β_n = The weight of the utility of attribute *n*

X_{inq} = The score of the alternative *i* on attribute *n* for individual *q*

One of the most used methods of analysis in Stated Choice Experiments is the Multinomial Logit model, which expresses a respondent’s utility regarding a choice. This means, that it predicts the respondent’s preference in a choice scenario (Kemperman, 2000). The result of this prediction is a probability which is expressed with a number between 0 and 1. The probability P_{iq} to choose a certain alternative can be calculated according to the following formula (Hensher et al., 2015):

P_{iq} $= \frac{\exp(V_{iq})}{\sum_{j=1}^{j} \exp(V_{jq})}$

P_{iq} = The probability individual *q* chooses alternative *i*

V_{iq} = The observed component of individual q choosing alternative *i*

V_{jq} = The observed component of the number of alternatives in the choice set of individual *q*

To determine whether the model provides a good explanation of the scenario, the model performance can be calculated. The McFadden's Rho² test can be used to assess the model performance. The model compares the model's Log-Likelihood (LL) to the base model for which all the β's are set to zero. Subsequently, the McFadden's Rho² test provides a goodness-of-fit. In the model, there were only three alternatives, in particularly, alternative 1 and 2, which are a natural gas-free renovation proposition and alternative 3, which is the none option where the respondents keep their own heating system. Multiplying the number of choices with ln(1/3), provides the LL(0). The model's Log-likelihood can be calculated with the formula's:

LL (β) $= \sum_{q}^{N} \sum_{i} y_{iq} \ln(P_{iq})$

LL (β) = The Log-likelihood with the estimated parameters (β)

N = The total number of choices made in the model

y_{iq} = The choice for an alternative *i* made by respondent *q*

P_{iq} = The probability that alternative *i* is chosen by respondent *q*

With the Log-likelihood, the McFadden's Rho² can be calculated. An addition to the McFadden's Rho² is the Rho² Adjusted, for which in the model, the number of choice alternative (N_{alt}) and parameters (N_{par}) are included. The benefit of the Rho² Adjusted is that it provides a less biased result than the McFadden's Rho². The formula's for the McFadden's Rho² and Rho² adjusted are constructed as follows:

ρ^2 $= 1.0 - [\frac{LL(\beta)}{LL(0)}]$

LL (β) = The estimated model's Log-likelihood

LL (0) = The null model's Log-likelihood

ρ^2adjusted $= 1.0 - \left[\frac{N_{alt}}{N_{alt} - N_{par}}\right] * [1.0 - \rho^2]$

N_{alt} = The number of choice alternatives

N_{par} = The number of parameters in the model

When a MNL model is conducted in combination with effect coding, n-1 parameters are estimated. The sum of the part worth utility (parameters) of all n level of one attribute should have a mean equal to zero. The final level, also known as the omitted attribute level can be calculated by taking the inverse of the sum of the estimated levels regarding that variable. These parameters for the omitted attribute levels have no significance, as this is not determined in the MNL model.

3.3.2 Latent class model

A Latent Class model can be used to group individual respondents with similar choices into classes. The model looks for classes of individuals with similar patterns of parameters, which in practice means the respondents have similar preferences. Consequently, every class in a Latent Class model has a set of parameters. Additionally, a Latent Class model relaxes the strong assumptions of a Multinomial Logit model, like the assumptions concerning multicollinearity, outliers, influential points, irrelevance of independent alternative (IIA) and the assumption of a linear relation between any continuous independent variables and the logit transformation of the dependent variable. The IIA property means that the taste variations in the MNL model are represented by a random utility component Ɛ, which follows a double exponential (Gumbel) distribution. Consequently, it assumes that there are no taste variations within the variables. A Latent Class model is based on observable attributes (like a MNL model) and latent heterogeneity, which varies with factors which are unobservable. In addition, it is assumed in a Latent Class model that individuals are implicitly sorted into a set of classes. The individuals might, or might not know to which class any of the individuals belongs to, while this is known by the researcher. The variables which determine the probability that an individual is a member of a certain class, can be studied to determine whether the variables are logical. These variables can be personal characteristics, like socio-demographics, dwelling characteristics, or statements like environmental attitude. As previously described, is it possible to predict the probability an individual *i* belongs to a class *c* based on parameters included in the model, like socio-demographics, etc.. This probability can be calculated with the aid of the following formula (Hensher et al., 2015):

$$P_{iqt|c} = \frac{\exp\left(V_{iqt|c}\right)}{\sum_{j=1}^{J}\exp\left(V_{jqt|c}\right)}$$

$V_{iqt|c}$ = The structural utility of alternative *i* for individual *q* in choice set *t* given class *c*

3.4 Methodological justification

The research study was classified as an explanatory research which used quantitative tests to value the motivators and barriers in the decision-making process of tenants of social housing for natural gas-free renovation projects. In this study, a Discrete Choice Model with stated preferences was used to statistically test the preferences of social tenants regarding the willingness to participate in natural gas-free renovation projects. There were various reasons to choose to conduct a research study based on a Stated Choice Experiment. First, the reason to choose for a Stated Choice Experiment was due to the absence of revealed data. The energy transition is a new transition mainly taking place in the Netherlands, which limits the scope of this research study to the Netherlands. The energy transition has only been started since a few years and only 206 of the 30,000 to 50,000 aspired dwellings have been transitioned (Van den Berg, 2021). Unfortunately this meant that there was limited revealed data available to study the willingness of tenants of social housing to participate in natural gas-free renovation projects. Second, a Stated Choice Experiment was preferred over stated preference, as a choice requires a respondent to really value which attribute was more important than the other. In stated preference a respondent can value multiple attributes as relatively important, while in stated choice the respondent is force to choose. Third, another reason to choose a Stated Choice Experiment was due to the decision-making process of tenants which is limited. Tenants cannot freely choose their preferred natural gas-free heating type, as this is a decision made by the housing association. Consequently, the decision-making process of a tenant is different compared to the decision-making process of a homeowner or housing association, as the motivations and barriers for adoption are different. The tenants do have the choice to accept or decline a natural gas-free renovation plan. When less than 70% of the tenants accepts a renovation plan, it is rejected. Fourth, in Stated Choice modeling, the participant cannot choose the attributes and their levels themselves. The respondents were asked to make a choice between a number of alternatives, which consisted of certain levels per attribute. This mimicked the real decision-making process of social tenants in relation to natural gas-free renovation projects as much as possible. In conclusion, due to the four reasons described above, it was chosen to do a Stated Choice Experiment.

The reason to choose Discrete Choice Modeling (DCM) to analyze the SCE was due to the fact that it is a multivariate technique which is ideal for measuring individual's preference and decision-making behavior, mainly for new, not yet existing alternatives. This was the case for the energy transitions, as there were only a handful of realized natural gas-free renovation projects. Discrete Choice Modeling is mainly and in a similar way used to determine residents preference for energy efficiency measures, as can be seen in Table 14 in Appendix 2. The Multinomial Logit model was chosen for the initial analyses, based on the fact that it is a good base model, useable to both understand and predict choices between alternatives. Besides, the MNL model can be estimated on a subset of alternatives, meaning that not all alternatives must be in the experiment, which allows for a fractional factorial design. By the same token, the MNL model can be used in two ways, to provide a measure of the appropriation of the predictor (parameter) and to determine the direction of the association, represented by the positive, or negative sign. Unfortunately, a MNL model has a number of limitations as elaborated on in the previous section, like the IIA property and assumptions of multicollinearity. Some of these limitations and assumptions of the MNL model can be relaxed with a Latent Class model. For instance, the IIA property is relaxed in a Latent Class model by adding a random component to the parameters of the variables, which represents random taste variations. This relaxes the IIA property problem from a MNL model and results in the fact that a Latent Class model can measure taste variations. Furthermore, the Latent Class model can be used to identify classes of respondent with different taste preferences, resulting in a different parameter set for every class of respondents.

Limitations

Several limitations arose when conducting this research study. First, one limitation refers to the modeling choice in combination with the research questions as not all attributes (variables) in the choice experiment were independent, which is a condition. It is almost impossible to achieve complete independence between variables, as there is often a small relation between them. For example, between house improvements and nuisance. When the bathroom, kitchen and toilet are renovated as well, this will result in more nuisance as the installers needs more time and needs to work in more rooms compared to the situation in which only the heating system would be replaced.

A second limitation in relation to the choice experiment and the questionnaire was the fact that it was impossible to provide random choice sets to the respondents. LimeSurvey did not allow randomization of choice sets, consequently, a partial workaround was created which provided two questionnaires with both eight of the 16 choice sets, which were randomly distributed to the respondents. As such, the two questionnaire versions were distributed randomly, but the choice sets were not created randomly for every respondent.

A third potential limitation had to do with the complexity of the choice experiment, which was indicated by housing associations as too difficult. To tackle above mentioned limitation as much as possible, the variables were already described in easy and intuitive terms and the natural gas-free renovation strategies and the experiment itself were explained in an informative introduction video. Furthermore, the questionnaire, which included the choice experiment, was tested in two rounds for which in the second round, all 15 social tenants stated that they understood the choice experiment and that they valued the introduction video. The difficulty of the choice experiment could be an explanation for the reason that 55% of the respondents did not finish the questionnaire. As eventually enough respondents filled in the questionnaire, this limitation was accepted and therefore neglected during analyses.

A final limitation to the questionnaire design was related to the lottery, which was included to motivate people to participate in the questionnaire. The lottery could motivate respondents with a stronger gain motive, as the prizes can be seen as a personal resource. This limitation is accepted, as it motivated the social tenants to participate in this research study. This resulted in a higher participation rate which in turn optimized the representation of the target group. A lower response rate would have been a larger limitation to the research than the limitation of the lottery.

3.5 Conclusion

Answering the research questions required the use of an experiment, which was chosen to be a Stated Choice Experiment. The methodology chapter justified the choice for this method and explained how it was used to determine the choice preference of Dutch tenants of social housing in relation to natural gas-free renovation projects. According to the literature review and the methodology, a Stated Choice Experiment was the most suitable method to assess behavior. With the aid of the questionnaire, data was collected which in turn was used for statistical tests and analyses. Based on the statistical analyses, a prediction of tenants' future behavior regarding their willingness to participate in natural gas-free renovation projects was made.

In order to study the tenant's decision-making behavior regarding the participation in natural gas-free renovation projects, several project alternatives were outlined in this research study. The first two alternatives were natural gas-free renovation alternatives, which consisted of six attributes. The third alternative was described as the "none" choice, which enabled respondents to keep their current heating system and benefit none of the advantages and disadvantages stated in the attributes. The six attributes used were the following; new natural gas-free heating system, housing costs, comfort change, nuisance, house and neighborhood improvement. The attributes consisted out of two or four values and were integrated in the experimental design. The experimental design consisted out of two questionnaires with eight different choice experiments for each questionnaire. The Stated Choice Experiment is the first out of three parts of the questionnaire. The second part of the questionnaire consisted of statements regarding the tenant's willingness to pay, satisfaction with the housing association's communication, trust in the housing association and environmental attitude. The statements were answered by the respondents on a 5-point Likert scale, ranging from Strongly disagree (1) to Strongly agree (5). The third and final part of the questionnaire was related to questions regarding personal, household, neighborhood and dwelling characteristics.

The two analysis methods which were used for the analyses of the Stated Choice Experiment were the Multinomial Logit and Latent Class model. The Multinomial Logit model was the first method which was used. The Multinomial Logit model had some limitations and assumptions which were relaxed with a Latent Class model. Additionally, this Latent Class model was used to determine the preferences of the different classes of tenants.

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4. Data collection

The hypothesized research questions were answered with the aid of extensive statistical testing and analyzing data obtained from tenants of social housing. In order to gather the necessary data, a questionnaire with an incorporated experiment was constructed and spread among tenants of social housing, as described in the previous chapter 3, Methodology. This chapter describes how the data was collected, how it was cleaned and what the descriptive analyses indicated regarding the data sample. The first section describes the data collection, the channels used and the organizations which were involved. The second section describes the way in which the data sample was cleaned for analyses. The third section entails the data sample, which contained the socio-demographics and zooms into whether these were representative for the Dutch population living in the social housing sector. Furthermore, this section describes the statements and how they varied among different groups of tenants.

4.1 Data collection

Answering the research question required primary data, which had to be collected. This data was collected with the aid of a questionnaire in LimeSurvey. From January 2021 until March 2021, the data collection took place. The questionnaire was distributed among tenants of social housing by e-mail, post, Facebook and Linked-In. The invitation to participate in the questionnaire was extensively reviewed with people from the departments of tenant communication of both Atriensis projecten and multiple housing associations. The reason the extensive reviewing of the invitation took place was to make sure that the invitation was clear and as appealing as possible for the tenants to participate in this research study. The invitation contained a hyperlink and QR-code which could be used to enter the web-based questionnaire. The invitation e-mail and letter are exhibited in Appendix 5. The address information and e-mail addresses of the tenants used to distribute the questionnaire were collected in collaboration with several housing association in the Netherlands. The contact information of tenants which was used to test the questionnaire was provided by the housing association Woonwenz, who first consulted this with the tenants before providing the contact information. The tenants which were asked to test the questionnaire all lived in the PAW neighborhood Hagerhof-Oost in Venlo. The overview of all the housing associations which participated in the questionnaire and the number of tenant contact information they provided is exhibited in Appendix 6. The tenants of social housing could both live in PAW neighborhoods and non-PAW neighborhoods. To determine whether the respondent where tenants of social housing, the respondents were asked whether they were social tenants. If a respondent was not a social tenant, the survey ended and the respondent could no longer participate in this research study, as the target group of the research study were tenants of social housing.

As the minimally required number of respondents was 250 and the housing associations indicated that they usually had a response rate on questionnaires below 10%, a minimal of 2,500 questionnaires had to be distributed. To be on the safe side, around 5,590 tenants were contacted to participate in the questionnaire. To persuade the tenants to participate in the questionnaire, prizes could be won. In a lottery, VVV gift cards and Atriensis energy boardgames were raffled. 1,067 people responded to the questionnaire, unfortunately many of them did not finish the questionnaire. The questionnaire provided a sample size of 481 respondents who filled in the complete questionnaire, as the respondents who did not complete the experiment were left out. The expected response rate was below 10%, as this was thought to be realistic by the housing associations. The actual response rate was 19.09%, but not all respondents completed the questionnaire. The response rate of people who completed the questionnaire was 8.60%, which is close to the estimated 10%.

When the questionnaire in LimeSurvey was closed, the data was exported for analyses. In order to take part in the lottery, respondents had to fill in their e-mail address in the questionnaire. Steps had to be taken in order to ensure the promised anonymity of the respondents. In specific, the data containing the e-mail addresses from the respondents was immediately separated from the data to ensure that the respondents' answers could not be traced back to them. Both data files were saved on the secured OneDrive folder of the TU/e in separate folders. When the lottery ended, the file containing the e-mail addresses was immediately deleted. Further information about this can be found on:

https://www.tue.nl/en/storage/privacy/

4.2 Data coding

In order to statistically analyze the collected data, the data had to be coded. One way to code is effect coding, as is the method of choice in this research study. The attributes consisted of two, or four values, so the levels were labelled from 1 to 2, or 1 to 4. In the coding scheme, the basic levels were coded as -1. As such, effect coding utilizes n-1 effect variables. The overview of the coded variables is illustrated in Table 1.

Table 1 Coding scheme

Attribute	***ID***	***Level***	***X1***	***X2***	***X3***
Heating type	1	Heat network WITH new radiators	-1	-1	-1
	2	Heat network WITHOUT new radiators	1	0	0
	3	Heat pump on electricity	0	1	0
	4	Heat pump on electricity and green gas	0	0	1
Housing costs	1	€0 p/m	-1	-1	-1
	2	€10 p/m LESS	1	0	0
	3	€5 p/m LESS	0	1	0
	4	€10 p/m MORE	0	0	1
Living comfort	1	Remains the same	-1	-1	-1
	2	Better	1	0	0
	3	A little better	0	1	0
	4	A little worse	0	0	1
Nuisance	1	Little nuisance	-1		
	2	A lot of nuisance	1		
House improvement	1	None	-1		
	2	New bathroom, kitchen and/or toilet	1		
Neighborhood improvement	1	None	-1		
	2	Your neighborhood will get better and the (social) problems will be fixed	1		

The statements regarding environmental attitude were not all measured on the same scale, as three out of the five variables which represented environmental attitude, were measured on a reversed scale. This implies that agreeing (Strongly agree (5)) to the statements 3 and 5 was considered to be a pro-environmental attitude, while agreeing to the statements 1, 2 and 4 was considered to be a non-pro-environmental attitude. To calculate the average environmental attitude, the results of these three statements 1, 2 and 4 were reversed, in order to make sure that agreeing to all statement was considered to be a pro-environmental attitude. To make the data usable in analyses the average statements were retransferred to a 5-point scale. This meant that the categories were as follows: category 1 (Strongly disagree) is 1 – 1.49, category 2 (Disagree) is 1.5 – 2.49, category 3 (Neutral) is 2.5 – 3.49, category 4 (Agree) is 3.5 – 4.49 and category 5 (Strongly agree) is 4.5 – 5. In order to combine the statements into statement factors (like environmental attitude), they had to be analyzed by means of a factor analysis and Cronbach's Alpha. The results of these analyses and the statement factors are discussed in section 4.4.2 Analysis of statements.

Ten housing associations facilitated the distribution of the questionnaire. Only five of these housing associations distributed the questionnaire in a PAW-neighborhood, as is displayed in Appendix 6. To determine which respondents lived in a PAW-neighborhood, the zip code was used. Only 11.5% of the respondents came from PAW-neighborhoods. This was due to a majority of the respondents coming from e-mail invitations, which were distributed in non-PAW neighborhoods.

Interaction terms

Socio-demographics and statement variables cannot be added into a MNL model similarly to the attribute variables. This is due to the fact that these variables, or any variable which specifies a personal characteristic does not vary between the choice alternatives within choice sets. This means that for example the gender of a respondent is the same in every choice experiment made by the respondent. As such, the MNL model cannot determine the utility of these variables. In order to integrate these variables into the MNL model, interaction terms were used. An interaction occurs when there is a relation between three or more variables. In practice, this means that the effect of a causal variable on an outcome is dependent on the state of the second causal variable. The interaction terms in this MNL model were based on literature and assumptions. The assumed interaction terms which were included in this MNL model are displayed in Table 2.

Table 2 Overview of the assumed interaction terms for the socio-demographic and statement variables used in the MNL model

Socio-demographic and statement variable	Attribute variable
Gender	Comfort
	Nuisance
	Heating type
Age 70- / 70+	Nuisance
Education high (hbo or higher) / low (below hbo)	Heating type
Children	Neighborhood improvement
Age of child 0-13 / >14	Neighborhood improvement
Work or not	Nuisance
Dwelling type (single-family / multifamily)	Comfort
	House improvement
	Neighborhood improvement
Time lived in house <1 / >2 years	House improvement
	Nuisance
Rent <€600 / >€600	Housing cost
Rent allowance	Housing cost
Income <€2212 / >€2212	Housing cost
Trust and satisfaction with communication	Housing costs
Environmental attitude	Housing costs
	Heating type
Willingness to pay	Housing costs

4.3 Data cleaning

Before any analyses could be conducted, the data had to be cleaned to ensure that only correct responses were used for analyses. The software which was used for the data cleaning is SPSS. As all the questions in the questionnaire were mandatory, this meant that there were no missing values in the data file. This was confirmed by a check for missing values. The initial sample size of respondents who completed the survey was 481. Additionally, the respondents who finished the questionnaire too fast or too slow were removed from the data file. Too fast was assumed to be under 4.5 minute, as this was tested by the test panel to be the least time needed to read and fill in the questions properly. Too long was assumed to be everything above 45 minutes with the exception of respondents who reviewed the introduction video. This resulted in the exclusion of 10 respondents. This resulted in a total sample size of 471 respondents. In addition, the (87) respondents who only filled in answer C in the Stated Choice Experiment were removed. The reason is that this data has no value in the Stated Choice Experiment, as there are no choices which can be valued. Finally, four respondents were removed who filled in an incorrect date of birth. This resulted in a final sample size of 380 respondents.

4.4 Descriptive analyses

Before the MNL and Latent Class model was estimated, some descriptive analyses were conducted to determine the quality and representativeness of the data sample. The analyses were conducted with the aid of SPSS. The third part of the questionnaire consisted of personal, household (socio-demographics), neighborhood and dwelling characteristics. The remainder of this section zooms into the socio-demographics and their representativeness, followed by an elaboration on the statements analyzed based on socio-demographics. For all the analyses a significance level of 5% is used, which means that there should be a significant level of $p<0.050$ in order to be significant.

4.4.1 Analysis of socio-demographics

The socio-demographics were analyzed and compared to the Dutch population to determine the representativeness of the data sample. The population data was based on information from the CBS (CBS, 2019, 2020a, 2020b, 2021). In SPSS the data sample was analyzed with the aid of frequency tables, histograms and cross-tabs, which are exhibited in Appendix 7. The results of these descriptive analyses were compared to the Dutch population with the aid of a Chi² test. The comparison between the sample and the Dutch population is displayed in Table 3. The first variable is the age category, which especially differed in the category 20-30 years old (1991 – 2001), which was the youngest category of tenants. The reason that this category was underrepresented in the sample was due to the fact that some people in this category still lived with their parents. As this category was underrepresented, this resulted in some of the other categories being a little overrepresented. Especially the category 60-70 (1952 – 1961) was overrepresented with about 10%. This given was confirmed by the statistically significant Chi² test with a result of 77.793 (p=0.000). A noteworthy phenomenon was the fact that the oldest category, 80 and older (1941 and older) had a good representation, which is usually the most difficult category to reach. The overrepresentation of elder tenants (>65) in the sample was explainable, as percentage wise, there are more elderly living in the social rental sector (Kullberg & Ras, 2018).

The second variable was gender, which had a good representation, with only a difference of 5%. To underline the representation of the data sample, a Chi² test was conducted, which had a statistically significant Chi² of 4.498 (p=0.034). The low value of the Chi² confirmed the representation of the data sample.

The third variable education had an overrepresentation in the category vmbo, mbo1, havo, vwo and mbo. This was confirmed by the statistically significant Chi², which had a value of 36.732 (p=0.000). The fact that the education category had a striking high Chi² was due to the fact that there were originally two categories, which were combined into one category in order to compare them to the Dutch population average. The categories were combined as the categories from the sample and the CBS were not exactly similar. An overrepresentation in this category could be due to the average tenant of social housing having a lower than average educational level (Kullberg & Ras, 2018).

The work status, the fourth variable in this research study, could not be compared one on one with the CBS data. In the sample the two levels of "work" and "one works, one does not" were both combined and considered as working, as this was necessary to compare them to the CBS data. The variable work status had an overrepresentation of retired tenants, and an underrepresentation of working tenants. This was due to the overrepresentation of elderly (>65), which was explainable, as there are on average more elderly living in the social rental sector (Kullberg & Ras, 2018). Consequently, this meant that the null-hypothesis (no difference) had to be rejected, based on the statistically significant Chi² value of 170.903 (p=0.000).

The household composition, represented as the fifth variable in this research study, displayed an overrepresentation of single parents with children and an underrepresentation of couples living together with children. This indicated that in social housing there are in comparison to the Dutch population, more households consisting of a single parent with children compared to the couples living together with children. These misrepresentations were confirmed by the high Chi² value of 79.490, which was significant (p=0.000).

The sixth variable investigated in this research study, was the number of children, which was relatively representable in comparison to the Dutch population, as the differences between the Dutch population and sample were only minor. As such, the Chi² was only 10.041, which was significant with a p-value of 0.018.

The seventh and final socio-demographic variable investigated in this research study, was the household income, which was on average significantly lower in the social housing sample in comparison to the Dutch population. The highest income class of more than €2,213 per month was 12% higher in the Dutch population in relation to the social housing sample. This automatically resulted in an overrepresentation in the lower income classes for the sample. As in the sample 17.40% of the respondents filled in the category “no answer”, it was assumed that this was similar in comparison to the Dutch population in order to compare the other categories. The misrepresentation of the household income was confirmed by the statistically significant Chi² value of 192.035 (p=0.000). The given that tenants of social housing earned on average a lower income in relation to the Dutch population was confirmed in a study has been conducted by the Dutch Social and Cultural Planning Office (Kullberg & Ras, 2018). These numbers could not be used in the Chi² test as they did not use the same categories as the CBS, which came up with the Dutch population data which was used as a benchmark in this research study.

Limitation to sample representation

It can be concluded that overall, the sample cannot be considered to represent the Dutch population, as all the measured socio-demographic variables were significant. It was impossible to compare the sample to data of the Dutch social housing sector, as there was insufficient data available. Consequently, it was impossible to conduct Chi² tests of goodness-of-fit, which made it impossible to determine whether the sample represented a Dutch social housing population.

Table 3 Representativeness of the sample (CBS, 2019, 2020a, 2020b, 2021)

			Sample count N=380	Sample percentage	Expected count	Netherland percentage	Residual
Age	1941 and older		25	6.60%	22	5.92%	3
x2 = 77.793	1942 - 1951		66	17.40%	42	11.10%	24
p = 0.000	1952 - 1961		93	24.50%	54	14.22%	39
	1962 - 1971		76	20.00%	72	18.93%	4
	1972 - 1981		53	13.90%	67	17.53%	-14
	1982 - 1991		48	12.60%	60	15.79%	-12
	1991 - 2001		19	5.00%	63	16.52%	-44
Gender	Male		168	44.20%	189	49.65%	-21
x2 = 4.498	Female		212	55.80%	191	50.35%	21
p = 0.034							
Education	Elementary school		20	5.30%	35	9.14%	-15
x2 = 36.732	Vmbo, mbo1, havo onderbouw + Havo bovenbouw, vwo, mbo		277	72.90%	219	57.56%	58
p = 0.000	Hbo, wo		83	21.80%	127	33.30%	-44
Work status	Work + One works, one does not		196	51.60%	271	71.23%	-75
x2 = 170.903	Do not work		55	14.50%	63	16.64%	-8
p = 0.000	Retired		129	33.90%	46	12.13%	83
Household composition	Living together		119	31.30%	102	26.81%	17
x2 = 79.490	Living together with children		47	12.40%	116	30.46%	-69
p = 0.000	Single		159	41.80%	136	35.86%	23
	Single parent with children		55	14.50%	26	6.87%	29
Number of children	0		282	74.21%	256	67.30%	26
x2 = 10.041	1		49	12.56%	53	13.99%	-4
p = 0.018	2		34	8.95%	51	13.54%	-17
	3 or more		15	3.95%	20	5.17%	-5
Household income	Less than 1791 / month	Less than 23283 / year	133	35.00%	127	33.42%	6
x2 = 192.035	1791 - 2212 / month	23283 - 28756 / year	86	22.60%	24	6.25%	62
p = 0.000	More than 2213 / month	More than 28756 / year	95	25.00%	163	42.93%	-68
	No answer	No answer	66	17.40%	66	17.40%	0

Tenant's knowledge about natural gas-free renovation projects

In the questionnaire, the respondents were asked whether they knew what a PAW neighborhood, or a Proeftuin was in order to determine their knowledge regarding natural gas-free renovation projects. The respondents were also asked whether their housing association informed them regarding natural gas-free renovation projects and how they were informed. 52.6% of respondents knew what a PAW-neighborhood or a Proeftuin was, which meant that about half of all respondents have some knowledge regarding the energy transition. The frequencies are displayed in Table 4. Likewise, the respondents were asked whether their housing association informed them about the energy transition and how they were informed, this is displayed in Table 5. The frequency table indicate how respondents were informed about the transition to go natural gas-free. 72.6% of respondents was not informed about the energy transition by their housing association, which can be explained, as the questionnaire was conducted among tenants in PAW-neighborhood and normal neighborhoods.

In order to determine whether the environmental attitude differentiates among these two groups, a Cross-tabs analysis and Chi² test was conducted, from which the results are displayed in Table 6 and Table 7. Table 6 displays the way in which tenants were informed about the energy transition. In the case the tenant was not informed in any way, they filled in "Yes" for the option "Not informed", as stated in the questionnaire (Appendix 7). The Chi² test indicated that tenants in PAW-neighborhoods had on average a lower environmental attitude ($p<0.001$). This was opposite to the expected results, as it was expected that tenants in PAW-neighborhoods had a higher environmental attitude. It was assumed that this was due to tenants living in a PAW-neighborhood being informed more by their housing association regarding natural gas-free renovation projects, as is displayed in Table 8. This table displays whether tenants living in a PAW-neighborhood (1) were informed about the energy transition by their housing association.

Table 4 Frequency table indicating whether the respondents know of PAW-neighborhoods or Proeftuinen

I know PAW or Proeftuin

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	200	52.6	52.6	52.6
	Yes	180	47.4	47.4	100.0
	Total	380	100.0	100.0	

Table 5 Frequency table indicating how respondents were informed about natural gas-free

Informed about energy transition

		Frequency	Percent	Valid Percent	Cum. Percent
Municipality	No	350	92.11	92.11	92.11
	Yes	30	7.89	7.89	100
	Total	380	100	100	
Letter	No	355	93.42	93.42	93.42
	Yes	25	6.58	6.58	100
	Total	380	100	100	
Newsletter	No	353	92.89	92.89	92.89
	Yes	27	7.11	7.11	100
	Total	380	100	100	
E-mail	No	353	93.42	93.42	93.42
	Yes	27	6.58	6.58	100
	Total	380	100	100	
Website	No	375	98.68	98.68	98.68
	Yes	5	1.32	1.32	100
	Total	380	100	100	
Social media	No	367	96.58	96.58	96.58
	Yes	13	3.42	3.42	100
	Total	380	100	100	
Not informed	No	104	27.37	27.37	27.37
	Yes	276	72.63	72.63	100
	Total	380	100	100	

Table 6 Cross-tab indicating the average environmental attitude for tenants living in PAW-neighborhoods vs other neighborhoods

Living in PAW * Environmental attitude (average) Crosstabulation

			1 (Low)	2	3	4	5 (High)	Total
PAW	No	Count	1	21	208	95	11	336
		Exp. Count	1.008	21.168	207.984	95.088	11.088	336
		% within PAW	0.30%	6.30%	61.90%	28.30%	3.30%	100.00%
	Yes	Count	0	6	31	7	0	44
		Exp. Count	0	5.984	31.020	6.996	0	44
		% within PAW	0.00%	13.60%	70.50%	15.90%	0.00%	100.00%
Total		Count	1	96	239	102	11	380
		Exp. Count	1	96	239	102	11	380
		% within PAW	0.30%	7.10%	62.90%	26.80%	2.90%	100.00%

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree
Yes = PAW-neighborhood, No = other neighborhood

Table 7 Chi² test regarding average environmental attitude for tenants living in PAW-neighborhood vs other neighborhoods

Chi² Tests

	Value	Asymptotic Significance (2-sided)
Pearson Chi²	7.227	1.904E-36

Table 8 Cross-tabs regarding tenants being informed about the energy transition in PAW-neighborhoods and other neighborhoods

Living in PAW * Informed about energy transition - Crosstabulation

			Yes	No	Total
PAW	No	Count	86	250	336
		% within PAW	25.60%	74.40%	100.00%
	Yes	Count	18	26	44
		% within PAW	40.91%	59.09%	100.00%
Total		Count	104	276	380
		% within PAW	27.37%	72.63%	100.00%

Yes = PAW-neighborhood, No = other neighborhood

4.4.2 Analysis of statements

The second part of the questionnaire contained statements, specifically statements regarding willingness to pay, satisfaction with the housing association's communication, trust in housing association and environmental attitude. The statements were answered with the aid of a 5-point Likert scale. A tenant's score for a single statement is an integer, as it represented one of five categories, specifically: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree. Prior to the analyses of the statements, it had to be determined whether the statement variables were reliable and represented a certain number of factors, as such a Factor analysis was conducted. The first section describes the Factor analysis, which is followed by a section regarding the actual analysis of the statement factors, as they were divided into the factors from the Factor analysis.

Factor analysis & Cronbach's Alpha

In addition to the statement analyses, a factor analysis and Cronbach's Alpha analysis had to be conducted in order to determine the factors the different statements variables represented. All the tables and figures regarding this chapter's Factor analysis can be found in Appendix 10. First a Descriptive analysis was conducted which included all the statement variables, which is displayed in Table 61, Appendix 10. The Descriptive analysis provided nothing noteworthy, as the distributions were plausible and there were no missing values. As all the statements were positively coded on a similar scale, this required no additional coding. Second, an Exploratory Factor analysis was conducted. The Total Variance Explained table (Table 64, Appendix 10) and the Scree plot (Figure 56, Appendix 10) displayed that there were four factors above the Eigenvalue of one, as the fourth factor had an Eigenvalue of 1.020. The four factors resulted in a cumulative representation of variance of 63%, while three factors explained 57% of the total variance. All but one of the statements had a R^2 value above 0.400, which is displayed in Table 63 in Appendix 10. This meant that the statement variable Environmental attitude 1, which had an R^2-value of 0.215 did not contribute much to measuring the underlying factors. The KMO and Bartlett's test had a significant ($p<0.000$) Kaiser-Meyer-Olkin measure of 0.822, which was above 0.500 as it is supposed to be, meaning it was meritorious. This indicated that the correlation matrix was significantly different from the identity matrix, indicating that the matrix was factorable. The Component matrix, exhibited in Table 65, Appendix 10 had cross loadings, which was fixed by (Viramax) rotation, which is exhibited the Rotated Component matrix in Table 66 in Appendix 10. The rotated Component matrix indicated that the seven Trust and Satisfaction with communication statements were one factor, the four WTP statements were one factor and that the five Environmental attitude statements were two factors. The two factors containing Environmental attitude statements still displayed cross loadings. As there were still cross loadings, the fourth factor was very close to an Eigenvalue of one (1.020), only added 5% extra variance explained and was below the threshold of a randomly generated Eigenvalue (as is exhibited in Figure 57 in Appendix 10), a Factor analysis was conducted containing only three fixed factors.

The Factor analysis based on three fixed factors displayed some R^2-values below 0.400 for three of the five Environmental attitude statements, which was only one in the previous Factor analysis. The Component matrix, displayed in Table 68 in Appendix 10 displayed cross loadings, similar to the Component matrix of the previous Factor analysis. As such, a (Viramax) rotation was conducted, resulting in a Rotated Component matrix, displayed in Table 69 in Appendix 10. The Rotated Component matrix of the Factor analysis with three fixed factors did not display any cross loading. The seven statements regarding Trust and Satisfaction with communication represented the first factor, the second factor contained the four statements regarding WTP and the final factor was represented by the five statement referring to Environmental attitude. As the second Factor analysis had no cross loading, it was concluded to be the best Factor analysis, resulting in three factors which were used in the further analyses. Additionally, a Reliability test was conducted, containing a Cronbach's Alpha test, exhibited in Table 71 in Appendix 10. The Cronbach's Alpha had to be above the satisfactory level of 0.700, which it was with 0.730.

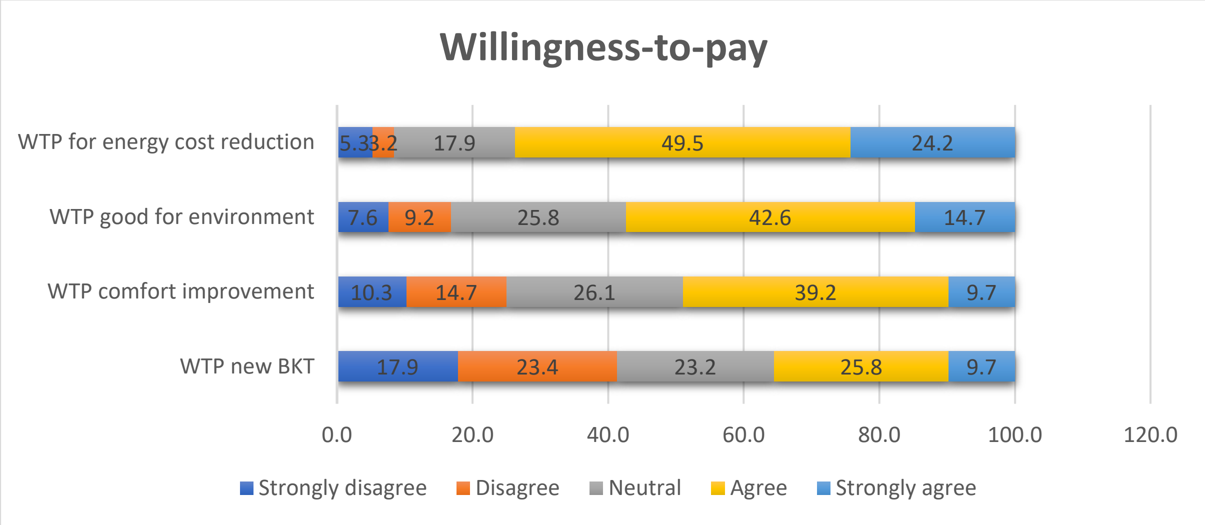
As the Factor analysis with three factors displayed the best results, the statements were combined according to the three factors from this analysis. The three factors were the WTP, containing the four WTP statements, the Satisfaction with housing association, containing seven statements regarding Trust and Satisfaction with communication and finally Environmental attitude, containing the five statements of the NEP-scale representing an ecological worldview. As adding Factor scores in the form of z-scores is not preferred, due to their complicated interpretation resulting from their mean of zero and standard deviation of one. Consequently, the Factors were computed based on the mean score of the related statement variables. This indicated the respondent's average score for that particular factor. Due to the mean computation, the factors no longer consisted of integers, but of decimal numbers on a scale from one to five. As such, for the descriptive analyses, the factors (like environmental attitude) were round off, in order to obtain an integer. This resulted in the following round off values: 0-1.49 = Strongly disagree, 1.50-2.49 = Disagree, 2.50-3.49 = Neutral, 3.50-4.49 = Agree, 4.50-5.00 = Strongly agree. Consequently, a tenant's average score for a certain factor was an integer. The statements were both analyzed individually and as factors. In the MNL and Latent Class model, the factors were not round off, as they were included as decimal numbers. Hence, it was not necessary to display the scores for the factors in terms of one of the five categories.

Analyses of individual statements and statement factors

The statements were individually analyzed with the aid of frequency tables and histograms, which can be found in Appendix 7. The frequency tables and histograms displayed normal distributions with a mean between 3.02 and 3.55 on a 5-point scale. These mean values indicated an average just above the neutral category (3 on the 5-point Likert scale). The statements were also grouped according to factors, as determined in the previous section. The factors were analyzed in a similar manner as the separate statements. The factors were as follows: Satisfaction with housing association, Environmental attitude and Willingness to pay. The statement factors were included in the analyses as the average score of the Satisfaction with the housing association, Environmental attitude and Willingness to pay.

The first statement factor described the respondent's willingness to pay (WTP) for certain measures, such as measurements which resulted in a reduction of energy costs, an improvement of the environment, an improvement of the comfort, or provided the tenant with a new bathroom, kitchen, or toilet. Table 9 displays the respondents' answers for the statement factor regarding the WTP. Figure 47 in Appendix 7 clearly shows that respondents' willingness to pay (mean = 3.84 on 5-point Likert scale) is the highest when the tenant was proposed with a natural gas-free renovation project leading to a reduction in energy costs. This given is probably due to two factors, on one hand, going natural gas-free saves money and on the other hand, it is good for the environment. This was confirmed by the results on the second statement regarding the environment, as respondents were also willing to pay for the good of the environment (mean = 3.48). The WTP for comfort improvements was just above average, with a mean of 3.23, while the willingness to pay for a new BKT was just below average with a mean of 2.86. The below average WTP could be due to the fact that respondents perceived this as the responsibility of the housing associations, who replaced the BKT's every x years. This was normally perceived as maintenance.

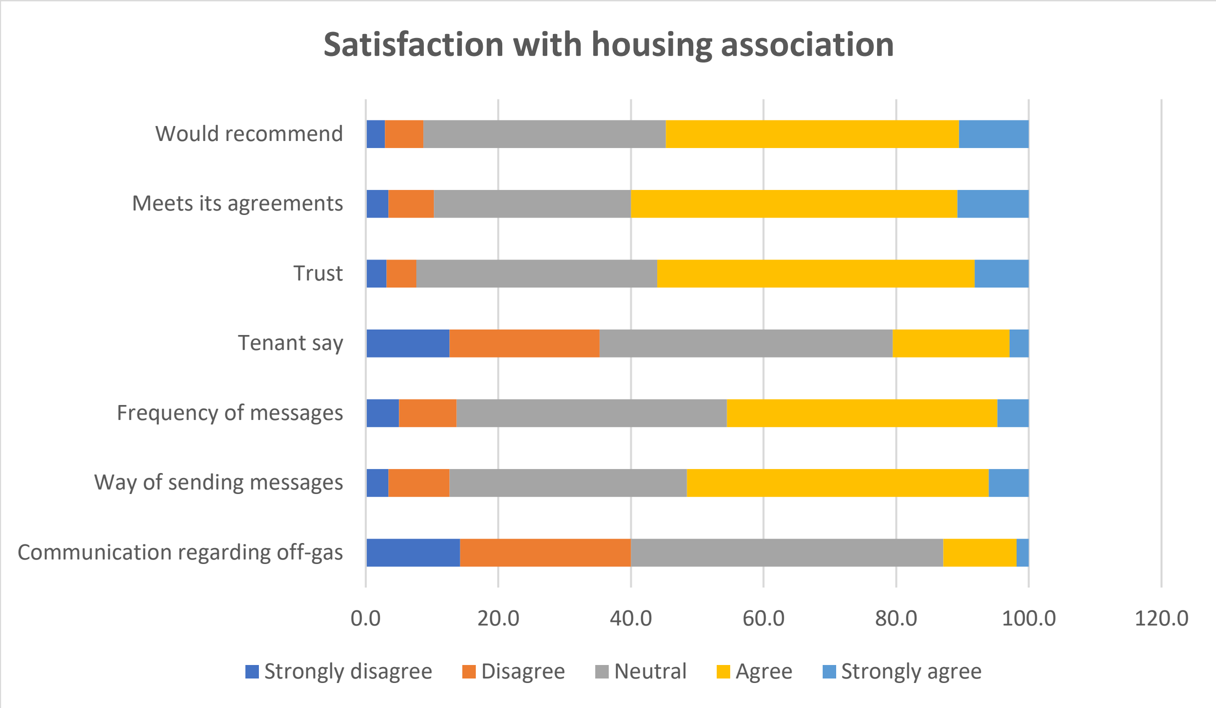
Table 9 Respondents' answers in percentages for the statements regarding the WTP



The second section of statement factors regarded the respondents' satisfaction with the housing association. This was divided into seven statements. The first four statements described the tenants satisfaction with the tenant say, which described how much influence a tenant had in the decision-making process regarding their house, the frequency the housing association send messages, the way of sending messages and housing associations' communication regarding the energy transition. Additionally, the remaining three statements described the respondent's trust in the housing association, whether the respondent would recommend the housing association to friends and family and finally the statement whether the housing association met their agreements.

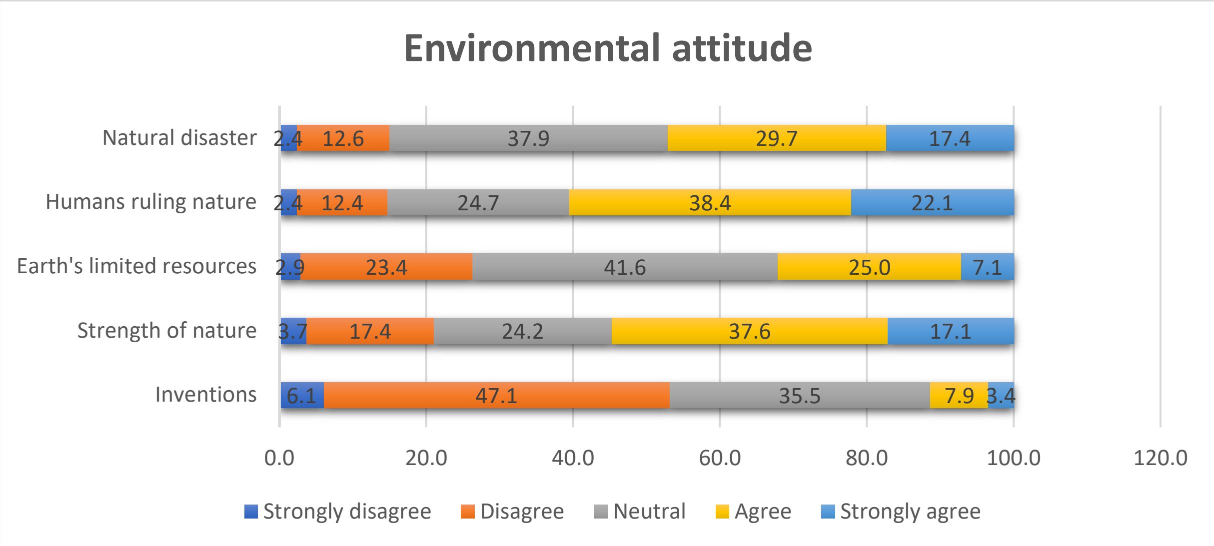
The results in Table 10 indicate that the housing associations on average met their agreements (mean = 3.57, Figure 35, in Appendix 7), that tenants would recommend the housing association to family and friends (mean = 3.54, Figure 36 in Appendix 7) and that the housing associations were perceived to be trustworthy (mean = 3.53, Figure 34 in Appendix 7). Additionally, the respondents were on average satisfied with the way the housing associations sent messages (mean = 3.42, Figure 30 in Appendix 7) and with the frequency the housing association sent messages, as the mean was above three, which is exhibited in Figure 30 and Figure 31 (mean = 3.32, Figure 31 in Appendix 7). The respondents were less satisfied with the housing association's communication regarding the energy transition (mean = 2.61, Figure 29 in Appendix 7) and the tenant say they had, as presented in Figure 29 and Figure 32 (mean = 2.76, Figure 32 in Appendix 7). The lower satisfaction regarding the communication of the energy transition could be explained, by the fact that not all respondents lived in PAW-neighborhoods, which meant their housing association probably had not informed them yet. Hence, this logically resulted in a lower satisfaction regarding the communication concerning the energy transition.

Table 10 Respondents' answers in percentages for the statements regarding the trust and satisfaction with the communication of the housing association



The fourth and final collection of statements regarded the environmental attitude. The respondents' answers to the statements in percentages are displayed in Table 11. The environmental attitude consisted of five question regarding the natural disasters, humankind ruling nature, earth's limited resources, the strength of nature and whether inventions would prevent climate change. The first four statements were skewed towards agreement regarding the statements, which indicated pro-environmental behavior. Only the fifth statement regarding the inventions was skewed towards disagreements, indicating non-pro-environmental behavior. The mean of the average environmental attitude was 3.251 (Figure 37 in Appendix 7) on a scale from 1 to 5. The mean was above 3 (neutral), which meant that the average environmental attitude was lightly skewed towards pro-environmental behavior.

Table 11 Respondents' answers in percentages for the statements regarding the environmental attitude variables.



Cross-tabs and Chi² tests were used to compare the statement factors to the socio-demographics in order to determine whether there were differences between various groups of people. The cross-tabs are displayed in Table 47 to Table 55 in Appendix 7. After statistically analyzing the statement factors with the aid of a Chi² test, it was concluded that, with the exception of one statement factor, there were no relationships between the statement factors and the socio-demographics. Statistical test confirmed a statistically significant relationship between environmental attitude and the tenant's educational level. The relation was weak, but significant between the environmental attitude and the education level with a Chi² value of 72.170 ($p=0.050$). In addition, a Cross-tabs table was made which displayed the percentual distributions of education for the environmental attitude. These Cross-tabs in Table 53 (Appendix 7), display that the higher education classes consisting of havo bovenbouw, vwo, mbo and hbo, wo had on average a higher environmental attitude in comparison to the lower educational classes. Specifically, the elementary school and vmbo, mbo1, havo onderbouw classes displayed a lower environmental attitude. From now on the three factors will be named statement factors.

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5. Results

This chapter describes the sample which was drawn from the questionnaire and the results of the extensively statistical analyses. The first section describes the results from the Multinomial Logit model. Followed by the second section which zooms into the results from the Latent Class model. Subsequently, this section ends with a discussion and conclusion.

5.1 Multinomial Logit model

The statistical analyses of the Multinomial Logit model (MNL) was estimated with the software "R". In order to find the best performing MNL model (based on McFadden's Rho² Adjusted), four MNL models were conducted. Only the model with the highest McFadden's Rho² Adjusted is discussed in this section. The other three MNL models can be found in Appendix 8 and 9. These three models are the MNL base model, the MNL model including socio-demographics and the MNL model including statement factors. The MNL model which is discussed in this section is the MNL model which included both the socio-demographic and statement factors.

The part worth utilities, or parameters which are estimated by a MNL model, represent an individual's utility they attach to an attribute level. Consequently, a higher parameter means that the attribute level has a higher influence on the individual's choice. The parameters can both be positive and negative. Negative parameters represent a negative relation between the variable level and the individual's choice (the dependent variable). The Pr(>|z|) represents the two-tailed significance of the variable value. In this research study, a value or result was perceived to be significant if $p<0.050$. Table 12 displays the results of the MNL model which includes both the socio-demographic variables and statement factors. The first attribute level of every attribute in Table 12 is the omitted variable, as such, they were never significant. Figure 23 presents a visual representation of the MNL model regarding the part worth utility and significance of the levels. The insignificant and omitted variable levels are presented in a grey color and the significant variable level are presented in a blue color. Figure 24 displays the relative importance of the significant variables which were included in the MNL model. The variables of the MNL model are discussed below.

Constant

The constant described an individual's overall preference for the natural gas-free renovation. The constant had a statistically significant parameter value of 1.017 ($p<0.001$). The constant parameter was relatively high (over 1, indicating acceptance), which indicated that tenants had a general preference for natural gas-free renovation projects, as all proposed alternatives were natural gas-free. This meant that the tenants prioritized a natural gas-free renovation in comparison to not renovating and keeping their own and current heating system. As the parameter was high in comparison to the parameters of the other variable levels, this meant that the constant had a high impact on the choice which was made by the individual. The parameter had a positive relation, which was expected, meaning that the constant had face validity.

Heating type

The attribute variable heating type had four levels, specifically: heat network with new radiators, heat network without new radiators, heat pump on electricity and heat pump on electricity and green gas. The new heating system attribute levels were all insignificant, so it was impossible to make interpretations based on the parameters. This indicated that tenants had no preference for either one of the natural gas-free heating types, as they did not base their decision between the natural gas-free alternatives on the different heating types. As such, the heating type did not influence the tenant's choice regarding the participation in natural gas-free renovation projects. It was expected that tenants would prefer heat networks over heat pumps. Consequently, it was expected that heating type would have a small influence on the willingness to participate in natural gas-free renovation projects, instead of no influence.

Housing costs

The results from the MNL model indicated that the attribute levels €10 per month LESS and €5 per month LESS corresponding to the attribute variable housing costs, positively influenced (0.633, $p<0.05$ and 0.988, $p<0.01$ respectively) the tenant's natural gas-free renovation choice. The attribute level of €10 per month MORE corresponding to the attribute variable housing cost had a negative effect (-1.067, $p<0.001$) on the natural gas-free renovation choice. The attribute level of €0 per month was the omitted variable, which meant that the utility of this variable is always zero, due to the setup of effect coding. This was caused by the fact that in effect coding, all the attribute levels for the omitted variable are multiplied by -1. Hence, the total utility of the omitted variable is always zero, despite the strength of the parameter.

The directions of the parameters of the attribute variable housing cost were as expected, as reducing the housing costs resulted in a positive relation, while increasing the housing costs resulted in a negative relation with the dependent variable. Increasing the housing costs had the strongest negative relation which was as expected. However, there was a striking result regarding the strength of the relation and the corresponding parameter. In specific, a higher decrease of the housing costs of €10 per month resulted in a weaker positive relation than decreasing the housing costs by €5 per month. It was expected that the higher the decrease in housing costs, the stronger the relation and the parameter. As the directions of all the attribute levels were as expected, the variable was perceived to have face validity.

The parameters for the attribute levels of housing costs were relatively high in comparison to the parameters of the other variable levels, presented in Figure 23. This indicated that the housing costs highly influence the tenant's decision-making process.

Comfort

The third variable of this research study was the attribute variable comfort. A better comfort (0.266, $p<0.001$) displayed the highest significant parameter, respectively followed by a little better comfort (0.124, $p<0.01$), comfort remains the same (0.137, omitted level), and finally a little worse comfort (-0.527, $p<0.001$). The latter had a negative relation to the willingness to participate in natural gas-free renovation projects. All these levels were ordered in relation to their possible utility score, as expected with the highest comfort improvement having the highest positive parameter and the comfort decrease having a negative parameter. Similar to the other significant variables, the comfort variable had face validity, as all relations between the attribute levels and the willingness to participate in natural gas-free renovation projects were as expected.

The parameters for the attribute levels of comfort were relatively high, especially the negative relation between the decreasing comfort level and the dependent variable, which was the willingness to participate in the natural gas-free renovation project. The parameters of the attribute variable comfort were lower than the parameters of housing costs, which is displayed in Figure 23. This indicated that comfort had a relatively high influence on the tenant's decision-making process, but the influence was weaker in relation to the strong influence of housing costs on the tenant's willingness to participate in natural gas-free renovation projects.

Nuisance

The fourth attribute variable, was about nuisance. The attribute was divided into two levels, which specified the negative relation of -0.311 between a lot of nuisance and the natural gas-free decision on one hand ($p<0.001$), and the positive relation of 0.311 (omitted level) between a little nuisance and natural gas-free decision on the other hand. The levels and corresponding directions of the relations were according to the expectations, as less nuisance had a positive relation, which resulted in a utility of zero, while more nuisance had a negative relation regarding the natural gas-free renovation choice, meaning the variable had face validity. The attribute variable nuisance had a relatively large influence on the tenant's decision-making process, as the parameters were of similar magnitude compared to the parameters of the attribute variable comfort. This given is exhibited in Figure 23.

House improvement

The fifth attribute variable, house improvement had a positive relation of 0.179 ($p<0.001$) for the level which contained the house improvement and a negative relation of -0.179 for the level which did not contain the house improvement (omitted level). The parameters of these levels were in accordance to the expectations, as individuals prefer house improvements. As the relations were as expected, the variable had face validity. The influence of this attribute variable on the tenant's decision-making process is lower in relation to the influence of housing costs, comfort and nuisance. This indicated the fact that tenants preferred improvements to their house instead of having no improvements to their house. Nonetheless, in comparison to other variables, whether or not the house got improved, had no major influence on the willingness to participate in natural gas-free renovation projects.

Neighborhood improvement

The sixth attribute variable was concerning neighborhood improvement. Likewise, the relation between house improvement and the tenant's decision-making process, there was a significant positive relation of 0.164 ($p<0.001$) between the neighborhood improvement and the decision to participate in natural gas-free renovation projects. Similarly, there was a negative relation of -0.164 (omitted variable) between no neighborhood improvements and the decision to participate in natural gas-free renovation projects. This relation was according to expectations as it is logical that tenants prefer neighborhood improvements, meaning the variable had face validity. The influence of the attribute variable neighborhood improvement was of a similar magnitude as house improvement. This indicated that tenants perceive the improvement of their neighborhood to be of a similar importance and influence on the decision-making process. Neighborhood improvement was not as influential on the tenant’s willingness to participate in natural gas-free renovation projects as the attribute variables housing cost, comfort and nuisance.

Gender

The socio-demographic variable gender was combined with the attribute variable comfort and nuisance with the aid of interaction terms. The first variable dealt with comfort, which indicated the fact that women had a more negative relation of -0.117 ($p<0.05$) to comfort decrease in comparison to men. The other three levels of the interaction term gender and comfort were insignificant, meaning that no assumptions could be made regarding these variable levels. The significant interaction term between gender and comfort had a parameter which was according to the expectation, as it was assumed that women have a more negative preference for comfort decrease in comparison to men. Additionally, the interaction term had face validity, as the relation between gender and comfort was according to the expectation. The influence of the relation was mediocre, as most attribute variables had higher parameters.

The second interaction combined the attribute nuisance with gender, which was used to investigate the expectation that women have a more negative relation with nuisance than men. Statistical analyses showed that there was a significant negative relation between the two variables of the interaction term, gender and nuisance in relation to the willingness to participate in natural gas-free renovation projects. With other words, women were negative towards renovation projects which bring along nuisance. This given was underlined by the negative interaction parameter of -0.065 ($p<0.01$) between women and a lot of nuisance. The given that women had a positive relation to little degrees of nuisance, in comparison to men was underlined by the positive interaction parameter of 0.065 (omitted variable). As expected, this indicated that women value nuisance caused by renovation works more negatively in comparison to men. As such, the interaction term was perceived to have face validity. The interaction term comprised about half the influence of the interaction term gender and comfort. This implied that women valued a decrease in comfort as worse, in comparison to an increase in nuisance.

Work status

The third interaction term combined the nuisance level with a respondent’s work status. It was expected that unemployed tenants (who do not work) perceived nuisance as more disturbing and consequently experienced a negative relation with higher nuisance levels, in comparison to employed tenants (who work). It was assumed that unemployed tenants spend more time in their house during the renovation works, whereas employed tenants are most of the time off to work. The expectation was confirmed by the interaction term, which provided face validity. The results displayed a negative relation of -0.057 ($p<0.01$) between not working and experiencing a lot of nuisance caused by the renovation works, whereas not working and experiencing a little nuisance had a positive relation of 0.0577 (omitted variable). As such, there was a significant negative relation between the tenant's work status and the perceived nuisance caused by the renovation works. This could be explained by the fact that an unemployed tenant spends more time in the house during the renovation works. The preference of the interaction term between work status and nuisance was of similar magnitude as the interaction term between gender and nuisance. Meaning that nuisance was similarly preferred by women and unemployed tenants.

Willingness to pay

The statement factor regarding willingness to pay and tenant's housing costs were grounded together with the aid of an interaction term. It was assumed that tenants with a high WTP were less influenced by a decrease in housing costs when deciding whether or not to participate in a natural gas-free renovation project. Additionally, it was assumed that tenants with a high WTP were more likely to accept a natural gas-free renovation project which would increase the housing costs, in comparison to tenants with a lower WTP. This implied a negative relation between WTP and housing cost decrease and a positive relation between WTP and housing cost increase.

The results confirmed the expectation, that WTP combined with a decrease of housing costs had a negative relation to the willingness to participate in natural gas-free renovation projects. A decrease of €10 per month showed a negative relation of -0.129 ($p<0.01$) for the interaction term with WTP. Unfortunately, a decrease of €5 per month showed only a significance of $p<0.10$, which was insignificant enough to be a meaningful influence. According to the expectations as outlined above, an increase of housing costs of €10 per month combined with WTP had a positive relation of 0.167 ($p<0.01$) on the willingness to participate in natural gas-free renovation projects. Not changing the housing costs with €0 per month combined with WTP also had a positive relation of 0.051 (omitted variable) on the willingness to participate in natural gas-free renovation projects, but this would result in a utility of 0, due to the setup of effect coding (all levels multiplied by minus 1). This confirmed the expectations and additionally the face validity, as tenants with a higher WTP were less influenced by a decrease of the housing costs (of €10 per month) due to the negative relation. Additionally, tenants with a higher WTP were less (negatively) influenced by an increase in housing costs (of €10 per month) and were willing to pay more for natural gas-free renovation projects, due to the positive relation.

The WTP might have had a significantly higher influence on the tenant's decision-making process in comparison to the other interaction terms elaborated on earlier. This was due to the fact that the parameters of the other interaction terms were always multiplied by either 0, 1, or -1, as they were categorical variables. The interaction terms regarding the statement factors on the other hand were multiplied by a decimal number in between -5 and 5. As a consequence, a parameter of a similar size might have had a utility up to five times as high as that of an attribute variable. As such, the WTP had a major impact on the tenant's decision-making process, influenced by the housing costs. As a result, tenants with a higher WTP were less positively influenced by a decrease in housing costs and likewise, less negatively influenced by an increase in housing cost in comparison to tenants with a lower WTP.

Environmental attitude

The statement factor regarding environmental attitude was combined with housing costs as an interaction term. Kerperien (2019) has found that the gain motive is more important for tenants who have an environmental attitude below four (on a 5-point Likert scale), in relation to the acceptance of energy efficiency measures. Hence, it was expected that tenants with a higher environmental attitude were less influenced by a decrease in housing costs and were more likely to accept an increase in housing costs for the good of the environment in comparison to tenants with a lower environmental attitude. Consequently, the statement factor regarding environmental attitude was combined with housing cost in an interaction term. The results indicated that there was a significant negative relation between a decrease in housing costs of €5 per month and the tenant's environmental attitude ($r= -0.181$, $p<0.05$). The other levels did not provide any scientific evidence to confirm any relation between the tenant's environmental attitude and housing costs, as they were insignificant, or the omitted variable. The significant interaction term level confirmed the expectation and provided the interaction term with face validity. This implied that tenants with a higher environmental attitude were less susceptible to a decrease in housing costs (of €5 per month) in comparison to tenants with a lower environmental attitude.

The interaction term between environmental attitude and housing costs had a similar influence on the tenant's decision-making process compared to the interaction term consisting of WTP and housing costs. The parameters were of a similar magnitude and were both multiplied on a scale from -5 to 5, meaning that the utility could be five times higher for this interaction term, in comparison to an attribute variables with a similar parameter. As such, the environmental attitude had a large impact on the tenant's decision-making process, influenced by the housing costs.

Model performance

The model performance was calculated with the Log-likelihood (LL) of the MNL model (LL(β)) and the Log-Likelihood of the null-model (LL(0)). These were used to calculate the McFadden's Rho^2 and the McFadden's Rho^2 adjusted. A McFadden's Rho^2 Adjusted value between 0.2 and 0.4 is perceived as an satisfactory fit (Hensher et al., 2015). The McFadden's Rho^2 Adjusted was relatively low, as it was 0.094 (displayed in Table 56), which meant that the base model did not have a satisfactory fit, despite this MNL model having the highest McFadden's Rho^2 Adjusted of all the MNL models (in appendix 8).

The utility scores of the attribute levels in the visual representation of the MNL model in Figure 23 displays the high influence of the constant and housing costs. This implied that tenants had a general preference for natural gas-free renovation projects, due to the constant. In relation to housing costs did both decreases and increases of housing costs have a strong influence on the tenant's decision-making process, where the prior had a positive relation, while the latter had a negative relation. Furthermore, it could be concluded that mainly a decrease in living comfort and nuisance had a large (negative) impact on the tenant's willingness to participate in natural gas-free renovation projects. In addition, the increase of comfort and improvement of the house and neighborhood had positive effects on the choice to participate, but they were not as influential as the constant, decrease of comfort and influence of housing costs.

In relation to the socio-demographic interaction terms, all three variables had a minor and negative influence on the tenant's decision-making process. On the other hand, the interaction terms of the statement factors had a larger influence than the socio-demographic interaction terms. This influence was increased due to these variables being measured on a 5-point Likert scale, meaning that the utility could be five times higher compared to the parameter. Consequently, the visual representation of the statement factor interaction terms was distorted.

The relative importance is the range of the part worth utility of an attribute in relation to the sum of all the attributes' part worth utility ranges. A relative importance diagram only includes the significant attribute levels. The relative importance of the variables in the MNL model is displayed in Figure 24, which shows that the attribute variables had the highest influence on the tenants decision-making process. The six attribute variables accounted for 83% of the relative important of the significant variables. The cause of this high relative importance were the two attribute variables housing cost and comfort, which represented almost threequarters of the relative importance. Noteworthy, nuisance was the third most important attribute and therefore had a major impact on the tenant's willingness to participate in natural gas-free renovation projects. As a result, the attribute variables house and neighborhood improvement and the socio-demographic and statement factor interaction terms represented only one quarter of the relative importance.

Table 12 Results from MNL model that includes the attribute, socio-demographic variables and statement factors

Attribute	Level	Parameters	Pr(>|z|)
Constant	Constant 1	1.017	0.001
Heating type	Heat network WITH new radiators	0.032	
	Heat network WITHOUT new radiators	-0.005	
	Heat pump on electricity	-0.012	
	Heat pump on electricity and green gas	-0.015	
Housing costs	Housing costs: €0 p/m	-0.554	
	Housing costs: €10 p/m LESS	0.633	0.05
	Housing costs: €5 p/m LESS	0.988	0.01
	Housing costs: €10 p/m MORE	-1.067	0.001
Comfort change	Comfort: Remains the same	0.137	
	Comfort: Better	0.266	0.001
	Comfort: A little better	0.124	0.01
	Comfort: A little worse	-0.527	0.001
Nuisance	Little nuisance	0.311	
	A lot of nuisance	-0.311	0.001
House improvements	None	-0.179	
	House improvement	0.179	0.001
Neighborhood improvements	None	-0.164	
	Neighborhood improvement	0.164	0.001
Gender	Women * Comfort: Remains the same	0.049	
	Women * Comfort: Better	0.036	
	Women * Comfort: A little better	0.032	
	Women * Comfort: A little worse	-0.117	0.05
	Women * Little nuisance	0.065	
	Women * A lot of nuisance	-0.065	0.01
No work	No work * Little nuisance	0.057	
	No work * A lot of nuisance	-0.057	0.01
WTP	WTP * Housing costs: €0 p/m	0.051	
	WTP * Housing costs: €10 p/m LESS	-0.129	0.01
	WTP * Housing costs: €5 p/m LESS	-0.089	
	WTP * Housing costs: €10 p/m MORE	0.167	0.01
Env. attitude	Env. Att. * Housing costs: €0 p/m	0.128	
	Env. Att. * Housing costs: €10 p/m LESS	0.028	
	Env. Att. * Housing costs: €5 p/m LESS	-0.181	0.05
	Env. Att. * Housing costs: €10 p/m MORE	0.025	
LL(0)	**-3045.5**		
LL(β)	**-2745.3**		
McFadden's Rho²	**0.099**		
Rho² adjusted	**0.094**		

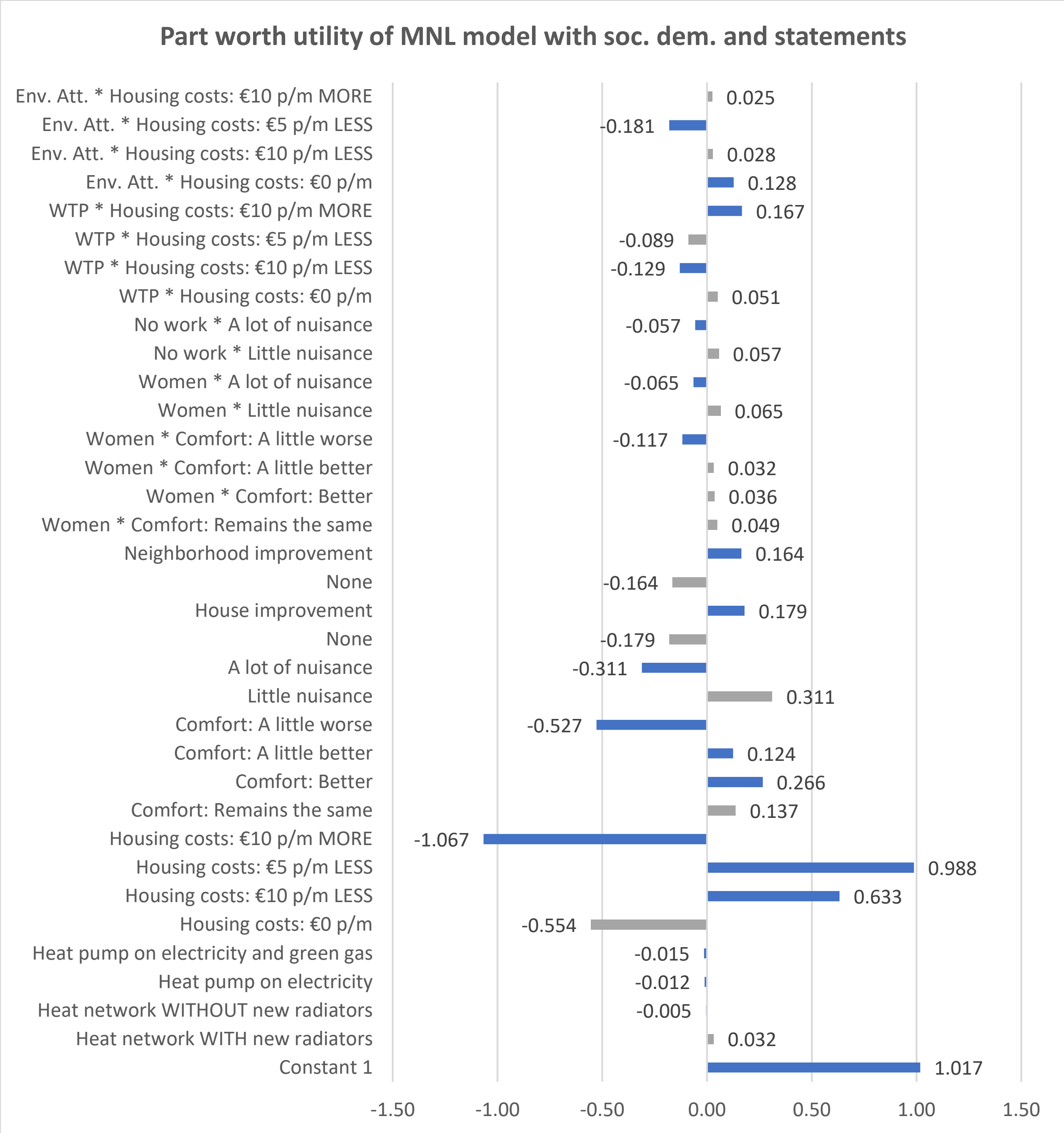

Figure 23 Part worth utility of MNL model with socio-demographic variables and statement factors

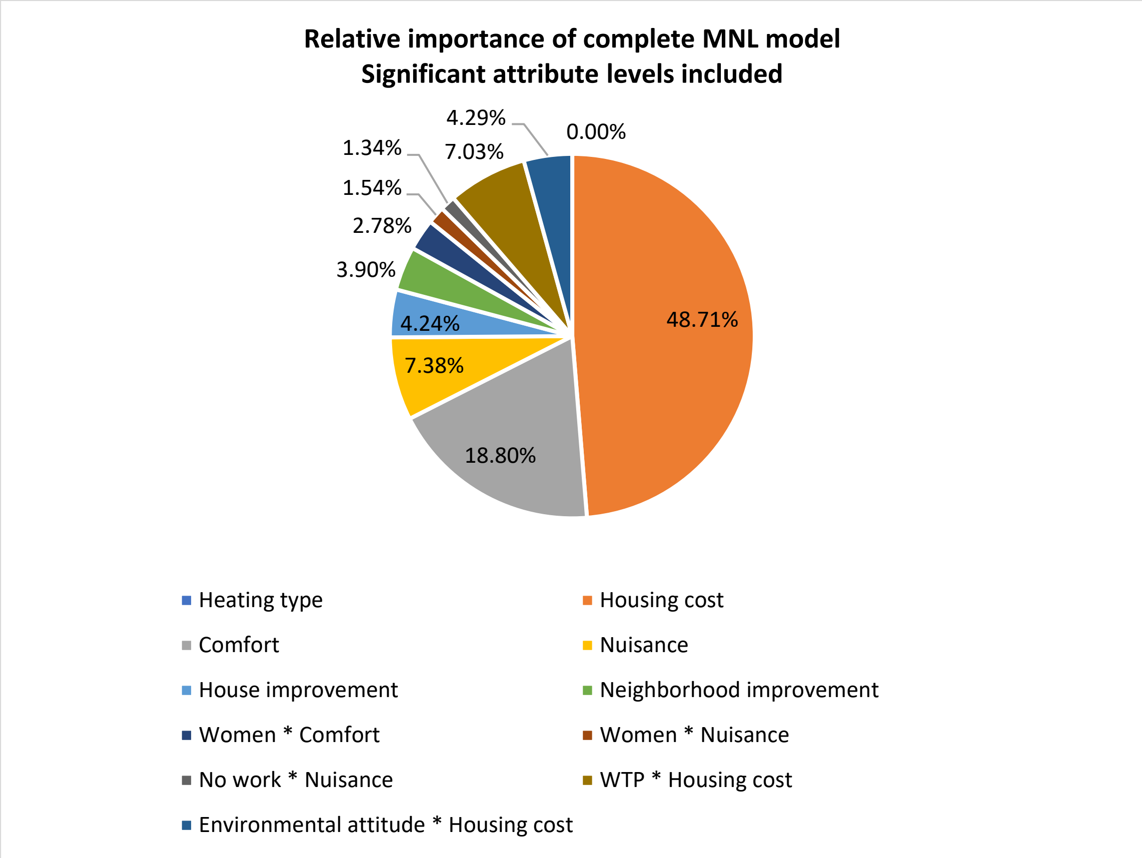

Figure 24 Relative importance of the complete MNL model, significant attribute levels included

5.2 Latent Class model

The next step to improve the estimation was to either use a Mixed Logit model, or Latent Class model. The latent Class model had a higher model performance, based on the McFadden's Rho² Adjusted, in comparison to the Mixed Logit model. Consequently, the ML model is not discussed in this section and is presented in Appendix 8.

A Latent Class model estimates the parameters in the model for a predefined number of classes. These classes are composing of a number of respondents, based on their preferences. The Latent Class model can either be run with or without explanatory variables. Both models with and without explanatory variables were conducted. The results of these two models can be found in appendix 9. This chapter zooms into the results of the Latent Class model with explanatory variables (socio-demographics and statement factors). The final Latent Class model is displayed in Table 13. The first part describes the parameters and the significance of the variables for the two classes. Increasing the number of classes did not provide any reasonable values, or increase the significance, so the model with two classes was chosen. The model included the probability that a tenant belonged to one of the classes. The second part of the model described class one based on the socio-demographics and statement factors, with class two as a base.

The Latent Class model in Table 13 had a McFadden's Rho² Adjusted of 0.231. This was considered to be a satisfactory fit, as it was in between 0.2 and 0.4 (Hensher et al., 2015). The constant in the Latent class model was different from the MNL models, as it was significantly higher in class one and negative in class two. It was noteworthy to mention that the constant was always positive and around one in all MNL models. The high constant meant that the respondents in class one had a higher preference for one of the two alternatives of accepting the natural gas-free renovation project. The respondents in class two had a general preference for alternative C, meaning they decline the natural gas-free renovation project. Consequently, there is a major difference between the general preference of the two classes. The differences between the two classes are displayed in the virtual representation of the part worth utility in Figure 25. The significant variables of class one are displayed in blue, whereas the significant variables of class two are displayed in orange. The insignificant variables are exhibited in grey. Class one was a little more susceptible to comfort change and home improvements in comparison to class two, whereas class two was more influenced by housing costs. Besides some minor differences in the parameters, there were some noteworthy differences in the significance of the variables. In class two there were five less significant attribute variables, as €5 per month housing cost decrease, better comfort, a little better comfort, house improvement and neighborhood improvement were insignificant in class two, whereas they were significant in class one. Class one had a probability to be chosen of 77.1%, whereas class two had a probability of 22.9% to be chosen.

The Latent Class model also estimated the composition of the classes with Theta (class) one and Theta (class) two. Theta represents the classes wherefore the class probability is determined by the corresponding variables. These variables were included in the membership function of the Latent Class model (lcm). In this research study, the variables which determined the class probability were the socio-demographics and statement factors. Theta two is considered to be the base. Consequently, Theta one consisted of explanatory variables with parameters and significances. These were the socio-demographic variables and statement factors which were included in the Latent Class model in the membership section (lcm). All socio-demographics and statement factors were included in the Latent Class model. Subsequently, the insignificant variables were removed. Theta one had a large constant (ONE) which was significant. As a consequence, a tenant is most likely to be part of class one, due to the high and significant ($p<0.05$) constant. Additionally, three other socio-demographics and statement factors determined whether a tenant belonged to class one or two. Following the constant, the willingness to pay was the first determinant, which was measured continuously and had a parameter of 0.6197 ($p<0.001$), meaning that tenants with a high WTP were more likely to be part of class one, in comparison to class two. As this was measured on a 5-point Likert scale and consequently could have a five times higher utility than the categorical variables, this meant that it had a large contribution to the total utility. The second determinant was not receiving rent allowance, which had a parameter of 0.2958 ($p<0.05$), implying that tenants who did not receive rent allowance were more likely to be in class one in comparison to class two. The determinants single family dwelling and having children were insignificant, but still included in the Latent Class model, as removing them meant other explanatory variables would become insignificant. No correlations between these variables were found. As these two variables were found to be insignificant, no assumptions could be made based of the parameters. The final determinant was living in the house less than one year, which had a negative relation of -0.7048 ($p<0.001$) with class one. This meant that a tenant who had lived in his or her dwelling for less than one year was more likely to be in class two, in comparison to class one.

Table 13 Results of the Latent Class model including explanatory variables

Attribute	Level	Parameters class 1	Pr(>|z|)	Parameters class 2	Pr(>|z|)
Constant	Constant 1	2.189	0.001	-0.789	0.01
Heating type	Heat network WITH new radiators	0.010		-0.085	
	Heat network WITHOUT new radiators	0.002		-0.065	
	Heat pump on electricity	-0.036		0.167	
	Heat pump on electricity and green gas	-0.066		-0.0167	
Housing costs	Housing costs: €0 p/m	-0.011		0.132	
	Housing costs: €10 p/m LESS	0.279	0.001	0.389	0.001
	Housing costs: €5 p/m LESS	0.145	0.01	0.146	
	Housing costs: €10 p/m MORE	-0.413	0.001	-0.667	0.001
Comfort change	Comfort: Remains the same	0.061		0.450	
	Comfort: Better	0.385	0.001	0.027	
	Comfort: A little better	0.179	0.001	-0.155	
	Comfort: A little worse	-0.625	0.001	-0.322	0.01
Nuisance	Little nuisance	0.314		0.395	
	A lot of nuisance	-0.314	0.001	-0.395	0.001
House improvements	None	-0.205		-0.048	
	House improvement	0.205	0.001	0.048	
Neighborhood improvements	None	-0.168		-0.110	
	Neighborhood improvement	0.168	0.001	0.110	
Theta 01	ONE	1.845	0.05		
	WTP	0.620	0.001		
	No rent allowance	0.296	0.05		
	Dwelling type: single family	-0.131			
	Have children	-0.084			
	Living in house for <1 year	-0.705	0.001		
LL(0)	**-3207.95**	**McFadden's Rho²**	**0.235**		
LL(β)	**-2453.36**	**Rho² adjusted**	**0.231**		

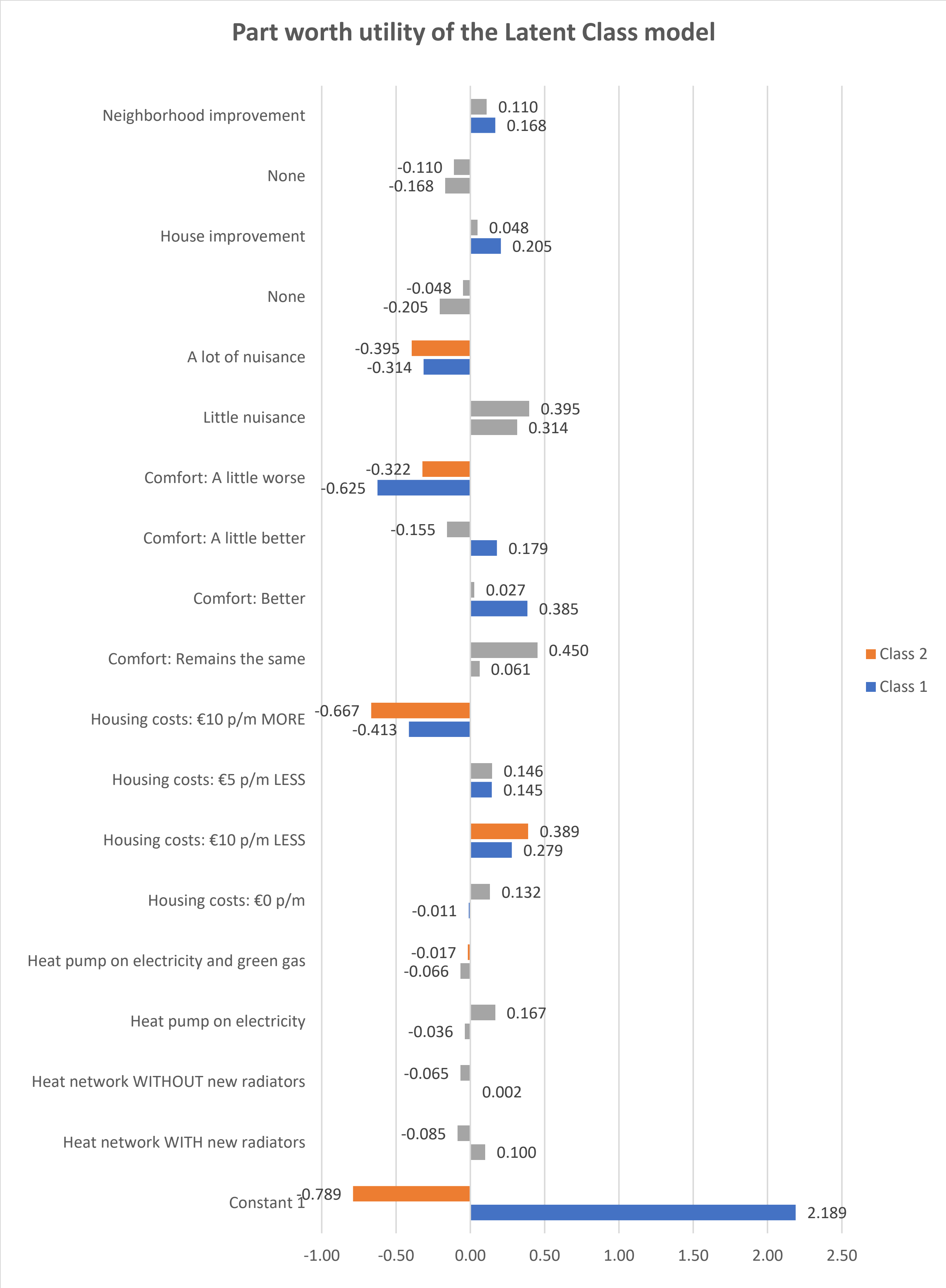

Figure 25 Part worth utility of the Latent Class model per class

5.3 Reflection on conceptual model

The conceptual model is elaborated on in section 3.1, which was based on the literature review. The conceptual model was adjusted based on the results from the analyses, which is described in this section and displayed in the revised conceptual model in Figure 26.

For the attributes of the Stated Choice Experiment it was determined that five out of six of the attribute variables had a significant influence on the tenant's willingness to participate in a natural gas-free renovation project. The relations of the different attribute levels were as expected, as no unexpected results were found, meaning the variables had face validity. The only insignificant attribute variable was the natural gas-free heating type. It was not predicted that this attribute variable would be insignificant, but it was assumed that this variable would have the least influence, as it related to the normative motive. Normative goals are most of the time opposite to gain and hedonic goals due to their related value types (Steg, Perlaviciute, et al., 2014). As all four types of the new natural gas-free heating were considered to be pro-environmental, the insignificance could be due to the tenants having no preference, as all the alternatives for this attribute were quite similar in their eyes. As such only heating type had no significant influence on the willingness to participate in a natural gas-free renovation project.

The socio-demographic variables included in the analyses were divided into personal, household and dwelling/neighborhood characteristics. For the dwelling and neighborhood characteristics no variables were found to have a significant influence on the dependent variable. All the dwelling and neighborhood characteristics were thus excluded from the revised conceptual model. In the category personal characteristics, one variable was found to be significant, which was gender, as it had an interaction with comfort and nuisance, which influenced the dependent variable. When zooming into the household characteristics, only one variable was found to have an influence on the dependent variable, namely work status, which had an interaction with nuisance. Two other household characteristics were found to be significant explanatory variables which indicated to which class a respondent belonged in the Latent Class model. The explanatory variable were WTP, rent allowance and time lived in the house. The class a tenant was a member of in the Latent Class model was determined by these explanatory variables. Consequently, the explanatory variables determined whether a tenant had parameter set one, or two, dependent on the class the tenant was a member of. As such, the explanatory variables, indirectly influenced the tenant's decision-making process regarding the willingness to participate in a natural gas-free renovation projects.

The statement factors were both used as interactions in the MNL model and as explanatory variables in the Latent Class model. It could be concluded that both environmental attitude and willingness to pay had an interaction with housing costs and consequently influenced the tenant's willingness to participate in a natural gas-free renovation project. The Latent Class model provided evidence to conclude that the willingness to pay of a tenant had an influence on the class the tenant belonged to, resulting in an indirect influence on the dependent variable. Trust and satisfaction with the communication of the housing association was found to be closely related. As such, the two statement factors were combined, but they were insignificant, which meant they were excluded from the revised conceptual model. All the changes in relations and variables are presented in the adjusted framework, displayed in Figure 26. The green arrows are confirmed relations, while the grey arrows are relations which were insignificant in this study and were consequently excluded from the revised conceptual model.

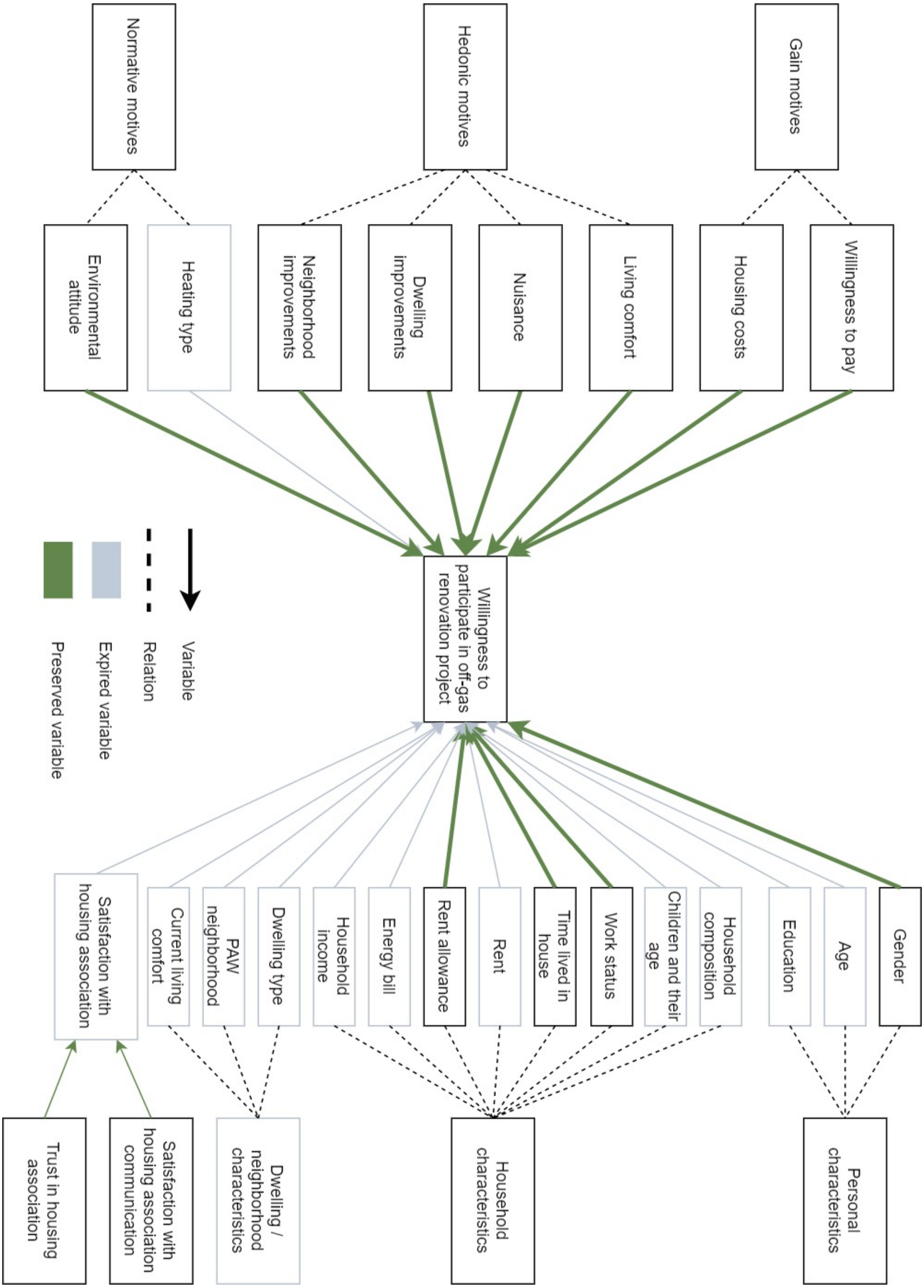

Figure 26 Revised conceptual model that represents the preserved and expired attribute, socio-demographic variables and statement factors

5.4 Discussion

In order to answer the research questions, a Multinomial Logit model and a Latent Class model was conducted. The Multinomial Logit model which included both the socio-demographic variables and statement factors had the highest goodness-of-fit. The MNL model displayed that 83% of the relative importance was due to the attribute variables of the natural gas-free renovation, which confirms the Diffusion of Innovation theory by Rogers (2003) which states that the innovation's attributes determine the adoption rate, while the adopter's characteristics are less important. The model included a relatively high and significant constant. This indicates that the tenants have a general preference for the alternatives which accept the natural gas-free renovation, no matter the attribute levels of the alternatives. As such, the average tenant of social housing can be perceived to be pro-environmental, due to his or her general preference for a pro-environmental measure in the form of an energy transition. The attribute variables of the Stated Choice Experiment were divided into three motive groups, the gain, hedonic and normative motives.

The normative motives included the attribute variable heating type, which described the new natural gas-free heating the two alternatives were centered around. An earlier research study has concluded that more negative feelings were associated with heat network, in comparison to all-electric transitions (Voesenek, 2020). Heating type was found to be insignificant in any of the MNL models, which indicates that tenants do not have a preference for either one of the heating types. A possible explanation is the fact that all the four attribute levels of the attribute heating type are natural gas-free heating types and thus pro-environmental, meaning that they are all (relative) equally good for the environment. As there is no difference for the environment, or society, there is no difference regarding the normative motive, which could explain the fact that tenants of social housing do not prefer any of the four natural gas-free heating types. In addition, another normative motive for the willingness to participate in the natural gas-free renovation is the environmental attitude of the tenants, which was measured as a statement factor and included in the MNL model with an interaction term in combination with housing costs. Statistical analyses confirmed that the interaction term regarding a decrease in housing costs of €5 per month was proven significant and had a negative relation to the dependent variable. Hence, it can be assumed that tenants with a higher environmental attitude are less susceptible to a decrease in housing costs in comparison to tenants with a lower environmental attitude. Consequently, the higher the environmental attitude of the tenant, the less positive, the tenant perceives a decrease in housing cost of €5 per month. This can be explained by the normative motives most of the time being opposite to the gain motive (Steg, Perlaviciute, et al., 2014) which consequently confirms the theory.

Literature has indicated that the gain motive was the main factor to influence pro-environmental behavior (McMakin & Malone, 2002; Mortensen et al., 2016; Sommerfeld et al., 2017; Van der Spank, 2013; C. Wilson et al., 2015). The gain motive included the attribute variable housing costs, which was found to be significant in all MNL models. In the MNL model with the best performance, the housing costs had a relative importance of 49%, which was the highest of all variables, confirming the literature which has stated that the gain motive was the main factor to influence pro-environmental behavior. The housing costs had a negative association with the dependent variable for increasing the housing costs with €10 per month, which was high enough to negated the positive effect of the constant. Consequently, increasing the housing costs by €10 per moth nullifies the social tenant's general preference for natural gas-free renovation, meaning that it is a major limitation for the energy transition. Decreasing the housing costs with €5 per month had a significant and positive relation on the dependent variable, which was in the same order of magnitude as the constant. It can be assumed that a decrease in housing costs is a large motivator for the willingness to participate in a natural gas-free renovation project. This is underlined by the attribute level of housing costs which lowered the housing costs by €10 per month. This level displayed a somewhat lower positive relation to the dependent variable, which is opposite of the expectation, as it was expected that the higher the reduction in housing costs, the stronger the positive relation. This appeared not to be the case, meaning that a reduction in housing costs of €5 per month has a more positive influence on the willingness to participate in natural gas-free renovation projects than a higher reduction in housing costs of €10 per month. A second gain motive in this Stated Choice Experiment was the willingness to pay, which was determined with the aid of statements and combined with housing costs as an interaction term to include it in the MNL model. This interaction term had two significant levels, specifically WTP combined with a housing cost decrease of €10 per month, which had a negative effect and the increase in housing costs of €10 per month, which had a positive relation. Based on the results, it can be assumed that tenants with a higher willingness to pay were less susceptible to a decrease in housing costs in comparison to tenants with a lower WTP. Additionally, this assumes that tenants with a higher WTP have a more positive preference for increasing the housing costs in comparison to tenants with a lower WTP. Hence, these relatively strong relations underline the given that housing costs and WTP have a strong influence on the decision-making process, via the gain motive.

The hedonic motive included four attribute variables. The first motive was the comfort change due to the renovation, which according to literature was perceived to be the benefit of technical improvements in a dwelling. This was found to be of importance regarding the decision whether or not to participate in energy efficiency renovations (Mortensen et al., 2014; Van der Spank, 2013; C. Wilson et al., 2015). In all the MNL models, the attribute variables were significant and indicated that tenants prefer their comfort to remain the same, or increase, as the parameters indicated an increasing utility from remaining the same, a little better, to better. The fourth level which represented a decrease in comfort was significantly negative and had a parameter twice as high as better comfort. This implies that tenants have a strong and negative preference for comfort decrease and a mediocre and positive preference for comfort improvement. As such, comfort had a high relative importance of 19%, which was the second most important variable. Additionally, the dwelling and neighborhood improvements were linked to the hedonic goal, as layout and interior improvements had been concluded by literature to be a main reason for renovations (Mortensen et al., 2014). Both variables had a significant influence on the dependent variable in the MNL model. Including a neighborhood improvement or house improvement had a mediocre positive effect, which was in the same order of magnitude for both variables, as they both accounted for 4% of the relative importance. The final hedonic motive, included in the MNL models was nuisance, which had been indicated by literature to be of major concern to residents in relation to renovation projects (Schillemans et al., 2006; Van der Spank, 2013), but not a crucial factor in their decision whether or not to participate in energy efficiency renovations (Quirijns, 2011; Werf, 2011). Nuisance is a hedonic motive wherefore the MNL indicated that tenants have a strong negative association with an increase in nuisance. This negative relation for a lot of nuisance (-0.311,p<0.001) was twice as high as a house (0.179, p<0.001) or neighborhood improvement (0.164, p<0.001) and of similar size as better comfort (0.266, p<0.001). Consequently, it is not worthwhile to improve the comfort, houses or the neighborhood, when it results in more nuisance for the tenants, as this will nullify, or even negatively influence the tenant's willingness to participate in natural gas-free renovation projects. Due to the strong negative relation of a lot of nuisance, the attribute is the third most relative variable with an importance of 8%.

Additionally, the socio-demographics were included in the MNL model with the aid of interaction terms. Two socio-demographic variables were proven to be significant, namely gender and work status. Gender was combined with comfort and nuisance in interaction terms, which displayed that women had a minor negative relation with higher degrees of nuisance and lower degrees of comfort in comparison to men. A lot of nuisance was found to be significant, as well as the level of a little comfort increase. The tenant's work status had a significant relation with nuisance, as unemployed tenants experienced a more negative association with higher degrees of nuisance, caused by the fact that they usually spend more time in their house compared to the employed tenants.

Finally, the statement factors were included in the MNL model, specifically with the aid of interaction terms. Two statement factors were found to be significant, specifically WTP and environmental attitude. Both statement factors were combined with the attribute variable housing costs. The parameters of these two interaction terms were mediocre, yet they were measured on a 5-point Likert scale, meaning the utility can be five times as high as that of an (categorical) attribute variable with a similar parameter. As such, these two interaction terms have a major influence on the willingness to participate in natural gas-free renovation projects. The WTP of a tenant can partially nullify the negative effect of housing cost increase due to the positive interaction parameter of 0.167 (p<0.01) for the level of a housing cost increase of €10 per month. The degree of influence on the dependent variable is influenced by the height of the WTP. The opposite is also true, as the WTP can partially nullify the positive relation of a housing costs decrease of €10 per month due to the interaction terms parameter of -0.129 (p<0.01). This can be interpreted as tenants of social housing with a higher WTP being less influenced by housing in- and decreases, in comparison to tenants with a lower WTP. In relation to the environmental attitude, the positive relation of the attribute variable housing cost can be partially nullified. This is due to the given that environmental attitude and a decrease in housing costs of €5 per month have a negative relation of -0.181 (p<0.05), dependent of the height of the environmental attitude of the tenant (-5 to 5). This translates into tenants of social housing with a higher environmental attitude being less influenced by a housing costs decrease.

To increase the goodness-of-fit, a Latent Class model was conducted with two classes. Class one has a higher general preference for accepting the natural gas-free renovation (Constant 1 = 2.189, $p<0.001$) than the constant found in the MNL model, whereas class two had a negative constant (-0.789, $p<0.01$) which indicates a general preference to decline the natural gas-free renovation and choosing for choice C – none of the above. The model performance of the Latent Class model was increased significantly in comparison to the MNL model and was considered to be a satisfactory fit, as the McFadden's Rho² Adjusted was 0.231, which is in between 0.2 and 0.4 (Hensher et al., 2015). The tenant's membership of either one of the two classes was explained by socio-demographic variables and statement factors. The variables found to influence the class membership were willingness to pay, rent allowance and the time a tenant has lived in the house. More general, class one includes a high and significant constant, indicating that the tenants in this class have a general preference to accept the natural gas-free renovation project, no matter the attribute levels. The utility of the constant for the second class in the Latent Class model is significant, yet negative, which indicates that this class of respondents has a general preference to decline the natural gas-free renovation projects, no matter the attribute levels of the alternatives. Besides the differences in constants, there were minor differences in the attribute parameters. Class one is more influenced by comfort change and house improvements, as these parameter are higher than in class two, while class two is more influenced by change in housing costs. Nuisance and neighborhood improvements are perceived relatively similar by both the classes, as they have similar influence on the willingness to participate in natural gas-free renovation projects. It is noteworthy that class two had five less significant attribute levels in comparison to class one. Besides some minor differences between the two classes, the largest difference is the constant, as class one is in general inclined to accept a natural gas-free renovation, whereas class two is not. Luckily the majority of respondents belonged to class one, as 77.1% of tenants were a member of class one in comparison to 22.9% who were a member of class two.

The only statement factors influencing the class membership was WTP, which had a positive relation to class one. This means that tenants with a higher WTP are more likely to be in class one. Additionally, the rent allowance influenced the class membership, as tenants who did not receive rent allowance were more likely to be in class one, due to the positive parameter. This given is according to the expectations, as tenants who do not receive rent allowance normally earn too much household income in order to be eligible for rent allowance. This implies they are probably more willing to pay for things, which was confirmed by the WTP variable. The final variable which influenced class membership was the variable that described the time a tenant has lived in the house. Tenants who lived in their house less than one year were more likely to be in class two due to the negative parameter. By means of the zip code, it was determined whether tenants from PAW neighborhoods had different preferences in natural gas-free renovation projects, or that they belonged to a different class in the Latent Class model. As the variable PAW was insignificant in the MNL and Latent Class model, it was assumed that tenants in PAW neighborhoods had similar preferences as all other tenants of social housing.

A limitation to the generalization of the results was caused by the representativeness of the sample. The sample was not representable for the Dutch population, as none of the measured socio-demographic variables were representative for the Dutch population. This given was according to the expectations, as there was no population data available of the Dutch social housing sector. Hence, the representativeness was calculated based on the data of Dutch population retrieved from the CBS. As the Dutch housing sector had a slightly different population in comparison to the complete Dutch population, it was expected that the sample would not be representative in relation to the Dutch population. Additionally, the data sample was compared to social housing sector data from the Dutch "Woononderzoek 2018" (Rijksoverheid, 2018). It was impossible to use this data in a Chi^2 test in order to determine the representativeness of the sample, as the variable categories were different. When only the category percentages of the variables were examined and the Chi^2 test was not taken into account, the sample looked somewhat representative for the social housing sector, as most of the percentages were in the same order of magnitude. This indicated that the sample was not extremely skewed. The more major differences between the sample and Dutch population data were most of the time explainable with the little social housing data which was available from the "Woononderzoek 2018" (Rijksoverheid, 2018). As the percentages indicated that the sample was not extremely skewed, generalizations will still be made despite the lack of representativeness. The reason that generalizations can still be made, is due to the fact that the sample looks representative for the social housing sector, but it is impossible to determine this, as there is no available data regarding the Dutch social housing sector.

5.5 Conclusion

This chapter elaborates on the results of the analyses conducted based on the data of the questionnaire. The aimed sample size was reached with 380 respondents which completed 190 complete Stated Choice Experiments. This was due to the fact that every respondent had only been presented with eight of the 16 choice sets from the fractional factorial design. Consequently, two respondents together completed one complete Stated Choice Experiment. The questionnaire consisted of a Stated Choice Experiment, statements and socio-demographic questions. The data from the statements and socio-demographic questions was used to conduct various statistical analyses in order to test the sample representativeness, which was not representative. Reason for the lack of representativeness was the unavailability of data regarding the Dutch social housing sector, which meant the data sample had to be compared to the general Dutch population. The Stated Choice Experiment was analyzed with the aid of three models, of which two are presented in this chapter. The best Multinomial Logit model had a model performance with a McFadden's Rho^2 Adjusted of 0.0943. The utility scores of the MNL model indicated a high constant. As such it can be concluded that tenants of social housing have a general preference to accept a natural gas-free renovation, no matter the attribute levels. Furthermore the MNL model displayed the fact that comfort increase, decrease in housing costs and limited levels of nuisance have a large positive effect on the willingness to participate in natural gas-free renovation projects. Comfort decrease, housing costs increase and higher levels of nuisance have a major negative effect on the willingness to participate in natural gas-free renovation projects. As the housing costs contributed 49% to the relative importance, it is concluded that the gain motive is the focal goal. Additionally, the MNL model determined that the heating source is not an influential motivator or barrier for the willingness to participate in natural gas-free renovation projects, as it is insignificant. On the other hand, the house and neighborhood improvements (renovation plan) are a mediocre motivator for the willingness to participate in natural gas-free renovation projects. With the aid of the MNL model, three research questions can be answered, as the MNL indicated the strength of the tenant's preferences for certain attributes in the decision-making process (research question II) regarding the willingness to participate in natural gas-free renovation projects. As such, the preferences indicated the influence of the alternative heating type (research question IV) and the renovation plan, which consists of house and neighborhood improvement (research question V).

As the McFadden's Rho² Adjusted of the MNL model was not satisfactory, a Latent Class model was conducted. The Latent Class model was divided into two classes, which were used to answer the research question (III) regarding the different groups of tenants and their preferences for the attributes. The first class represented a higher preference for natural gas-free renovation projects, while the second had a negative preference for natural gas-free renovation projects, no matter the attribute levels. Consequently, it can be concluded that there is a major difference between two classes of tenants in relation the general preference regarding the willingness to participate in natural-gas free renovation projects. The first class is more likely to consist of tenants with a higher willingness to pay, who receive no rent allowance and who have lived in their house for more than one year. The differences in preferences between these two classes were mediocre, as beside the constant, there were only minor differences in the parameters. Class one is more susceptible for comfort change, while class two is more susceptible to changes in housing costs. Class two is also less susceptible to improvements in their house, whereas neighborhood improvement and nuisance is perceived quite similarly by both classes. It was noteworthy that the second class has five less significant attribute levels. Hence, the largest difference between the two classes was the constant, which was high in class one and negative in class two. This means that class one is most likely to accept a natural gas-free renovation, while class two is more like to decline one. Luckily the probability to belong to class one is higher with 77.1% in comparison to class two with 22.9%.

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6. Conclusion

All around the world there are signs of climate change. To mitigate these effects, the United Nations have agreed on global climate goals, which The Dutch government translated into the Energy Agreement and Climate Agreement. These agreements aim to reduce greenhouse gas emissions in all sectors. For the built environment this includes an energy and heat transition from natural gas-fired heating systems to natural gas-free heating systems for all the 7 million houses in the Netherlands. The transition aims to reduce the total energy consumption by reducing the use of natural gas and implementing more sustainable alternative heat sources in the Netherlands. As about one-third of all the houses in the Netherlands belong to housing associations, they have been assigned to be the starting engine of the transition. To gather knowledge and experience about this transition, a subsidy programs with a neighborhood oriented approach was introduced. The 46 neighborhoods which applied to this PAW program are called Proeftuinen. For the housing associations there is a crucial factor in the energy transition, which is the participation of the tenants, as by Dutch civil law, 70% of the tenants have to agree to project based renovation works. The problem in creating a support base among tenants lies in the limited research regarding the identification of motivators and barriers for tenants regarding the willingness to participate in natural gas-free renovation projects. The quantitative literature in this field has mainly focused on homeowners' motives for energy efficiency renovations, resulting in limited research into the motives of tenants in natural gas-free renovation projects. Therefore, this research study aims to determine and value the motivators and barriers for tenants of social housing regarding the willingness to participate in natural gas-free renovation projects. Additionally, this research study aims to specify different groups of tenants which have different preference regarding the energy transition. These results are useful for housing associations to create natural gas-free renovation plans which align with the preferences of tenants. The creation of natural gas-free renovation plans which are in alignment with the preferences of tenants will benefit the likelihood to achieve the 70% participation rate necessary for project based renovations. Hence, the main research questions of this thesis are as follows:

How do tenants of social housing value their preferences for certain motivators and barriers (attributes) in the decision-making process, which influences their willingness to participate in natural gas-free renovation projects?

What are the characteristics of different groups of tenants of social housing in relation to their preferences for the motivators and barriers (attributes) in the decision-making process, regarding the willingness to participate in natural gas-free renovation projects?

To answer the research questions, a number of sub-questions were formulated, which started by identifying the motivators and barriers that influence the tenant's decision-making process for natural gas-free renovation projects. To answer this question, a literature review was conducted which provided insight in the behavioral theories and models which could explain the tenants' behavior and motives. Additionally, (pro-)environmental behavior models were studied, as the willingness to participate in a natural gas-free renovation project is considered to be pro-environmental behavior. In the second part of the literature review, the Goal-Framing Theory and the gain, hedonic and normative motives were used to study the motivators and barriers of both tenants and homeowners in order to engage in energy efficiency renovations and pro-environmental behavior. These motives provided insight in the motivators and barriers which influenced the tenant's decision-making process. The literature which zoomed into the three goal frames pointed out the fact that in relation to pro-environmental behavior, the gain and hedonic goal were mostly positively related, while most of the time they were opposite to the normative goal. This indicated that pro-environmental behavior (normative goal-frame) often required a sacrifice in relation to the gain and hedonic goal-frame, for example in monetary terms. The third part of the literature review described the modeling approaches which could be used to study and value the motivators and barriers (attributes) of tenants in relation to the decision-making process for natural gas-free renovation projects.

In order to answer the research question regarding the valuation of the motivators and barriers that influence the tenants' decision-making process regarding natural gas-free renovation projects, a Stated Choice Experiment was conducted. From the literature review it could be concluded that there were six main attributes, consisting of heating type, housing costs, comfort, nuisance and house and neighborhood improvement. These attributes had two, or four levels, which were measured with the aid of an online questionnaire. Analyses of the results, by means of a Multinomial Logit model indicated a general preference for the willingness to participate in natural gas-free renovation projects, no matter the levels of the attributes. This means that tenants have a positive attitude towards the energy transition, regardless of the attributes of the natural gas-free renovation project. For the six attributes, only heating type was found to be insignificant, meaning tenants have no preference regarding their new natural gas-free heating type. This answered the research question regarding the importance of the alternative heat source. From the other five attributes, the housing costs, comfort improvement and nuisance were respectively found to be most influential in the decision-making process of tenants, as they accounted for over three-quarters of the relative importance. As housing costs contributed 49% of the relative importance, it can be concluded that the gain motive is the focal goal. The remaining two attributes, house and neighborhood improvement have a minor influence on the tenant's decision-making process regarding the willingness to participate in natural gas-free renovation projects. This answered the research question whether the renovation plan has a major influence on the tenants' willingness to participate. Additionally, the results indicated that it is not worthwhile to improve the house or neighborhood, or to increase the comfort if this results in higher levels of nuisance. This given is due to the fact that the strong and negative preference of higher degrees of nuisance will nullify the positive relations of these variables, or even result in a negative influence on the tenant's willingness to participate.

The socio-demographic variables which were included in the MNL model only had minor influences on the willingness to participate in the natural gas-free renovation projects, as the parameters of the significant interaction terms gender and work status were small. The statement factors, specifically willingness to pay and environmental attitude had mediocre parameters, yet they were influential on the tenant's willingness to participate. This given is due to the fact that they were measured on a 5-point Likert scale, meaning the parameters could have a five times larger utility in comparison to categorical attribute variables with a similar order of magnitude. Higher degrees of WTP resulted in tenants being less influenced by housing cost increases and decreases, as the significant parameters of the interaction term were opposite to that of the attribute variable housing costs. Similarly, higher degrees of environmental attitude resulted in tenant's being less influence by housing cost increases of €5 per month, due to the significant parameter of the interaction term being opposite to that of the attribute level housing costs.

As the McFadden's Rho² Adjusted of the MNL model was not satisfactory, a Latent Class model was conducted. Additionally, the research question regarding the different groups of tenants was answered with the aid of the Latent Class model, which contained two classes. The first class shows a high general preference towards natural gas-free renovation projects, whereas class two shows a negative association. Consequently, it can be concluded that there is a major difference between the two tenant classes in relation to their general preference regarding the willingness to participate in natural-gas free renovation projects. The results indicated the probability to be a member of class one to be highest with 77.1% in comparison to 22.9% for class two. The class characteristics were estimated with the socio-demographics and statement factors. Class one has a higher representation of tenants who do not receive rent allowance, lived in their house for less than one year and have a higher WTP. The tenants in class one are more influenced by comfort change and house improvements, whereas the tenants in class two are more influenced by changes in housing costs. All and all, the most important motivators and barriers regarding the willingness to participate in natural gas-free renovation projects for tenants of social housing are housing costs, comfort and nuisance, respectively. The largest difference between the two classes is their general preference, which is followed by their preferences for the different attributes, mainly housing costs, comfort and nuisance.

A limitation of this research study was the distribution of the choice sets in the Stated Choice Experiment, which was not completely random. In the application which was used (LimeSurvey), it was only possible to create two questionnaire versions with eight fixed choice sets per questionnaire, which were randomly distributed among the respondent. As a result, the questionnaire was partially random, as not every alternative in the choice sets was drawn randomly from a complete sample. Another limitation of the Stated Choice Experiment was caused by the MNL model's assumption of independent variables. The independent variables were not completely independent, as for example the nuisance level is related to the amount of renovation works, which can be influenced by the attribute house improvements. As this was a study which intended to provide general results, this limitation was accepted. A limitation regarding the generalization of the results was the fact that this research was unable to confirm the representativeness of the sample in relation to the Dutch social housing sector, due to the lack of available data. This has to be taken into account when generalizing the results and findings.

6.1 Recommendations

The lessons learned and insights gained during this research study provided valuable knowledge which will enhance future research. In this explanatory research study, a Stated Choice Experiment was conducted to value the motivator and barriers of the decision-making process and to determine which motive had the largest influence on the willingness to participate, the focal goal. As this study was a Stated Choice Experiment where the respondents were able to choose as they saw fit, it would be an interesting addition to this research study to verify the results and findings with a research study based on revealed data. With the aid of revealed data, it would be interesting to see whether tenants made similar choices in real life, which could indicate whether or not there is a gap between behavioral intention (willingness to participate) and behavior (participation). Additionally, a research study based on revealed data could indicate whether tenants perceive the decision-making process differently when there is no choice between different strategies, or alternatives, but there is only one natural gas-free alternative. In a real life scenario, the housing association normally has one natural gas-free strategy, which a tenant has to accept, or decline. This could influence the tenant's ability to express concerns, have tenant say and eventually result in feeling of not being heard, whereof literature indicated to be very important for participation (Voesenek, 2020).

In relation to the Stated Choice Experiment and the limitations discussed in the previous section, there are four recommendations. The first recommendation for future research, is to conduct the research study with a fully random stated choice experiment, meaning that the choice sets a respondent is presented with in the SCE are generated randomly for every respondent. Consequently, every respondent will have different combinations of choice sets and alternatives. In order to do this, a different online questionnaire tools has to be used. The second recommendation is to conduct the research with a representative sample representing the Dutch social housing population. In order to do this, it is necessary to gather data regarding the Dutch social housing sector, which can be used to determine the representativeness of the data sample. This research study experienced some drawbacks regarding the comparison of the data sample to the Dutch social housing population. These drawbacks might have caused the socio-demographic variables and statement factors to be partially insignificant. It would be interesting for further researches to dive into the transition towards natural gas-free heating systems and investigate whether socio-demographics affect the tenant's decision-making behavior. Third, a larger sample size could be useful to study the number of possible classes of the Latent Class model. This research study could not completely underline that the current position in life has an influence on the willingness to participate in energy renovations (Mortensen et al., 2016). Having a larger sample size could possibly improve the Latent Class model, which might lead to new insights in relation to the number of tenant classes and the corresponding explanatory variables. Lastly, a large number of respondents ended the questionnaire before finishing the entire questionnaire, which could indicate that it was too long, or too difficult for the target group. The questionnaire was tested with a test panel consisting of tenants of social housing, which unanimously stated that the questionnaire was not too difficult. Consequently, it is concluded that difficulty was not a contributing factor to the fact that a large number of respondents did not entirely finished the questionnaire.

Regarding the analyses methods, it is recommended to expand the Latent Class model by including a membership function, in order to classify cases according to their maximum likelihood class membership. Consequently, an individual will be assigned to the class with the highest membership probability. This is possible, as in a Latent Class model, each individual has an own set of parameters. When it is determined which respondents belong to which class, the parameter sets, socio-demographics and statement variables can be analyzed, in order to search for similar patterns of parameters, or variables. A reason to utilize this method, is the limited explanatory power of the explanatory variables belonging to Theta 01 (class 1) in the Latent Class model. The three significant explanatory variables do not provide a clear picture of the differences between the two classes. As such, a maximum likelihood class membership analysis could provide additional insight in the different preferences of tenants of social housing regarding their willingness to participate in natural gas-free renovation projects.

In relation to the research study design, there are two recommendations. First, this research study focused on the preferences of social tenants regarding the attributes of the natural gas-free renovation project. Consequently, the attributes were all technical components of the renovation plan. For future research purposes, it might be worthwhile to study non-technical attributes of the renovation project. For example, it would be interesting to study information provision and personal information needs in relation to the energy transition. Literature has namely stated that tenants have individual information needs. Sufficient and personalized information about the consequences of the energy transition might increase the tenant's knowledge and insight (Voesenek, 2020). The second recommendation is to study both the motives of tenants (of social housing) and homeowners in relation to natural gas-free renovation projects, as most neighborhoods are a combination of owner and tenant occupied houses. Applying a heat network in a neighborhood means that the homeowners also have to transition to natural gas-free heating systems. There is sufficient knowledge regarding the motives of homeowners in relation to energy efficiency and sustainable renovations, but the knowledge regarding homeowners and their preferences in relation to the energy transition is meagre. Studying both target groups can provide knowledge, which can be used in the creation of natural gas-free strategies and to increase the speed of the energy transition.

Finally, there are recommendations regarding the renovation package the housing associations can offer to their tenants, in order to persuade them to participate in the natural gas-free renovation project. First, it is recommended not to increase the housing costs, or reduce the comfort level, as this will have a major negative effect on the tenants' willingness to participate in a natural gas-free renovation project. Decreasing the housing costs, or increasing the comfort level on the other hand, has a positive effect on the tenants' willingness to participate, so this is recommended. Second, it is advised to minimize the nuisance tenants will experience, as higher degrees of nuisance will drastically reduce the tenants' willingness to participate. Increased levels of nuisance even have a more negative effect on the willingness to participate then the positive effects of house, neighborhood and mediocre comfort improvements. Consequently, it was concluded that house, neighborhood and mediocre comfort improvements are only worthwhile if they do not result in additional nuisance. As a result, it is advised for housing associations to only implement house, neighborhood and mediocre comfort improvements in their renovation plans when they do not result in increased levels of nuisance, as this will have a negative effect on the tenants' willingness to participate in the natural gas-free renovation project. Third, it is advised to both implement housing cost decrease and comfort increase in a natural gas-free renovation project, as there are two classes of tenants. Class one is more heavily influenced by comfort increase, whereas class two is mainly influenced by housing cost decrease. As class one represents 77.1% of the tenants and class two represents 22.9% of the tenants, it is not advised to solely focus on class one to achieve the 70% participation rate. The reason for the recommendation to focus on both classes is the fact that only focusing on class one would require almost all tenants who are a member of class one to agree to the natural gas-free renovation project, which would be a risk regarding the achievement of the participation rate. The fourth and final recommendation is to ensure that as many class 1 tenants as possible agree to the natural gas-free renovation project. Reason is the fact that even with the most optimal renovation package, it will be hard to persuade tenant belonging to class two to participate. As a consequence, almost all tenants who are a member of class one, will need to give their consent for the natural gas-free renovation project, in order to achieve the 70% participation rate.

6.2 Scientific relevance

This research study provides evidence concerning the preferences of tenants of social housing regarding the willingness to participate in natural gas-free renovation projects. Hence, this research study enriches already existing literature, as little quantitative research regarding the energy transition and the preferences of tenants of social housing exists. Most quantitative literature has focused on the preferences of homeowners in relation to energy efficiency renovations, not natural gas-free renovation projects. These previous researches have studied the preferences of homeowners or residents concerning energy efficiency renovations (Hauge et al., 2013; Mortensen et al., 2014, 2016; C. Wilson et al., 2015), solar PV (W. M. H. Broers et al., 2019; Sommerfeld et al., 2017) and RHS (Michelsen & Madlener, 2012). Some qualitative studies have focused on the preferences of tenants in sustainability renovations (Glumac, Reuvekamp, Han, & Schaefer, 2013; Kerperien, 2019; Reuvekamp, 2013; Van der Spank, 2013). There were studies which have focused on the participation of tenants in natural gas-free renovation projects (Voesenek, 2020), but these were qualitative. Previous research studies have not quantitatively explored the preferences of tenants of social housing regarding natural gas-free renovation projects, but have focused on either a different target group, or looked at more general energy efficiency, or sustainable renovations. Therefore, this research study enriches already existing literature concerning natural gas-free renovation projects by focusing on the preferences of tenants of social housing regarding the characteristics of the natural gas-free renovation projects. Additionally, this research study investigated the characteristics of the tenants, their household, dwelling and neighborhood and their influence on the tenant's willingness to participate in natural gas-free renovation projects.

6.3 Societal relevance

According to the Climate and Energy Agreement, the housing associations are responsible for the energy transition of one-third of the total housing stock, resulting in 2.4 million social rental properties. For the energy transition to succeed in the Netherlands, the participation of tenants is crucial. The major limitation of the neighborhood-oriented approach, is the minimal tenant participation rate of 70%. Consequently, the participation of social tenants is a mayor interest in the energy transition. As the energy transition is mainly a transition which is occurring in the Netherlands, there is limited research which identifies the motives of tenants of social housing to participate in energy or natural gas-free renovation projects. In order to understand the tenants' decision-making process regarding the willingness to participate in natural gas-free renovation projects, it is essential to identify and value their preferences for the motivators and barriers, influencing their decision-making process. This knowledge is necessary in order to determine how tenants can be persuaded to support the energy transition of the social housing stock. In practice, this means that the housing associations are aware of the effects of certain aspects of the natural gas-free renovation projects. These effects and influences on the tenants' willingness to participate can be used in order to create competitive renovation propositions, consisting of sufficient advantages (motivators) and a minimum amount of disadvantages (barriers). As housing associations are able to create competitive renovation plans, it is more likely that the projects will be accepted by more than 70% of the tenants.

This research study helped to do just that, as it identified and valued tenant's preferences for the motivators and barriers of natural gas-free renovation projects. Consequently, these preferences can be used by the housing associations to determine whether their natural gas-free renovation plans are competitive, in order to achieve the 70% participation rate. Additionally, this research study provides insight in the relative importance of certain aspects of the natural gas-free renovation projects. For example, this research study identified most house improvements not to be worthwhile if they results in higher degrees of nuisance. Consequently, housing associations are aware of the fact that they have to minimize nuisance in order to create a support base among tenants of social housing for the transition towards natural gas-free heating systems. A strong support base for the energy transition among tenants of social housing can eventually result in an increased rate of the energy transition, which is necessary to achieve the aimed 2.4 million natural-gas free rental properties. Eventually, this will contribute to the achievement of the climate goals and the mitigation of climate change.

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7. References

Abrahamse. (2007). *Energy conservation through behavioral change: Examining the effectiveness of a tailor-made approach*. University of Groningen.

Abrahamse, W., & Steg, L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *Journal of Economic Psychology*, *30*(5), 711–720. https://doi.org/10.1016/j.joep.2009.05.006

Abrahamse, W., & Steg, L. (2011). Factors Related to Household Energy Use and Intention to Reduce It: The Role of Psychological and Socio-Demographic Variables. *Human Ecology Review*, *18*(1), 30–40.

Abrahamse, W., & Steg, L. (2013). Social influence approaches to encourage resource conservation: A meta-analysis. *Global Environmental Change*, *23*(6), 1773–1785. https://doi.org/10.1016/j.gloenvcha.2013.07.029

Abreu, M. I., Oliveira, R., & Lopes, J. (2017). Attitudes and Practices of Homeowners in the Decision-making Process for Building Energy Renovation. *Procedia Engineering*, *172*, 52–59. https://doi.org/10.1016/j.proeng.2017.02.016

Adnan, Y. M., Daud, M. N., Aini, A. M., Yassin, A. M., & Razali, M. N. (2013). Malay Reservation Land – Unleashing A Century of Trust. *International Surveying Research Journal*, *3*(2), 1–28.

Advisory committee Programma aardgasvrije wijken. (2020). Tweede ronde proeftuinen - Programma Aardgasvrije Wijken. Retrieved from Programma aardgasvrije wijken website: https://www.aardgasvrijewijken.nl/proeftuinen/tweedeuitvraag/default.aspx

Aedes. (2017). *Routeplanner CO2-neutraal 2050*. Retrieved from https://dkvwg750av2j6.cloudfront.net/m/51e5cf916940fed1/original/Routeplanner-CO2-neutraal-2050-november-2017-Aedes.pdf

Ajzen, I. (1985). *From Intentions to Actions: A Theory of Planned Behavior* (Action Con; J. Kuhl & J. (Eds. . Beckmann, Eds.). Springer.

Ajzen, I. (1991). The theory of planned behavior. *Handbook of Theories of Social Psychology: Volume 1*, *211*, 438–459. https://doi.org/10.4135/9781446249215.n22

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology*, *22*(5), 453–474. https://doi.org/10.1016/0022-1031(86)90045-4

Allcott, H. (2011). Rethinking real-time electricity pricing. *Resource and Energy Economics*, *33*(4), 820–842. https://doi.org/10.1016/j.reseneeco.2011.06.003

Armitage, C. J., & Conner, M. (2001). *Efficacy of the Theory of Planned Behaviour : A Meta-Analytic Review E Y cacy of the Theory of Planned Behaviour : A meta-analytic review*. (July 2017), 471–499.

Attenborough, D. (2018). David Attenborough tells Davos: 'The Garden of Eden is no more.' Retrieved from The Guardian website: https://www.theguardian.com/tv-and-radio/2019/jan/21/david-attenborough-tells-davos-the-garden-of-eden-is-no-more

Bagozzi, R. P., & Dabholkar, P. A. (1994). Consumer recycling goals and their effect on decisions to recycle: A means-end chain analysis. *Psychology & Marketing*, *11*(4), 313–340. https://doi.org/10.1002/mar.4220110403

Banfi, S., Farsi, M., Filippini, M., & Jakob, M. (2008). Willingness to pay for energy-saving measures in residential buildings. *Energy Economics*, *30*(2), 503–516. https://doi.org/10.1016/j.eneco.2006.06.001

Barr, S., Guilbert, S., Metcalfe, A., Riley, M., Robinson, G. M., & Tudor, T. L. (2013). Beyond recycling: An integrated approach for understanding municipal waste management. *Applied Geography*, *39*, 67–77. https://doi.org/10.1016/j.apgeog.2012.11.006

Bem, D. J. (1967). Self-Perception: an Alternative Interpretation of Cognitive Dissonance Phenomena. *Psychological Review*, *74*(3), 183–200. https://doi.org/10.1037/h0024835

Bem, D. J. (1972). Self-perception theory. *Advances in Experimental Social Psychology, Vol. 6*, 1–57.

Bernstad, A. (2014). Household food waste separation behavior and the importance of convenience. *Waste Management*, *34*(7), 1317–1323. https://doi.org/10.1016/j.wasman.2014.03.013

Binnenlands Bestuur. (2020). *Rekenkamer zeer kritisch over Programma Aardgasvrije Wijken*. Retrieved from https://www.binnenlandsbestuur.nl/ruimte-en-milieu/nieuws/rekenkamer-fileert-programma-aardgasvrije-wijken.13302080.lynkx

Bolderdijk, J. W., Steg, L., Geller, E. S., Lehman, P. K., & Postmes, T. (2013). Comparing the effectiveness of monetary versus moral motives in environmental campaigning. *Nature Climate Change*, *3*(4), 413–416. https://doi.org/10.1038/nclimate1767

Borgers, A. (2019). *Urban Research Methods: (Advanced) Discrete choice models*.

Broers, W. M. H., Vasseur, V., Kemp, R., Abujidi, N., & Vroon, Z. A. E. P. (2019). Decided or divided? An empirical analysis of the decision-making process of Dutch homeowners for energy renovation measures. *Energy Research and Social Science*, *58*(September), 101284. https://doi.org/10.1016/j.erss.2019.101284

Broers, W., & Vasseur, V. (2021). *Not all homeowners are alike : a segmentation model based on a quantitative analysis of Dutch adopters of residential photovoltaics*.

Carrus, G., Passafaro, P., & Bonnes, M. (2008). Emotions, habits and rational choices in ecological behaviours: The case of recycling and use of public transportation. *Journal of Environmental Psychology*, *28*(1), 51–62. https://doi.org/10.1016/j.jenvp.2007.09.003

CBS. (2019). Inkomen van personen; persoonskenmerken. Retrieved from Statline website: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83931NED/table?dl=D4D1

CBS. (2020a). Hoogstbehaald onderwijsniveau en onderwijsrichting. Retrieved from Statline website: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82816NED/table?ts=1602762528279

CBS. (2020b). Leeftijdsverdeling. Retrieved from Statline website: https://www.cbs.nl/nl-

nl/visualisaties/dashboard-bevolking/leeftijd/bevolking

CBS. (2021). Huishoudens nu. Retrieved from Statline website: https://www.cbs.nl/nl-nl/visualisaties/dashboard-bevolking/woonsituatie/

Central Bureau for Statistics. (2020). *Hernieuwbare energie in Nederland 2019*. Retrieved from https://www.cbs.nl/nl-nl/publicatie/2015/40/hernieuwbare-energie-in-nederland-2014

Contreras, F., Hanaki, K., Aramaki, T., & Connors, S. (2008). Application of analytical hierarchy process to analyze stakeholders preferences for municipal solid waste management plans, Boston, USA. *Resources, Conservation and Recycling*, *52*(7), 979–991. https://doi.org/10.1016/j.resconrec.2008.03.003

Corraliza, J. A., & Berenguer, J. (2000). Environmental values, beliefs, and actions: A situational approach. *Environment and Behavior*, *32*(6), 832–848. https://doi.org/10.1177/00139160021972829

Costa, A. I. A., Dekker, M., & Jongen, W. M. F. (2004). An overview of means-end theory: Potential application in consumer-oriented food product design. *Trends in Food Science and Technology*, *15*(7–8), 403–415. https://doi.org/10.1016/j.tifs.2004.02.005

Council of state. *Woningwet*. , (2017).

de Groot, J. I. M., & Steg, L. (2008). Value Orientations to Explain Beliefs Related to Environmental Significant Behavior. *Environment and Behavior*, *40*(3), 330–354.

De Jonge, B. (n.d.). De 70 procent-regeling. Retrieved February 18, 2020, from https://www.aedes.nl/artikelen/energie-en-duurzaamheid/achtergrond/de-70-procent-regeling.html#:~:text=Daarmee wordt voorkomen dat de,geacht wordt redelijk te zijn.

DellaValle, N., Bisello, A., & Balest, J. (2018). In search of behavioural and social levers for effective social housing retrofit programs. *Energy and Buildings*, *172*, 517–524. https://doi.org/10.1016/j.enbuild.2018.05.002

Delmas, M., & Lessem, N. (2013). *Saving power to conserve your reputation? The effectiveness of private versus public information.* 1–40. Retrieved from http://escholarship.org/uc/item/7d16s49d.pdf

Devine-Wright, P. (2003). *A cross-national, comparative analysis of public understanding of, and attitudes towards nuclear, renewable and fossil-fuel energy sources*. 160–173.

Diekmann, A., & Preisendörfer, P. (2003). Green and Greenback: The Behavioral Effect of Environmental Attitudes in Low-Cost and High-Cost Situations. *Rationality and Society*, *15*(4), 441–472. https://doi.org/10.1177/1043463103154002

Dóci, G., & Vasileiadou, E. (2015). “Let’s do it ourselves” Individual motivations for investing in renewables at community level. *Renewable and Sustainable Energy Reviews*, *49*, 41–50. https://doi.org/10.1016/j.rser.2015.04.051

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A

Revised NEP Scale. *Journal of Social Issues*, *56*(3), 425–442. https://doi.org/10.1111/0022-4537.00176

Dunlap, R., & Van Liere, K. (1978). The "new environmental paradigm." *Journal of Environmental Education*, *40*(1), 19–28. https://doi.org/10.3200/JOEE.40.1.19-28

Dutch central government. (n.d.). Rijksoverheid stimuleert ontwikkeling bio-energie. Retrieved from https://www.rijksoverheid.nl/onderwerpen/duurzame-energie/bio-energie#:~:text=Biomassa is organisch materiaal%2C zoals,Daarbij ontstaat brandbaar biogas.

Dutch government. (2018). *Kabinet: einde aan gaswinning in Groningen*. Retrieved from https://www.rijksoverheid.nl/actueel/nieuws/2018/03/29/kabinet-einde-aan-gaswinning-in-groningen

Dutch government. (2020). *Monitoring en evaluatie Programma Aardgasvrije Wijken - Plan van Aanpak*.

Dutch Government. *Climate Agreement (Klimaatakkoord)*. , (2019).

Dutch Government. *artikel 7:220 lid 3 bw*. , (2020).

Dutch Government. *Gas Law*. , (2020).

E. Wiebes. (2018). Kamerbrief over gaswinning Groningen. *Ministerie van Economische Zaken En Klimaat (2018)*, 23. Retrieved from http://www.joim.pl/pdf/MAZURv2n2.pdf

E. Wiebes. *Gaswinningsniveau Groningen in 2019-2020*. , (2019).

E. Wiebes. *Gaswinningsniveau Groningen gasjaar 2020-2021*. , (2020).

Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2019). Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? *Energy Policy*, *129*(June 2018), 546–561. https://doi.org/10.1016/j.enpol.2019.02.046

Ekkers, H. (2016). 100.000 mensen met aardbevingsschade in Groningen - NOS. *NOS Nieuws - Binnenland*.

Erdmann, T. P., & Haigh, M. D. (2013). *The Energy Ladder: A Model for Projecting Energy Demand*. Retrieved from http://www.biee.org/wpcms/wp-content/uploads/Erdmann-The-Energy-Ladder-v2.pdf

European Commission. (2019). EU climate action. Retrieved October 16, 2020, from https://ec.europa.eu/clima/citizens/eu_en

Ewing, G., & Sarigöllü, E. (2000). Assessing consumer preferences for clean-fuel vehicles: A discrete choice experiment. *Journal of Public Policy and Marketing*, *19*(1), 106–118. https://doi.org/10.1509/jppm.19.1.106.16946

Festinger, L. (1957). *The Theory of Cognitive Dissonance*. Stanford: CA: Stanford Univ. Press.

Figueredo, F. R., & Tsarenko, Y. (2013). Is "being green" a determinant of participation in university sustainability initiatives? *International Journal of Sustainability in Higher Education*, *14*(3), 242–253. https://doi.org/10.1108/IJSHE-02-2011-0017

Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention and behavior: An introduction to theory and research. *Addison-Wesley*.

Fornara, F., Pattitoni, P., Mura, M., & Strazzera, E. (2016). Predicting intention to improve household energy efficiency: The role of value-belief-norm theory, normative and informational influence, and specific attitude. *Journal of Environmental Psychology*, *45*, 1–10. https://doi.org/10.1016/j.jenvp.2015.11.001

Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences*, *37*(8), 1597–1613. https://doi.org/10.1016/j.paid.2004.02.015

Fujii, S. (2006). Environmental concern, attitude toward frugality, and ease of behavior as determinants of pro-environmental behavior intentions. *Journal of Environmental Psychology*, *26*(4), 262–268. https://doi.org/10.1016/j.jenvp.2006.09.003

Gardner, G. T., & Stern, P. C. (1996). *Environmental problems and human behavior.*

Glumac, B., Reuvekamp, S., Han, Q., & Schaefer, W. F. (2013). Tenant participation in sustainable renovation projects: using AHP and case studies. *Journal of Energy Technologies and Policy – Special Issue for International Conference on Energy, Environment and Sustainable Economy (EESE 2013)*, *3*(11), 16–26.

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Quarterly*, *82*(4), 581–629. https://doi.org/10.1111/j.0887-378X.2004.00325.x

Guagnano, G. A., Stern, P. C., & Dietz, T. (1995). Influences on Attitude-Behavior Relationships: A Natural Experiment with Curbside Recycling. *Environment and Behavior*, *27*(5), 699–718. https://doi.org/10.1177/0013916595275005

Guy, S., Kashima, Y., Walker, I., & O'Neill, S. (2014). Investigating the effects of knowledge and ideology on climate change beliefs. *European Journal of Social Psychology*, *44*(5), 421–429. https://doi.org/10.1002/ejsp.2039

Haegeli, P., Haider, W., Longland, M., & Beardmore, B. (2010). Amateur decision-making in avalanche terrain with and without a decision aid: A stated choice survey. *Natural Hazards*, *52*(1), 185–209. https://doi.org/10.1007/s11069-009-9365-4

Hage, O., Sandberg, K., Söderholm, P., & Berglund, C. (2008). Household plastic waste collection in Swedish municipalities: a spatial-econometric approach. *16th Annual Conference of the European Association of Environmental and Resource Economists (EAERE)*, (October), 1–30. Retrieved from http://pure.ltu.se/portal/files/2207880/Paper.pdf

Hancock, G. R. (2003). Fortune cookies, measurement error, and experimental design. *Journal of Modern Applied Statistical Methods*, *2*(2), 293–305. https://doi.org/10.22237/jmasm/1067644980

Hardeman, W., Johnston, M., Johnston, D., Bonetti, D., Wareham, N., & Kinmonth, A. L. (2002). Application of the theory of planned behaviour in behaviour change interventions: A systematic review. *Psychology and Health*, *17*(2), 123–158.

https://doi.org/10.1080/08870440290013644a

Hargreaves, T. (2011). Practice-ing behaviour change: Applying social practice theory to pro-environmental behaviour change. *Journal of Consumer Culture*, *11*(1), 79–99. https://doi.org/10.1177/1469540510390500

Harland, P., Staats, H., & Wilke, H. A. M. (1999). Explaining proenvironmental intention and behavior by personal norms and the theory of planned behavior. *Journal of Applied Social Psychology*, *29*(12), 2505–2528. https://doi.org/10.1111/j.1559-1816.1999.tb00123.x

Hauge, Å. L., Thomsen, J., & Löfström, E. (2013). How to get residents/owners in housing cooperatives to agree on sustainable renovation. *Energy Efficiency*, *6*(2), 315–328. https://doi.org/10.1007/s12053-012-9175-5

Heidhues, F., & Brüntrup, M. (2003). *Subsistence agriculture in development: Its role in processes of structural change.* (S. Abele & K. Frohberg, Eds.).

Hensher, D. A., Rose, J. M., & Greene, W. H. (2015). *Applied Choice Analysis* (2nd ed.). https://doi.org/10.1017/CBO9781316136232

Hicks, J., & Allen, R. (1934). A Reconsideration of the Theory of Value. *Economica*, *1*(1), 52–76.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behaviour: a meta analysis. *Journal of Enviornmental Education*, *18*(2), 1–8.

Hölsgens, R. (2019). Resource dependence and energy risks in the Netherlands since the mid-nineteenth century. *Energy Policy*, *125*(October 2018), 45–54. https://doi.org/10.1016/j.enpol.2018.10.020

Hoogenraad, E. (2019). *The successfulness of social housing energy renovation projects. An exploration into the effects of the project on tenants' satisfaction and their energy consumption*. Eindhoven university of technology.

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe. *Resources and Energy*, *9*(4), 347–361. https://doi.org/10.1016/0165-0572(87)90003-x

Jager, G. (2018). *Draagvlak voor energiebesparing*.

Judea, P. (2000). *Causality: Models, reasoning, and inference*. Cambridge University Press.

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., & Mandel, G. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change*, *2*(10), 732–735. https://doi.org/10.1038/nclimate1547

Kaplan, D. (2008). *Structural Equation Modeling: Foundation and Extensions*.

Karatasou, S., Laskari, M., & Santamouris, M. (2014). Models of behavior change and residential energy use: A review of research directions and findings for behavior-based energy efficiency. *Advances in Building Energy Research*, *8*(2), 137–147. https://doi.org/10.1080/17512549.2013.809275

Kemperman, A. (2000). *Temporal Aspects of Theme Park Choice Behavior.* Retrieved from https://doi.org/10.6100/IR542240

Kemperman, A. (2017). *Urban Research Methods: Discrete Choice Models - Stated Choice Experiments*.

Kerperien, S. (2019). *Preferences of social tenants in energy efficiency investments and the effect of information provision*. Eindhoven University of Technology.

Kline, R. B. (2011). *Convergence of Structural Equation Modeling and Multilevel Modeling* (M. Williams & W. P. Vogt, Eds.).

Koch, J., & Christ, O. (2018). Household participation in an urban photovoltaic project in Switzerland: Exploration of triggers and barriers. *Sustainable Cities and Society*, *37*(November 2017), 420–426. https://doi.org/10.1016/j.scs.2017.10.028

Kollmuss, A., & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *40*(2), 49–58. https://doi.org/10.1080/1350462022014540

Kotchen, M. J., & Moore, M. R. (2007). Private provision of environmental public goods: Household participation in green-electricity programs. *Journal of Environmental Economics and Management*, *53*(1), 1–16. https://doi.org/10.1016/j.jeem.2006.06.003

Kullberg, J., & Ras, M. (2018). De sociale staat van Nederland. Retrieved April 21, 2021, from https://digitaal.scp.nl/ssn2018/wonen/

Leidelmeijer, K., van Iersel, J., & Frissen, J. (2018). *Veerkracht in het corporatiebezit. Kwetsbare bewoners en leefbaarheid*.

Lindenberg, S., & Steg, L. (2007). Normative, gain and hedonic goal frames guiding environmental behavior. *Journal of Social Issues*, *63*(1), 117–137. https://doi.org/10.1111/j.1540-4560.2007.00499.x

M. Rutte (VVD), S. van Haersma Buma (CDA), A. Pechtold (D66), G. J. S. (ChristenUnie). Vertrouwen in de toekomst? - Regeerakkoord 2017-2021. , 79 Rijksoverheid (2017) § (2017).

MacCallum, R. C., & Austin, J. T. (2000). Applications of Structural Equation Modeling in Psychological Research. *Annu. Rev. Psychol.*, *51*, 201–226.

Macovei, O.-I. (2015). Determinants of Consumers' Pro-Environmental Behavior – Toward an Integrated Model. *Journal of Danubian Studies and Research*, *5*(2), 261–275.

McCright, A. M., Dunlap, R. E., & Xiao, C. (2013). Perceived scientific agreement and support for government action on climate change in the USA. *Climatic Change*, *119*(2), 511–518. https://doi.org/10.1007/s10584-013-0704-9

McFadden, D. (1986). The Choice Theory Approach to Market Research. *Marketing Science*, *5*(4), 275–297.

McMakin, A. H., & Malone, E. L. (2002). Motivating residents to conserve energy without financial incentives. *Environment and Behavior*, *34*(6), 848–863. https://doi.org/10.1177/001391602237252

Meinhold, J. L., & Malkus, A. J. (2005). Adolescent environmental behaviors: Can knowledge, attitudes and self-efficacy make a difference? *Environment and Behavior*, *37*(4), 511–532. https://doi.org/10.1177/0013916504269665

Mekonnen, A., GebreEgziabher, Z., Kassie, M., & Kölin, G. (2009). *Income alone doesn't determine adoption and choice of fuel types*.

Michelsen, C. C., & Madlener, R. (2012). Homeowners' preferences for adopting innovative residential heating systems: A discrete choice analysis for Germany. *Energy Economics*, *34*(5), 1271–1283. https://doi.org/10.1016/j.eneco.2012.06.009

Milieu centraal. (n.d.). Biomassa. Retrieved from https://www.milieucentraal.nl/klimaat-en-aarde/energiebronnen/biomassa/#Duurzaam-of-niet?

Ministry of the Interior and Kingdom Relations. (2012). *Convenant energiebesparing huursector*.

Ministry of the Interior and Kingdom Relations. (2018). 120 miljoen euro voor 'proeftuinen' aardgasvrije wijken in 27 gemeenten. Retrieved October 19, 2020, from Rijksoverheid.nl website: https://www.rijksoverheid.nl/actueel/nieuws/2018/10/01/120-miljoen-euro-voor-'proeftuinen'-aardgasvrije-wijken-in-27-gemeenten

Ministry of the Interior and Kingdom Relations. (2019). *Staat van de volkshuisvesting Jaarrapportage 2019*. Retrieved from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2019/05/28/rapport-staat-van-de-volkshuisvesting/rapport-staat-van-de-volkshuisvesting.pdf

Monteiro, C. S., Causone, F., Cunha, S., Pina, A., & Erba, S. (2017). Addressing the challenges of public housing retrofits. *Energy Procedia*, *134*, 442–451. https://doi.org/10.1016/j.egypro.2017.09.600

Morris, J., Marzano, M., Dandy, N., & O'Brien., L. (2012). Theories and models of behaviour and behaviour change. *Forestry, Sustainable Behaviours and Behaviour Change: Theories*, 1–27.

Morrison, G. M., & Lin Lawell, C. Y. C. (2016). Driving in force: The influence of workplace peers on commuting decisions on U.S. military bases. *Journal of Economic Behavior and Organization*, *125*, 22–40. https://doi.org/10.1016/j.jebo.2016.01.010

Mortensen, A., Heiselberg, P., & Knudstrup, M. (2014). Economy controls energy retrofits of Danish single-family houses. Comfort, indoor environment and architecture increase the budget. *Energy and Buildings*, *72*, 465–475. https://doi.org/10.1016/j.enbuild.2013.12.054

Mortensen, A., Heiselberg, P., & Knudstrup, M. (2016). Identification of key parameters determining Danish homeowners' willingness and motivation for energy renovations. *International Journal of Sustainable Built Environment*, *5*(2), 246–268. https://doi.org/10.1016/j.ijsbe.2016.09.002

Motivaction. (2020). *Vijf tinten groener*. Retrieved from https://www.motivaction.nl/kennisplatform/publicaties/whitepaper-duurzaamheidscommunicatie-doe-je-zo?chronoform=WHITEPAPER-Vijf-tinten-groener&event=submit

Nair, G., Gustavsson, L., & Mahapatra, K. (2010). Factors influencing energy efficiency investments in existing Swedish residential buildings. *Energy Policy*, *38*(6), 2956–2963. https://doi.org/10.1016/j.enpol.2010.01.033

Nansaior, A., Patanothai, A., Rambo, A. T., & Simaraks, S. (2011). Climbing the energy ladder or diversifying energy sources? The continuing importance of household use of biomass energy in urbanizing communities in Northeast Thailand. *Biomass and Bioenergy*, *35*(10), 4180–4188. https://doi.org/10.1016/j.biombioe.2011.06.046

Nguyen, T. N., Lobo, A., & Greenland, S. (2017). Energy efficient household appliances in emerging markets: the influence of consumers' values and knowledge on their attitudes and purchase behaviour. *International Journal of Consumer Studies*, *41*(2), 167–177. https://doi.org/10.1111/ijcs.12323

Nijënstein, S. (2012). *Determining the role of values in students' housing choice behaviour with latent class and mixed logit conjoint analysis methods*. Eindhoven university of techonology.

Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2008). Normative social influence is underdetected. *Personality and Social Psychology Bulletin*, *34*(7), 913–923. https://doi.org/10.1177/0146167208316691

Noppers, E. H., Keizer, K., Bolderdijk, J. W., & Steg, L. (2014). The adoption of sustainable innovations: Driven by symbolic and environmental motives. *Global Environmental Change*, *25*(1), 52–62. https://doi.org/10.1016/j.gloenvcha.2014.01.012

NOS. (2020a). Kamer blij met SER-advies tegen biomassa, maar ook roep om meer duidelijkheid. Retrieved February 22, 2021, from https://nos.nl/artikel/2339090-kamer-blij-met-ser-advies-tegen-biomassa-maar-ook-roep-om-meer-duidelijkheid.html

NOS. (2020b, October 20). Proef in Purmerend met gasvrij maken van woonwijk ligt stil. *NOS Nieuws - Binnenland*. Retrieved from https://nos.nl/artikel/2352510-proef-in-purmerend-met-gasvrij-maken-van-woonwijk-ligt-stil.html

O'Connor, R. E., Bord, R. J., & Fisher, A. (1999). Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Analysis*, *19*(3), 461–471. https://doi.org/10.1023/A:1007004813446

Ölander, F., & Thøgersen, J. (1995). Folke Olander and John Thogersen Understanding of Consumer Behaviour as a Prerequisite for Environmental Protection. *Journal of Consumer Policy*, *18*(4), 345–385. Retrieved from https://link.springer.com/content/pdf/10.1007%2FBF01024160.pdf

Ollongren, K. H. (2020). *Tussentijdse evaluatie Programma aardgasvrije wijken*.

Paunio, M. (2018). *Kicking Away the Ladder: How environmentalism destroys hope for the poorest*. https://doi.org/10.2307/j.ctt1gxp77q.31

Pelletier, L. G., Tuson, K. M., Green-Demers, I., Noels, K., & Beaton, A. M. (1998). Why are you doing things for the environment? The Motivation Toward the Environment Scale (MTES). *Journal of Applied Social Psychology*, *28*(5), 437–468.

https://doi.org/10.1111/j.1559-1816.1998.tb01714.x

Perlaviciute, G., & Steg, L. (2015). The influence of values on evaluations of energy alternatives. *Renewable Energy*, *77*, 259–267. https://doi.org/10.1016/j.renene.2014.12.020

Perlaviciute, Goda, Steg, L., Contzen, N., Roeser, S., & Huijts, N. (2018). Emotional responses to energy projects: Insights for responsible decision making in a sustainable energy transition. *Sustainability (Switzerland)*, *10*(7). https://doi.org/10.3390/su10072526

Perlaviciute, Goda, Steg, L., Hoekstra, E. J., & Vrieling, L. (2017). Perceived risks, emotions, and policy preferences: A longitudinal survey among the local population on gas quakes in the Netherlands. *Energy Research and Social Science*, *29*(December 2016), 1–11. https://doi.org/10.1016/j.erss.2017.04.012

Programma aardgasvrije wijken. (2019). Programma Aardgasvrije Wijken. Retrieved October 20, 2020, from Paw website: https://www.aardgasvrijewijken.nl/home/default.aspx

Quirijns, P. (2011). *Complex gemengd complex een exploratief onderzoek naar de belemmeringen voor woningcorporaties bij het doorvoeren van energiebesparende maatregelen binnen gemengde wooncomplexen*. Technische Universiteit Eindhoven.

Raffaele Zanoli, & Simona Naspetti. (2002). Consumer motivations in the purchase of organic food: A means-end approach. *British Food Journal*, *104*(8/9), 643.

Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *Practicing History: New Directions in Historical Writing after the Linguistic Turn*, *5*(2), 245–263. https://doi.org/10.4324/9780203335697-23

Reddy, S. (1995). *A Multilogit Model for Fuel Shifts in the Dometic Sector.*

Reuvekamp, S. (2013). *Tenant participation in sustainable renovaition projects* (Eindhoven University of Technology). https://doi.org/10.1016/0301-679x(85)90008-8

Rijksoverheid. (2018). Woononderzoek Nederland 2018. Retrieved May 31, 2021, from https://www.woononderzoek.nl/Jive/?workspace_guid=c45e0c1e-67d9-4d99-b5e5-534cab53906f

Rogers, E. M. (2003). *Diffusion of Innovations* (Fifth). Retrieved from teddykw2.files.wordpress.com/.../everett-m-rogers-diffusion-of-innovati..

Rokeach, M. (1973). The nature of human values. In *The nature of human values.* New York, NY, US: Free Press.

RVO. *Factsheet wijziging gasaansluitingplicht per 1 juli 2018.* , 10 § (2018).

Sawe, B. E. (2018). The Largest Natural Gas Fields In The World. Retrieved October 19, 2020, from 2018 website: file:///C:/Users/20183668/Documents/TUe/Master/Graduation/References/Proposal/The Largest Natural Gas Fields In The World - WorldAtlas.html

Schillemans, R., Rooijers, F., & Benner, J. (2006). *Belemmeringen binnen en buiten de muren*.

Schlag, N., & Zuzarte, F. (2008). *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa:*

A Review of Literature. Retrieved from http://sei-international.org/mediamanager/documents/Publications/Climate/market_barriers_clean_cooking_fuels_21april.pdf

Schuitema, G., & Steg, L. (n.d.). Percepties van energieverbruik van huishoudelijke apparaten. *Ontwikkelingen in Het Marktonderzoek, Jaarboek 2005*, 165–180.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. *Advances in Experimental Social Psychology*, *25*(C), 1–65. https://doi.org/10.1016/S0065-2601(08)60281-6

Shove, E., Pantzar, M., & Watson, M. (2012). *The Dynamics of Social Practice London*. *10*(2005), 5–6.

Shove, Elizabeth. (2010). Beyond the ABC: Climate change policy and theories of social change. *Environment and Planning A*, *42*(6), 1273–1285. https://doi.org/10.1068/a42282

Sloot, D., Jans, L., & Steg, L. (2019). In it for the money, the environment, or the community? Motives for being involved in community energy initiatives. *Global Environmental Change*, *57*(December 2018), 101936. https://doi.org/10.1016/j.gloenvcha.2019.101936

Smith, S. M., Haugtvedt, C. P., & Petty, R. E. (1994). Attitudes and recycling: Does the measurement of affect enhance behavioral prediction? *Psychology & Marketing*, *11*(4), 359–374. https://doi.org/10.1002/mar.4220110405

Sommerfeld, J., Buys, L., & Vine, D. (2017). Residential consumers' experiences in the adoption and use of solar PV. *Energy Policy*, *105*(February), 10–16. https://doi.org/10.1016/j.enpol.2017.02.021

Srdjevic, B., & Srdjevic, Z. (2013). Synthesis of individual best local priority vectors in AHP-group decision making. *Applied Soft Computing Journal*, *13*(4), 2045–2056. https://doi.org/10.1016/j.asoc.2012.11.010

Steg, L. (2008). Promoting household energy conservation. *Energy Policy*, *36*(12), 4449–4453. https://doi.org/10.1016/j.enpol.2008.09.027

Steg, L. (2016). Values, Norms, and Intrinsic Motivation to Act Proenvironmentally. *Annual Review of Environment and Resources*, *41*, 277–292. https://doi.org/10.1146/annurev-environ-110615-085947

Steg, L., Bolderdijk, J. W., Keizer, K., & Perlaviciute, G. (2014). An Integrated Framework for Encouraging Pro-environmental Behaviour: The role of values, situational factors and goals. *Journal of Environmental Psychology*, *38*, 104–115. https://doi.org/10.1016/j.jenvp.2014.01.002

Steg, L., de Groot, J. I. M., Dreijerink, L., Abrahamse, W., & Siero, F. (2011). General antecedents of personal norms, policy acceptability, and intentions: the role of values, worldviews, and environmental concern. *Society and Natural Resources*, *24*(4), 349–367. https://doi.org/10.1080/08941920903214116

Steg, L., Perlaviciute, G., & van der Werff, E. (2015). Understanding the human dimensions of a sustainable energy transition. *Frontiers in Psychology*, *6*(June), 1–17. https://doi.org/10.3389/fpsyg.2015.00805

Steg, L., Perlaviciute, G., van der Werff, E., & Lurvink, J. (2014). The Significance of Hedonic Values for Environmentally Relevant Attitudes, Preferences, and Actions. *Environment and Behavior*, *46*(2), 163–192. https://doi.org/10.1177/0013916512454730

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, *29*(3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Steg, Van den Berg, A. E., & De Groot, J. I. M. (2019). *Environmental psychology: An introduction* (Second edi; Hoboken, Ed.). NJ: John Wiley & Sons L.t.d.

Stern, P. C. (1999). Information, Incentives, and Proenvironmental Consumer Behavior. *Journal of Consumer Policy*, *22*, 461–478.

Suhr, D. (2006). *The Basics of Structural Equation Modeling*. 1–19.

Sunblad, E.-L., Biel, A., & Gärling, T. (2009). Knowledge and Confidence in Knowledge About Climate Change Among Experts, Journalists, Politicians, and Laypersons. *Environment And Behavior*, 281–302.

Tarka, P. (2017). An overview of structural equation modeling: its beginnings, historical development, usefulness and controversies in the social sciences. *Quality and Quantity*, *52*(1), 313–354. https://doi.org/10.1007/s11135-017-0469-8

Taylor, D., Bury, M., Campling, N., Carter, S., Garfield, S., Newbould, J., & Rennie, T. (2007). A Review of the use of the Health Belief Model (HBM), the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB) and the Trans-Theoretical Model (TTM) to study and predict health related behaviour change. *Health (San Francisco)*, (June), 1–215.

The European parliament and the council of the European Union. *Directive 2009/28/EC of the European parliament and of the council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC*. , (2009).

Thøgersen, J. (2005). How may consumer policy empower consumers for sustainable lifestyles? *Journal of Consumer Policy*, *28*(2), 143–177. https://doi.org/10.1007/s10603-005-2982-8

Tobler, C., Visschers, V. H. M., & Siegrist, M. (2012). Consumers' knowledge about climate change. *Climatic Change*, *114*(2), 189–209. https://doi.org/10.1007/s10584-011-0393-1

Toole, R. (2015). *The Energy Ladder : A Valid Model for Household Fuel Transitions in Sub-Saharan Africa ?*

United Nations. Kyoto protocol - United Nations framework convention on climate change (UNFCCC). , United Nations Climate Change § (1998).

United Nations. Paris Agreement - UNFCCC. , United Nations Climate Change § (2015).

United Nations. (2016). Climate Change - United Nations Sustainable Development.

Valente, T.W., & Schuster, D. V. (2002). *The public health perspective for communicating environmental issues.* 105–124.

Valente, Thomas W., & Rogers, E. M. (1995). The Origins and Development of the Diffusion of Innovations Paradigm as an Example of Scientific Growth. In *Science Communication* (Vol. 16). https://doi.org/10.1177/1075547095016003002

Van den Berg, J. (2021). Na twee jaar experimenteren in 'aardgasvrije wijken' zijn slechts 206 huizen van het gas af. *De Volkskrant*.

Van der Grient, R., Kamphuis, A., & De Vos, M. (2019). *Publieksmonitor Klimaat en Energie 2019*.

Van Der Kroon, B., Brouwer, R., & Van Beukering, P. J. H. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and Sustainable Energy Reviews*, *20*, 504–513. https://doi.org/10.1016/j.rser.2012.11.045

Van der Spank, M. (2013). *Convincing tenants to participate in sustainable renovation*. Eindhoven University of Technology.

van der Werff, E., & Steg, L. (2016). The psychology of participation and interest in smart energy systems: Comparing the value-belief-norm theory and the value-identity-personal norm model. *Energy Research and Social Science*, *22*, 107–114. https://doi.org/10.1016/j.erss.2016.08.022

Vicente-Molina, M. A., Fernández-Sáinz, A., & Izagirre-Olaizola, J. (2013). Environmental knowledge and other variables affecting pro-environmental behaviour: Comparison of university students from emerging and advanced countries. *Journal of Cleaner Production*, *61*, 130–138. https://doi.org/10.1016/j.jclepro.2013.05.015

Voesenek, N. P. (2020). The motives of social tenants in the transition towards non-natural gas housing and the effect of information provision.

Walker, B., Marsh, A., Wardman, M., & Niner, P. (2002). Modelling tenants' choices in the public rented sector: A stated preference approach. *Urban Studies*, *39*(4), 665–688. https://doi.org/10.1080/00420980220119516

Waris, I., & Hameed, I. (2020). Promoting environmentally sustainable consumption behavior: an empirical evaluation of purchase intention of energy-efficient appliances. *Energy Efficiency*, *13*(8), 1653–1664. https://doi.org/10.1007/s12053-020-09901-4

Webb, T. L., Sniehotta, F. F., & Michie, S. (2010). Using theories of behaviour change to inform interventions for addictive behaviours. *Addiction*, *105*(11), 1879–1892. https://doi.org/10.1111/j.1360-0443.2010.03028.x

Werf, E. Van Der. (2011). *Bewonersbelangen bij renovatie in bewoonde staat*.

Whitmarsh, L., Seyfang, G., & O'Neill, S. (2011). Public engagement with carbon and climate change: To what extent is the public "carbon capable"? *Global Environmental Change*, *21*(1), 56–65. https://doi.org/10.1016/j.gloenvcha.2010.07.011

Wilson, C., Crane, L., & Chryssochoidis, G. (2015). Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy. *Energy Research and*

Social Science, *7*, 12–22. https://doi.org/10.1016/j.erss.2015.03.002

Wilson, C., Pettifor, H., & Chryssochoidis, G. (2018). Quantitative modelling of why and how homeowners decide to renovate energy efficiently. *Applied Energy*, *212*(November 2017), 1333–1344. https://doi.org/10.1016/j.apenergy.2017.11.099

Wilson, Charlie, & Dowlatabadi, H. (2007). Models of decision making and residential energy use. *Annual Review of Environment and Resources*, *32*, 169–203. https://doi.org/10.1146/annurev.energy.32.053006.141137

Wind, Y., & Saaty, T. (1980). Marketing Applications of the Analytic Hierarchy Process. *Management Science*, *26*(7), 641–658.

Yuriev, A., Dahmen, M., Paillé, P., Boiral, O., & Guillaumie, L. (2020). Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources, Conservation and Recycling*, *155*(January), 104660. https://doi.org/10.1016/j.resconrec.2019.104660

Appendix 1 – Green consumer profiles

Summary of the five green consumer profiles by Motivaction (2020)

This summary is from Voesenek (2020):

Dutiful (plichtsgetrouwen): This group is committed to traditional norms and values, and the family. They want to leave the world well for future generations. They are often socially involved and locally oriented. Show a lot of sustainable behavior based on the principles of economy and cleanliness. Consume less than average and do not like waste or superfluous luxury. This group is open to information, guidelines and knowledge about sustainability. This information must be provided to them, preferably by a government agency or institute. This group wants a clear explanation of the measurements, illustrated by examples. The lack of knowledge hinders them from making (even) more sustainable choices. This group is open to sustainability, step by step. The costs are always important here.

Structure seekers (structuur zoekers): Almost a third of the Dutch people belongs to this group. This group likes an easy and regular life. They are little concerned with sustainability and do not believe that personal behavior will make the difference. Often this group has limited knowledge about climate friendly alternatives and life style. By increasing attention to pro-environmental behavior, this group is now also beginning to see that personal choices can also make a positive contribution to combating climate change. Most choices that this group makes are based on quality, comfort and costs. They are not willing to pay for a more sustainable alternative. Only if a climate friendly measurement results in a cost reduction, this group is willing to apply it. This group is characterized by the following behavior. If neighbors or known exhibit certain pro-environmental behavior or take measures, this group will be more inclined to do the same. This group is focused on personal benefits. Unburdening and emphasizing guarantees, securities and the participation of others will help to increase the willingness to participate. This group believes that business and government are primarily responsible for climate change mitigation.

Status conscious (statusbewusten): Individualistic and often socially involved as entrepreneurship. Status and career oriented, looking for personal success and luxury. Interest in technological gadgets. Therefor is this group more willing to use electrical vehicles, like Tesla. This group wants to be well informed and is critical about the proposed measurements. Would like to have an equal conversation. Personal benefits such as comfort, convenience, innovative technology, win-win situation and smart investment make measures attractive to this group. The importance of sustainability or pro-environmental behavior plays a minimal role for status conscious people.

Responsible ones (verantwoordelijken): Are happy to contribute and are socially involved. People in this group strive for a conscious and sustainable lifestyle. They look for a balance between sustainability, comfort and enjoyment. They believe that citizens can and must make an important contribution. This group is well aware of sustainability policy and goals and is concerned about climate change. This group is already well informed but can be triggered by providing factual information and point out more possibilities. Appreciation for pro-environmental behavior that this group has already shown is important to keep them motivated. This group sees sustainable developments as a structural and necessary course of events. They are willing to pay more for sustainable energy.

Developers (ontplooiers): Personal freedom, pleasure and making independent choices is important for this group. They do not like to follow the masses. People are willing to make more sustainable choices as long as this does not hinder their own pleasure and freedom. Factors such as money, effort and time are decisive when deciding to make investments. Doing something new together is more important than the future.

Appendix 2 – Previous research studies

Table 14 Overview of previous research studies into pro-environmental behavior, residential preference and modeling approach

Author	Year	Title	Research method	Behavioral theory	Behavioral model	Modeling approach
R. H. Hosier, & J. Dowd	1987	Household Fuel Choice In Zimbabwe. An Empirical Test of the Energy Ladder Hypothesis	Household energy use data base	Energy ladder		Multinomial Logit model
R. P. Bagozzi, & P. A. Dabholkar	1994	Consumer Recycling Goals and Their Effect on Decisions to Recycle: A Means-End Chain Analysis	Questionnaire in which attitudes, subjective norms and intentions were measured	Means-End Theory, Theory of Reasoned Action		Multiple regression
P. Harland, H. Staats, & H.A.M. Wilke	1999	Explaining Pro-environmental Intention and Behavior by Personal Norms and the Theory of Planned Behavior	Behavioral change intervention program based on a questionnaire.	Theory of Planned Behavior	Attitude-behavioral model	Intercorrelations and hierarchical regression analyses.
G. Ewing, and & E. Sarigöllü	2000	Assessing Consumer Preferences for Clean-Fuel Vehicles: A Discrete Choice Experiment	Questionnaire (stated preference)		Stated Choice Experiment (Discrete choice experiment)	Multinomial Logit model
B. Walker, A. Marsh, M. Wardman, & P. Niner	2002	Modeling Tenants' Choices in the Public Rented Sector: A Stated Preference Approach	Questionnaire (stated preference)	Random Utility Theory	Stated Choice Experiment	Multinomial Logit model
A. Diekmann, & P. Preisendörfer	2003	The Behavioral Effects of Environmental Attitudes in Low-Cost and High-Cost Situations		Rational-Choice Theory and Game Theory.	Attitude-behaviors-external conditions model (A-B-C)	(Binary) logit model

S. Fujii	2006	Environmental concern, attitude toward frugality, and ease of behavior as determinants of pro-environmental behavior intentions	Questionnaire to aimed at measuring the stated intentions to engage in pro-environmental behavior	Norm Activation Theory & Theory of Planned Behavior	Structural Equation Model	Correlation matrix
W. Abrahamse	2007	Energy conservation through behavioral change	Multidisciplinary study	Theory of Planned Behavior	Norm activation model	
G. Carrus, P. Passafaro, & M. Bonnes	2008	Emotions, habits and rational choices in ecological behaviors: The case of recycling and use of public transportation	Field studies predicted the intention to use public transport instead of private car and to recycle household waste.	Theory of Planned Behavior	Goal-directed model (MGB) encompasses Theory of Planned Behavior	Multiple regression, hierarchical regression and Structural Equation Modeling.
S. Banfi, M. Farsi, M. Filippini, & M. Jakob	2008	Willingness to pay for energy-saving measures in residential buildings	Questionnaire (stated preference)	Random Utility Theory	Stated Choice Experiment (Discrete choice experiment)	Multinomial Logit model, fixed-effects binary logit model
F. Contrerasa, K. Hanakia, T. Aramakia, & S. Connors	2008	Application of Analytical Hierarchy Process to analyze stakeholders preferences for municipal solid waste management plans, Boston, USA		Multi-Attribute Utility Theory	Analytical Hierarchy Process	
W. Abrahamse, & L. Steg	2009	How do socio-demographic and psychological factors relate to households' direct and	Intervention study based on questionnaire consisting of a group that received	Theory of Planned Behavior	Norm activation model	Correlation and regression analyses.

		indirect energy use and savings?	tailored information and a control group.			
T. Hargreaves	2011	Practicing behavior change: Applying Social Practice Theory to pro-environmental behavior change	Semi-structured interview	Social Practice Theory		
C. C. Michelsen, & R. Madlener	2012	Homeowners' preferences for adopting innovative residential heating systems: A discrete choice analysis for Germany	Stated preferences, combined with revealed preference data.	Random Utility Theory	Stated Choice Experiment (Discrete Choice Model)	Multinomial Logit model
S. Nijënstein	2012	Determining the role of values in students' housing choice behavior with latent class and mixed logit conjoint analysis methods	Questionnaire (stated preference)	Schwartz' Value Theory, Multi-Attribute Utility Theory	Stated Choice Experiment (Conjoint analysis experiment)	Multinomial Logit model, latent class model, mixed logit model
F. R. Figueredo, & Y. Tsarenko	2013	Is “being green” a determinant of participation in university sustainability initiatives?	Questionnaire	Theory of Planned Behavior & Theory of Reasoned Action & Self-Perception Theory		Linear regression
M. A. Van der Spank	2013	Convincing tenants to participate in sustainable renovation. Research into the willingness-to-pay for renovation packages of choice.	Questionnaire consisting of conjoint choice experiment, housing and socio-demographic characteristics, tenant's satisfaction with dwelling and attitude	Random Utility Theory	Conjoint (discrete) choice experiment (stated, choice, decompositional)	Multinomial Logit model, Latent class analysis, scenario analysis.

			towards renovation aspects.		
S. Reuvekamp	2013	Tenant participation in sustainable renovation projects. The influence of project content on the tenant participation of sustainable renovation projects within housing associations, using AHP and case study	Case studies		Analytical Hierarchy Process
Y. M. Adnan, M. N. Daud, A. M. Aini, A. M. Yassin, & M. N. Razali	2013	Tenants' Preference for Green Office Building Features	Questionnaire among tenants		Analytical Hierarchy Process
L. Steg, J. W. Bolderdijk, K. Keizer, & G. Perlaviciute	2014	An Integrated Framework for Encouraging Pro-environmental Behavior: The role of values, situational factors and goals		Goal-Framing Theory	Integrated theoretical framework for encouraging pro-environmental behavior (IFEP)

F. Fornara, P. Pattitoni, M. Mura, & E. Strazzera	2016	Predicting intention to improve household energy efficiency: The role of Value-Belief-Norm Theory, normative and informational influence, and specific attitude	Self-reported questionnaire aimed to measuring the intention to use green energy devices.	Value-Belief Norm Theory	Structural Equation Model	Correlation matrix
T. N. Nguyen, A. Lobo, & S. Greenland	2017	Energy efficient household appliances in emerging markets: the influence of consumers' values and knowledge on their values and knowledge on their		Theory of Reasoned Action and Theory of Planned Behavior.	(VKAB) Value, knowledge, attitudes and behavior	Structural Equation Modeling (SEM)
C. Wilson, H. Pettifor, & G. Chryssochoidis	2018	Quantitative modeling of why and how homeowners decide to renovate energy efficiently	Questionnaire	Diffusion of Innovation Theory	Innovation-decision model, which included Stated Choice Experiment	Path analysis and Multivariate Probit model
S. Kerperien	2019	Preferences of social tenants in energy efficiency investments and the effect of information provision			Stated Choice Experiment (Discrete Choice Modeling)	Multinomial Logit model, nested logit model
E. Hoogenraad	2019	The successfulness of social housing energy renovation projects. An exploration into the effects of the project on tenants' satisfaction and	Questionnaire	Theory of Planned Behavior	Structural Equation Model	Path analysis

		their energy consumption				
I. Waris, & I. Hameed	2020	Promoting environmentally sustainable consumption behavior: an empirical evaluation of purchase intention of energy-efficient appliances	Self-administered questionnaire	Theory of Planned Behavior	Structural Equation Model	Covariance-based Structural Equation Model

Appendix 3 – Experimental design

Experimental design of the Stated Choice model

```
Saturated      = 13
Full Factorial = 512

Some Reasonable                    Cannot Be
   Design Sizes       Violations   Divided By

          16 *                 0
          32 *                 0
          24                   3    16
          20                  12     8 16
          28                  12     8 16
          14                  18     4  8 16
          18                  18     4  8 16
          22                  18     4  8 16
          26                  18     4  8 16
          30                  18     4  8 16
          13 S                21     2  4  8 16

* - 100% Efficient design can be made with the MktEx macro.
S - Saturated Design - The smallest design that can be made.
    Note that the saturated design is not one of the
    recommended designs for this problem.  It is shown
    to provide some context for the recommended sizes.
```

Design Number	D-Efficiency	A-Efficiency	G-Efficiency	Average Prediction Standard Error
1	100.0000	100.0000	100.0000	0.6374

```
       Final Results

Design                     3
Choice Sets               16
Alternatives               2
Parameters                12
Maximum Parameters        16
D-Efficiency         11.3137
Relative D-Eff       70.7107
D-Error               0.0884
1 / Choice Sets       0.0625
```

Obs	Design	Efficiency	Index	Set	Prob	n	f1	f2	x1	x2	x3	x4	x5	x6
1	3	11.3137	25	1	0.5	65	1	1	1	1	3	1	1	1
2	3	11.3137	4	1	0.5	66	1	1	2	4	1	2	2	2
3	3	11.3137	27	2	0.5	67	1	1	4	2	3	2	2	1
4	3	11.3137	32	2	0.5	68	1	1	3	3	1	1	1	2
5	3	11.3137	24	3	0.5	69	1	1	2	3	2	2	1	1
6	3	11.3137	22	3	0.5	70	1	1	4	4	1	1	2	2
7	3	11.3137	30	4	0.5	71	1	1	1	2	4	1	2	2
8	3	11.3137	14	4	0.5	72	1	1	3	1	3	2	1	1
9	3	11.3137	2	5	0.5	73	1	1	1	4	2	2	2	1
10	3	11.3137	31	5	0.5	74	1	1	2	1	4	1	1	2
11	3	11.3137	17	6	0.5	75	1	1	2	4	4	1	1	1
12	3	11.3137	18	6	0.5	76	1	1	4	3	3	2	2	2
13	3	11.3137	20	7	0.5	77	1	1	4	3	2	1	1	1
14	3	11.3137	11	7	0.5	78	1	1	3	2	4	2	2	2
15	3	11.3137	29	8	0.5	79	1	1	1	4	3	1	1	2
16	3	11.3137	8	8	0.5	80	1	1	3	3	4	2	2	1
17	3	11.3137	7	9	0.5	81	1	1	2	1	1	2	2	1
18	3	11.3137	21	9	0.5	82	1	1	4	2	2	1	1	2
19	3	11.3137	12	10	0.5	83	1	1	4	1	1	1	2	1
20	3	11.3137	28	10	0.5	84	1	1	3	4	3	2	1	2
21	3	11.3137	6	11	0.5	85	1	1	2	3	3	1	2	2
22	3	11.3137	1	11	0.5	86	1	1	1	2	1	2	1	1
23	3	11.3137	10	12	0.5	87	1	1	3	1	2	1	2	2
24	3	11.3137	15	12	0.5	88	1	1	4	4	4	2	1	1
25	3	11.3137	5	13	0.5	89	1	1	1	1	2	2	2	2
26	3	11.3137	26	13	0.5	90	1	1	3	2	1	1	1	1
27	3	11.3137	13	14	0.5	91	1	1	1	3	4	1	2	1
28	3	11.3137	16	14	0.5	92	1	1	2	2	2	2	1	2
29	3	11.3137	3	15	0.5	93	1	1	1	3	1	2	1	2
30	3	11.3137	9	15	0.5	94	1	1	3	4	2	1	2	1
31	3	11.3137	19	16	0.5	95	1	1	4	1	4	2	1	2
32	3	11.3137	23	16	0.5	96	1	1	2	2	3	1	2	1

Set	x1	x2	x3	x4	x5	x6
1	1	1	3	1	1	1
	2	4	1	2	2	2

Set	x1	x2	x3	x4	x5	x6
9	2	1	1	2	2	1
	4	2	2	1	1	2

Set	x1	x2	x3	x4	x5	x6
2	4	2	3	2	2	1
	3	3	1	1	1	2

Set	x1	x2	x3	x4	x5	x6
10	4	1	1	1	2	1
	3	4	3	2	1	2

Set	x1	x2	x3	x4	x5	x6
3	2	3	2	2	1	1
	4	4	1	1	2	2

Set	x1	x2	x3	x4	x5	x6
11	2	3	3	1	2	2
	1	2	1	2	1	1

Set	x1	x2	x3	x4	x5	x6
4	1	2	4	1	2	2
	3	1	3	2	1	1

Set	x1	x2	x3	x4	x5	x6
12	3	1	2	1	2	2
	4	4	4	2	1	1

Set	x1	x2	x3	x4	x5	x6
5	1	4	2	2	2	1
	2	1	4	1	1	2

Set	x1	x2	x3	x4	x5	x6
13	1	1	2	2	2	2
	3	2	1	1	1	1

Set	x1	x2	x3	x4	x5	x6
6	2	4	4	1	1	1
	4	3	3	2	2	2

Set	x1	x2	x3	x4	x5	x6
14	1	3	4	1	2	1
	2	2	2	2	1	2

Set	x1	x2	x3	x4	x5	x6
7	4	3	2	1	1	1
	3	2	4	2	2	2

Set	x1	x2	x3	x4	x5	x6
15	1	3	1	2	1	2
	3	4	2	1	2	1

Set	x1	x2	x3	x4	x5	x6
8	1	4	3	1	1	2
	3	3	4	2	2	1

Set	x1	x2	x3	x4	x5	x6
16	4	1	4	2	1	2
	2	2	3	1	2	1

Choice sets questionnaire 1

Choice set 1

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtenet ZONDER nieuwe radiatoren	
Woonlasten	€10 p/m MINDER	€10 p/m MEER	
Woongemak	Blijft hetzelfde	Beter	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 2

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtepomp op stroom en groengas	Warmtepomp op stroom	
Woonlasten	€5 p/m MINDER	€ 0 p/m	
Woongemak	Blijft hetzelfde	Beter	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 3

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet ZONDER nieuwe radiatoren	Warmtepomp op stroom en groengas	
Woonlasten	€ 0 p/m	€10 p/m MEER	
Woongemak	Beetje beter	Beter	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 4

Kenmerken renovatie	*Keuze A*	*Keuze B*	*Keuze C - Uw huidige verwarming*
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtepomp op stroom	
Woonlasten	€5 p/m MINDER	€10 p/m MINDER	
Woongemak	Beetje slechter	Blijft hetzelfde	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Choice set 5

Kenmerken renovatie	*Keuze A*	*Keuze B*	*Keuze C - Uw huidige verwarming*
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtenet ZONDER nieuwe radiatoren	
Woonlasten	€10 p/m MEER	€10 p/m MINDER	
Woongemak	Beetje beter	Beetje slechter	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 6

Kenmerken renovatie	*Keuze A*	*Keuze B*	*Keuze C - Uw huidige verwarming*
Nieuwe verwarming	Warmtenet ZONDER nieuwe radiatoren	Warmtepomp op stroom en groengas	
Woonlasten	€10 p/m MEER	€ 0 p/m	
Woongemak	Beetje slechter	Blijft hetzelfde	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 7

Kenmerken renovatie	Keuze A	Keuze B	Keuze C- Uw huidige verwarming
Nieuwe verwarming	Warmtepomp op stroom en groengas	Warmtepomp op stroom	
Woonlasten	€ 0 p/m	€5 p/m MINDER	
Woongemak	Beetje beter	Beetje slechter	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 8

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Huidige verwarming
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtepomp op stroom	
Woonlasten	€10 p/m MEER	€ 0 p/m	
Woongemak	Blijft hetzelfde	Beetje slechter	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Choice sets questionnaire 2

Choice set 9

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet ZONDER nieuwe radiatoren	Warmtepomp op stroom en groengas	
Woonlasten	€10 p/m MINDER	€5 p/m MINDER	
Woongemak	Beter	Beetje beter	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 10

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtepomp op stroom en groengas	Warmtepomp op stroom	
Woonlasten	€10 p/m MINDER	€10 p/m MEER	
Woongemak	Beter	Blijft hetzelfde	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 11

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet ZONDER nieuwe radiatoren	Warmtenet MET nieuwe radiatoren	
Woonlasten	€ 0 p/m	€5 p/m MINDER	
Woongemak	Blijft hetzelfde	Beter	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Choice set 12

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtepomp op stroom	Warmtepomp op stroom en groengas	
Woonlasten	€10 p/m MINDER	€10 p/m MEER	
Woongemak	Beetje beter	Beetje slechter	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Choice set 13

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtepomp op stroom	
Woonlasten	€10 p/m MINDER	€5 p/m MINDER	
Woongemak	Beetje beter	Beter	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Choice set 14

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtenet ZONDER nieuwe radiatoren	
Woonlasten	€ 0 p/m	€5 p/m MINDER	
Woongemak	Beetje slechter	Beetje beter	
Overlast	Veel overlast	Weinig overlast	
Betere woning	Geen verandering	Nieuwe badkamer, keuken en/of toilet	
Betere wijk	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	Geen verandering	

Choice set 15

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtenet MET nieuwe radiatoren	Warmtepomp op stroom	
Woonlasten	€ 0 p/m	€10 p/m MEER	
Woongemak	Beter	Beetje beter	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Choice set 16

Kenmerken renovatie	Keuze A	Keuze B	Keuze C - Uw huidige verwarming
Nieuwe verwarming	Warmtepomp op stroom en groengas	Warmtenet ZONDER nieuwe radiatoren	
Woonlasten	€10 p/m MINDER	€5 p/m MINDER	
Woongemak	Beetje slechter	Blijft hetzelfde	
Overlast	Weinig overlast	Veel overlast	
Betere woning	Nieuwe badkamer, keuken en/of toilet	Geen verandering	
Betere wijk	Geen verandering	Uw wijk wordt fijner en de (sociale) problemen worden opgelost	

Appendix 4 – Questionnaire

Are you a tenant of a housing association?

Yes / no

Choice experiment

(2 questionnaires with) 8 choice sets based on the following attributes and levels.

1. New heating
   I) Heat network WITH new radiators II) Heat network WITHOUT new radiators
   III) Heat pump on electricity IV) Heat pump on electricity and green gas

2. Housing costs; this is the rent increase minus the saving on energy costs. If the number is - you will pay LESS, if the number is + you will pay MORE.
   *This has no influence on the rent allowance
   I) €10 p/m LESS II) € 5 p/m LESS
   III) € 0 p/m IV) €10 p/m MORE

3. Living comfort; consists of draft and temperature change
   I) Better II) A little better
   III) Remains the same IV) A little worse

4. Nuisance; you will be disturbed, you have to tidy up your house, there will be clutter
   I) A lot of nuisance II) Little nuisance

5. House improvement
   I) New bathroom, kitchen and/or toilet
   II) None

6. Neighborhood improvement
   I) Your neighborhood will get better and the (social) problems will be fixed
   II) None

Statements

1. I think my current living comfort is good.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

I would be willing to pay a bit more rent if …

2. … that would get me a new bathroom, kitchen and/or toilet.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

3. … that would make my dwelling more comfortable.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

4. … that would make my dwelling better for the environment.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

5. … that would decrease my energy bill (gas and electricity).

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

6. I know what a "Proeftuin" neighborhood or the program for natural gas-free neighborhoods is.
Yes / No

7. Did your housing association inform you about the energy transition in any of the ways described below? Indicate in which way.
Municipality, Letter, Newsletter, E-mail, Website, Social media, Not informed, Other.

8. I am satisfied with the communication from my housing association in relation to the energy transition.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

9. I am satisfied with the way my housing association sends me messages.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

10. I am satisfied with the amount of letters and / or emails my housing association sends.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

11. I am satisfied with the degree of participation I have in decisions the housing association makes regarding my house.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

12. I trust my housing association.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

13. My housing association adheres to agreements.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

14. I would recommend my housing associations to my family and friends.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

15. I believe that eventually something clever will be invented, so that the world will NOT become uninhabitable.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

16. I believe nature and the environment are strong enough to survive in today's modern (industrial) world.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

17. On earth, there are few places and resources (like food) that we have to share.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

18. The intention is that man is in charge of the rest of nature (like plants and animals).

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

19. If we continue like this, a major natural disaster will soon come.

STRONGLY AGREE, AGREE, NEUTRAL, DISAGREE, STRONGLY DISAGREE

General questions

20. I received this questionnaire by ……
E-mail / post / Linked-in / Facebook

21. I am …..
Male / Female

22. I am born in the year …..
…… (Ratio)

23. My highest education level (graduated) is……
1) Elementary school, 2) Vmbo, mbo1, havo onderbouw,
3) Havo bovenbouw, vwo, mbo, 4) Hbo, wo

24. I am ……
Single, living together, living together with child(ren), single parent, other

Question 25 is based on single/living together from question 24.

25A. I am …..
Working, not working, student, retired

25B. My household consists of ……
2 persons working, 1 person working and 1 person not working,
2 persons not working, students, retiree

26. How many children live in your house?
……. (ratio)

27. What age is the youngest child that lives in your house?
0-8, 9-13, 14-18, >18

28. My zip code is …… (4 numbers and 2 letters)
…. (ratio)

29. I live in a …..
Apartment, row house, corner house

30. I have lived in my house for ….. years.
    0-1, 2-5, 6-10, 11-15, 16-20, >20

31. I pay € ….. in rent per month (included service costs etc.)
    <300, 300-400, 400-500, 500-600, 600-752.33, >752.33, No answer

32. I receive rent allowance.
    Yes / No / No answer

33. I pay € …. for the energy bill per month (gas and electricity).
    <100, 100-130, 130-160, >160, No answer

34. My/our annual household income is € ……
    <1,791, 1,791-2,212, 2,212-3,000, 3,000-3,500, >3,500, No answer

35. Do you have any remarks?
    Open question

Appendix 5 – Questionnaire invitation letter

Questionnaire invitation e-mail (NL)

Onderwerp Uitnodigingsbrief deelname onderzoek

Datum 15 februari 2021

Contactpersoon Tom Wielders

Geachte heer/mevrouw,

Mijn naam is Tom Wielders en ik studeer aan de Technische Universiteit Eindhoven. Ik doe onderzoek samen met adviesbureau Atriensis projecten. Zoals u misschien weet worden er landelijk en in uw stad plannen gemaakt om in de toekomst genoeg energie te leveren. Met uw hulp wil ik bepalen wat u als huurder van een corporatiewoning het belangrijkste vindt wanneer u een verwarming in uw woning zou krijgen zonder aardgas. Door het invullen van de vragenlijst weten gemeenten en woningcorporaties beter wat wensen van huurders zijn en kunnen ze hier rekening mee houden.

De vragen uit de vragenlijst zijn alleen voor dit onderzoek bedoeld. Uw antwoorden op de vragen hebben dus geen enkele invloed op u, uw woning, of uw huurprijs. De vragenlijst is namelijk ANONIEM. Dat betekent dat uw persoonlijke antwoorden en gegevens NIET worden gedeeld met uw woningcorporatie of iemand anders. Alles wordt verwerkt tot een algemeen onderzoek op complex niveau en dat wordt gedeeld met de andere partijen.

Het invullen van de vragenlijst duurt ongeveer 10 minuten. Doet u mee? Dan maakt u kans op:

Eén van de 11 VVV-cadeaubonnen tussen de € 10 en € 25 of één van de Atriensis energiespellen.

U kunt deelnemen aan de vragenlijst door hier op de link te klikken of door de QR-code te scannen met uw mobiele telefoon.

Heel erg bedankt dat u wilt meedoen aan mijn onderzoek.

Hartelijke groet,

Tom Wielders

Questionnaire invitation letter (NL)

Onderwerp Uitnodigingsbrief deelname onderzoek

Datum 15 februari 2021

Contactpersoon Tom Wielders

Geachte heer/mevrouw,

Mijn naam is Tom Wielders en ik studeer aan de Technische Universiteit Eindhoven. Ik doe onderzoek samen met adviesbureau Atriensis projecten. Zoals u misschien weet worden er landelijk en in uw stad plannen gemaakt om in de toekomst genoeg energie te leveren. Met uw hulp wil ik bepalen wat u als huurder van een corporatiewoning het belangrijkste vindt wanneer u een verwarming in uw woning zou krijgen zonder aardgas. Door het invullen van de vragenlijst weten gemeenten en woningcorporaties beter wat wensen van huurders zijn en kunnen ze hier rekening mee houden.

De vragen uit de vragenlijst zijn alleen voor dit onderzoek bedoeld. Uw antwoorden op de vragen hebben dus geen enkele invloed op u, uw woning, of uw huurprijs. De vragenlijst is namelijk ANONIEM. Dat betekent dat uw antwoorden en gegevens NIET worden gedeeld met uw woningcorporatie of iemand anders. Alles wordt verwerkt tot een algemeen onderzoek en dat wordt gedeeld met de andere partijen.

Het invullen van de vragenlijst duurt ongeveer 10 minuten. Doet u mee? Dan maakt u kans op:

Eén van de 11 VVV-cadeaubonnen tussen de € 10 en € 25 of één van de Atriensis energiespellen.

U kunt deelnemen aan de vragenlijst door de URL-code in te vullen in de zoekbalk op het internet of door de QR-code te scannen met uw mobiele telefoon.

https://tueindhoven.limequery.com/783423?newtest=Y&lang=nl

Heel erg bedankt dat u wilt meedoen aan mijn onderzoek.

Hartelijke groet,

Tom Wielders

Appendix 6 – Participating housing associations

Table 15 Participating housing associations and potential respondents

Neighborhood	Housing association	Potential participants	PAW-neighborhood	Post / E-mail	Corporation name included
Hagerhof-Oost	Woonwenz	508	Yes	Post	Yes
-	Ons Huis	1168	No	E-mail	Yes
Beuningen en Druten West	Woonwaarts	1554	No	E-mail	Yes
Terheijden	Woonvizier	77	Yes	Post	No
	Waardwonen	350	No	Post	Yes
Delfzijl-Noord	Acantus	1503	Yes	Post	Yes
Maasniel, Tegelarijenveld	Nester	50	Yes	Post	No
Quirijnstok	Wonen Breburg	132	Yes	Post	No
Swalmen centrum	Nester	248	No	Post	No
	Tablis Wonen		No		
	Total	**5590**			

Appendix 7 – Descriptive analyses

Frequency tables

Table 16 Frequency table of acceptance and rejection of renovation proposition in choice experiment

Acceptance or rejection of renovation proposition

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Answer C (none of the above)	429	14.11	14.11	14.11
	Answer A or B (acceptance of renovation)	2611	85.89	85.89	100.0
	Total	3040	100.0	100.0	

Table 17 Frequency table containing how the respondents received the questionnaire

Received Questionnaire

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	E-mail	294	77.4	77.4	77.4
	Facebook	6	1.6	1.6	78.9
	Linked-in	10	2.6	2.6	81.6
	Post	70	18.4	18.4	100.0
	Total	380	100.0	100.0	

Table 18 Frequency table containing the gender of the respondents

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Man	168	44.2	44.2	44.2
	Woman	212	55.8	55.8	100.0
	Total	380	100.0	100.0	

Table 19 Frequency table containing the year of birth of the respondents

Year of birth

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1941 and older	25	6.6	6.6	6.6
	1942-1951	66	17.4	17.4	23.9
	1952-1961	93	24.5	24.5	48.4
	1962-1971	76	20.0	20.0	68.4
	1972-1981	53	13.9	13.9	82.4
	1982-1991	48	12.6	12.6	95.0
	1992-2001	19	5.0	5.0	100.0
	Total	380	100.0	100.0	

Table 20 Frequency table containing the education level of the respondents

Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Elementary school	20	5.3	5.3	5.3
	Havo bovenbouw, vwo, mbo	141	37.1	37.1	42.4
	Hbo, wo	83	21.8	21.8	64.2
	Vmbo, mbo1, havo onderbouw	136	35.8	35.8	100.0
	Total	380	100.0	100.0	

Table 21 Frequency table containing the household composition of the respondents

Household Composition

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Living together	119	31.3	31.3	31.3
	Living together with children	47	12.4	12.4	43.7
	Single	159	41.8	41.8	85.5
	Single parent with children	55	14.5	14.5	100.0
	Total	380	100.0	100.0	

Table 22 Frequency table containing the respondents' work status

Work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Do not work	55	14.5	14.5	14.5
	One works one does not work	40	10.5	10.5	25.0
	Retired	129	33.9	33.9	58.9
	Work	156	41.1	41.1	100.0
	Total	380	100.0	100.0	

Table 23 Frequency table containing the number of children the respondents have

Number of Children

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	49	50.0	50.0	50.0
	2	34	34.7	34.7	84.7
	3 or more	15	15.3	15.3	100.0
	Total	98	100.0	100.0	

Table 24 Frequency table containing the age of respondent's youngest child

Age Youngest Child

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 - 8	28	28.6	28.6	28.6
	9 - 13	20	20.4	20.4	49.0
	14 -18	20	20.4	20.4	69.4
	Older than 18	30	30.6	30.6	100.0
	Total	98	100.0	100.0	

Table 25 Frequency table containing the respondents' dwelling type

Dwelling Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Apartment	119	31.3	31.3	31.3
	Corner house	79	20.8	20.8	52.1
	Row house	182	47.9	47.9	100.0
	Total	380	100.0	100.0	

Table 26 Frequency table containing the number of years the respondents have lived in their current house

Time Lived In House (in years)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-1	39	10.3	10.3	10.3
	11-20	64	16.8	16.8	27.1
	2-5	93	24.5	24.5	51.6
	6-10	69	18.2	18.2	69.7
	more than 20	115	30.3	30.3	100.0
	Total	380	100.0	100.0	

Table 27 Frequency table containing the amount of rent the respondents pay

Rent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	500 - 600	120	31.6	31.6	31.6
	600 - 752	195	51.3	51.3	82.9
	Less than 500	33	8.7	8.7	91.6
	More than 753	23	6.1	6.1	97.6
	No answer	9	2.4	2.4	100.0
	Total	380	100.0	100.0	

Table 28 Frequency table containing whether the respondents receive rent allowance

Rent Allowance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	189	49.7	49.7	49.7
	No answer	15	3.9	3.9	53.7
	Yes	176	46.3	46.3	100.0
	Total	380	100.0	100.0	

Table 29 Frequency table containing the amount of energy costs the respondents pay per month

Energy Costs (p/m)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	100 - 130	130	34.2	34.2	34.2
	130 - 160	90	23.7	23.7	57.9
	Less than 100	107	28.2	28.2	86.1
	More than 160	34	8.9	8.9	95.0
	No answer	19	5.0	5.0	100.0
	Total	380	100.0	100.0	

Table 30 Frequency table containing the household income the respondents receive

Household Income

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1791 - 2212	86	22.6	22.6	22.6
	Less than 1791	133	35.0	35.0	57.6
	More than 2212	95	25.0	25.0	82.6
	No answer	66	17.4	17.4	100.0
	Total	380	100.0	100.0	

Table 31 Frequency table containing the respondents' satisfaction with the housing association's communication about natural gas-free

Satisfied with housing association's communication about natural gas-free

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	54	14.2	14.2	14.2
	2	98	25.8	25.8	40.0
	3	179	47.1	47.1	87.1
	4	42	11.1	11.1	98.2
	5	7	1.8	1.8	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 32 Frequency table containing the respondents' satisfaction with the way their housing association communicates (sends messages)

Satisfied with housing association's way of communicating (sending messages)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	13	3.4	3.4	3.4
	2	35	9.2	9.2	12.6
	3	136	35.8	35.8	48.4
	4	173	45.5	45.5	93.9
	5	23	6.1	6.1	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 33 Frequency table containing the respondents' satisfaction with the number of messages their housing association sends

Satisfied with number of messages my housing association sends

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	19	5.0	5.0	5.0
	2	33	8.7	8.7	13.7
	3	155	40.8	40.8	54.5
	4	155	40.8	40.8	95.3
	5	18	4.7	4.7	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 34 Frequency table containing the respondents satisfaction about their tenant say in relation to decisions regarding their house

Satisfied with the amount of tenant say I have in relation to decisions regarding my house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	48	12.6	12.6	12.6
	2	86	22.6	22.6	35.3
	3	168	44.2	44.2	79.5
	4	67	17.6	17.6	97.1
	5	11	2.9	2.9	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 35 Frequency table containing the respondents' trust in their housing association

I trust my housing association

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	12	3.2	3.2	3.2
	2	17	4.5	4.5	7.6
	3	138	36.3	36.3	43.9
	4	182	47.9	47.9	91.8
	5	31	8.2	8.2	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 36 Frequency table containing whether the respondents think their housing association meets their agreements

My housing association meets its agreements

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	13	3.4	3.4	3.4
	2	26	6.8	6.8	10.3
	3	113	29.7	29.7	40.0
	4	187	49.2	49.2	89.2
	5	41	10.8	10.8	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 37 Frequency table containing whether the respondents would recommend their housing association to their family and friends

I would recommend my housing association to family and friends

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	2.9	2.9	2.9
	2	22	5.8	5.8	8.7
	3	139	36.6	36.6	45.3
	4	168	44.2	44.2	89.5
	5	40	10.5	10.5	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 38 Frequency table containing whether respondents think that something smart will be invented so that the world will not become uninhabitable

Something smart will be invented so that the world will not become uninhabitable

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	23	6.1	6.1	6.1
	2	179	47.1	47.1	53.2
	3	135	35.5	35.5	88.7
	4	30	7.9	7.9	96.6
	5	13	3.4	3.4	100.0
	Total	380	100.0	100.0	

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree **(reversed)**

Table 39 Frequency table containing whether respondents think that nature and the environment are strong enough to survive the modern (industrial) world

Nature and the environment are strong enough to survive the modern (industrial) world

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	14	3.7	3.7	3.7
	2	66	17.4	17.4	21.1
	3	92	24.2	24.2	45.3
	4	143	37.6	37.6	82.9
	5	65	17.1	17.1	100.0
	Total	380	100.0	100.0	

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree **(reversed)**

Table 40 Frequency table containing whether respondents think the earth has limited space and resources (like food) that we have to share

The earth has limited space and resources (like food) that we have to share

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	2.9	2.9	2.9
	2	89	23.4	23.4	26.3
	3	158	41.6	41.6	67.9
	4	95	25.0	25.0	92.9
	5	27	7.1	7.1	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 41 Frequency table containing whether respondent think humans are meant to rule over the rest of nature

Humans are meant to rule over the rest of nature

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	2.4	2.4	2.4
	2	47	12.4	12.4	14.7
	3	94	24.7	24.7	39.5
	4	146	38.4	38.4	77.9
	5	84	22.1	22.1	100.0
	Total	380	100.0	100.0	

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree **(reversed)**

Table 42 Frequency table containing whether respondents think that a major natural disaster will occur if we continue like this

If we continue like this a major natural disaster will occur soon

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	2.4	2.4	2.4
	2	48	12.6	12.6	15.0
	3	144	37.9	37.9	52.9
	4	113	29.7	29.7	82.6
	5	66	17.4	17.4	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 43 Frequency table containing whether respondents are willing to pay for a new bathroom, kitchen, or toilet

Willingness to pay for new bathroom, kitchen, or toilet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	68	17.9	17.9	17.9
	2	89	23.4	23.4	41.3
	3	88	23.2	23.2	64.5
	4	98	25.8	25.8	90.3
	5	37	9.7	9.7	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 44 Frequency table containing whether respondents are willing to pay for a comfort improvement

Willingness to pay for comfort improvement

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	39	10.3	10.3	10.3
	2	56	14.7	14.7	25.0
	3	99	26.1	26.1	51.1
	4	149	39.2	39.2	90.3
	5	37	9.7	9.7	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 45 Frequency table containing whether respondent are willing to pay to improve their dwelling so that it is better for the environment

Willingness to pay to improve dwelling so that it is better for the environment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	29	7.6	7.6	7.6
	2	35	9.2	9.2	16.8
	3	98	25.8	25.8	42.6
	4	162	42.6	42.6	85.3
	5	56	14.7	14.7	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 46 Frequency table containing whether respondent are willing to pay for a reduction in energy costs

Willingness to pay to reduce energy costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	20	5.3	5.3	5.3
	2	12	3.2	3.2	8.4
	3	68	17.9	17.9	26.3
	4	188	49.5	49.5	75.8
	5	92	24.2	24.2	100.0
	Total	380	100.0	100.0	

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Histograms

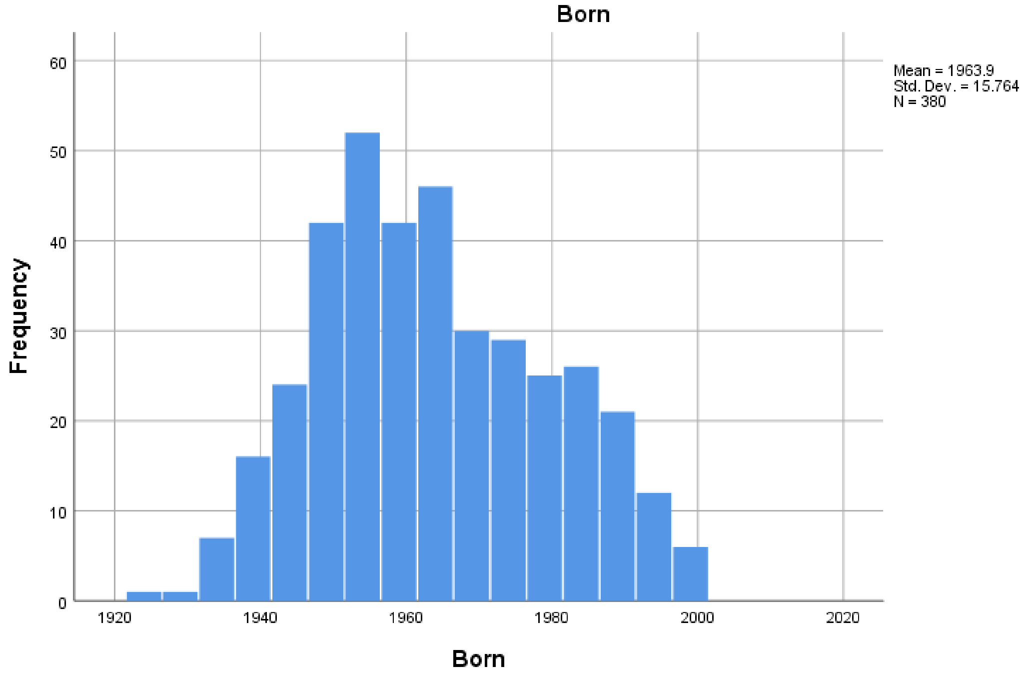


Figure 27 Histogram containing the respondents' year of birth

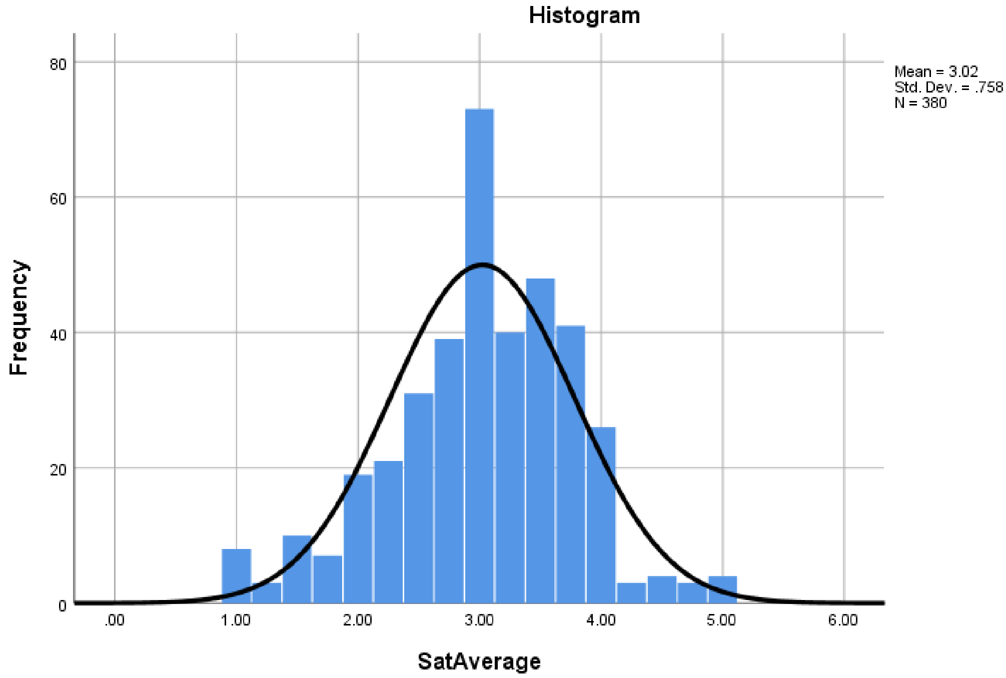
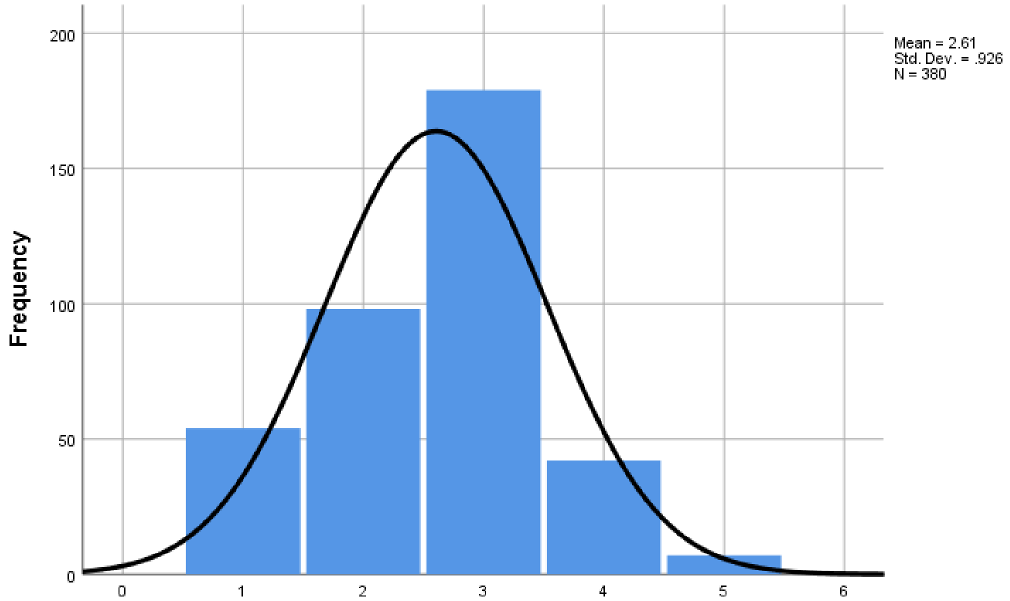
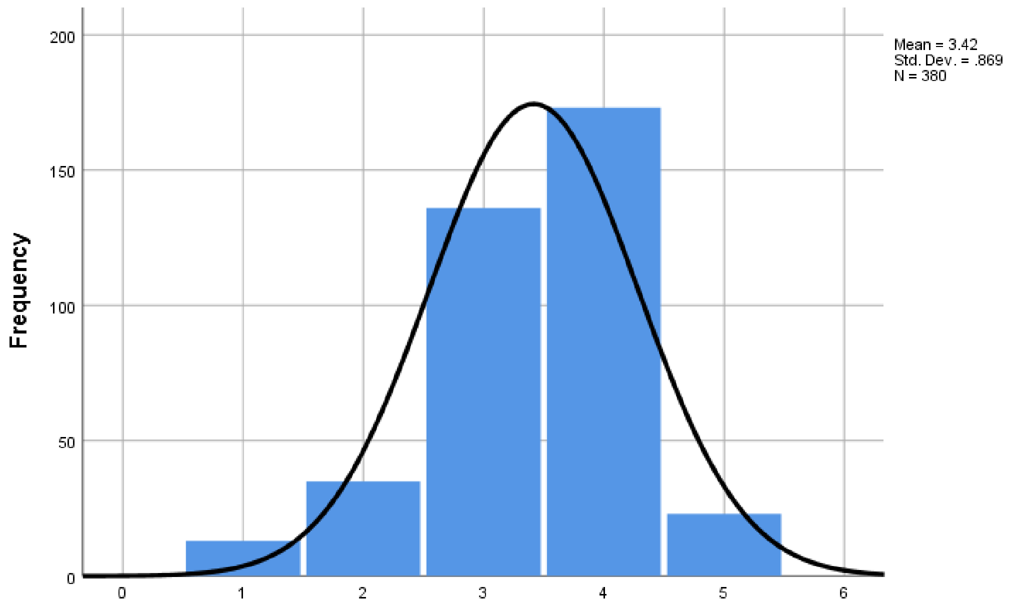


Figure 28 Histogram containing the respondents' average satisfaction with their housing association's communication



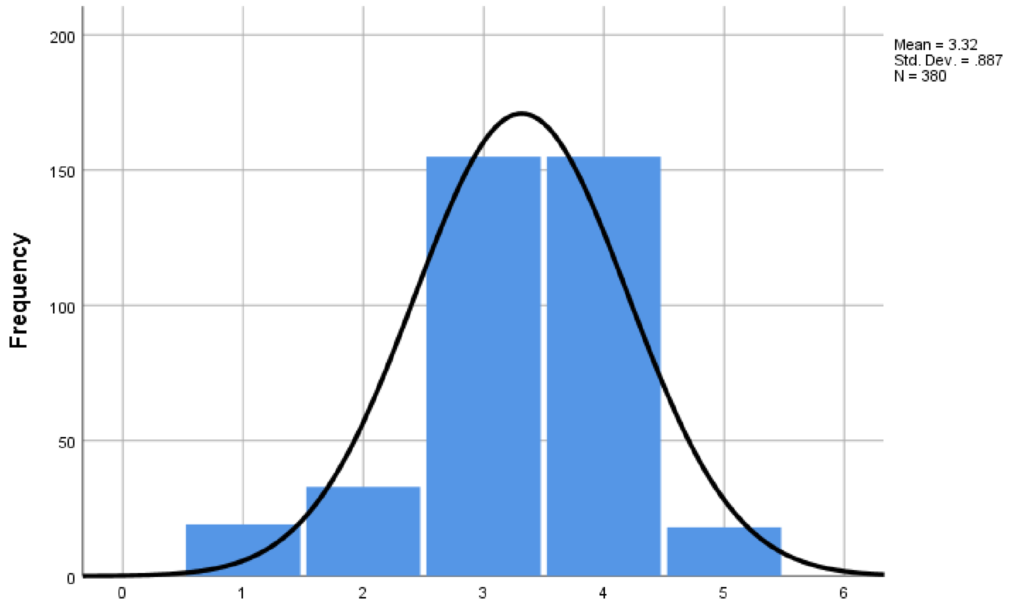
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 29 Histogram containing the respondents' satisfaction with their housing association's communication about natural gas-free



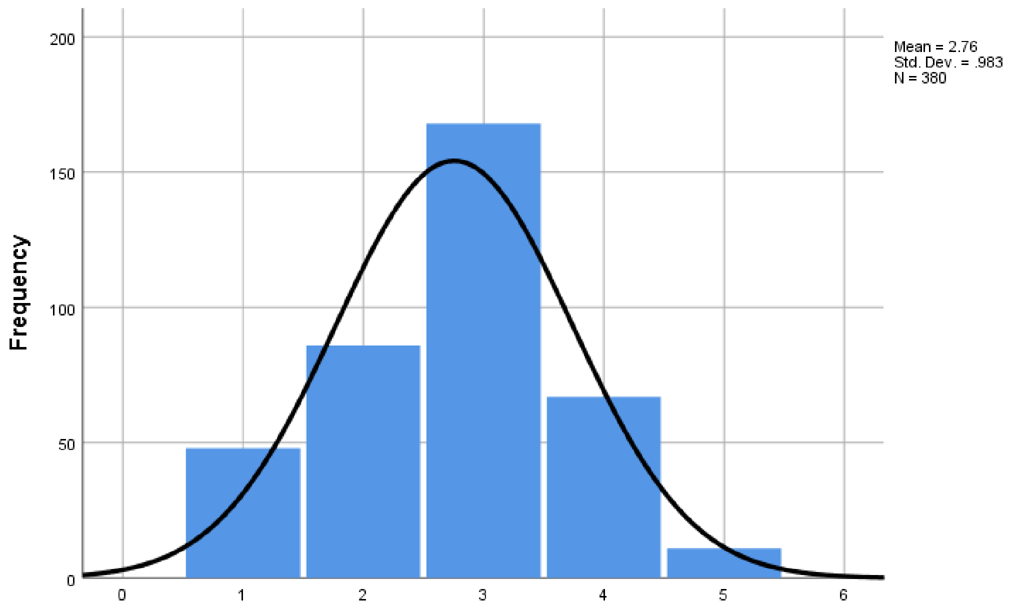
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 30 Histogram containing the respondents' satisfaction with the housing association's way of communicating (sending messages)



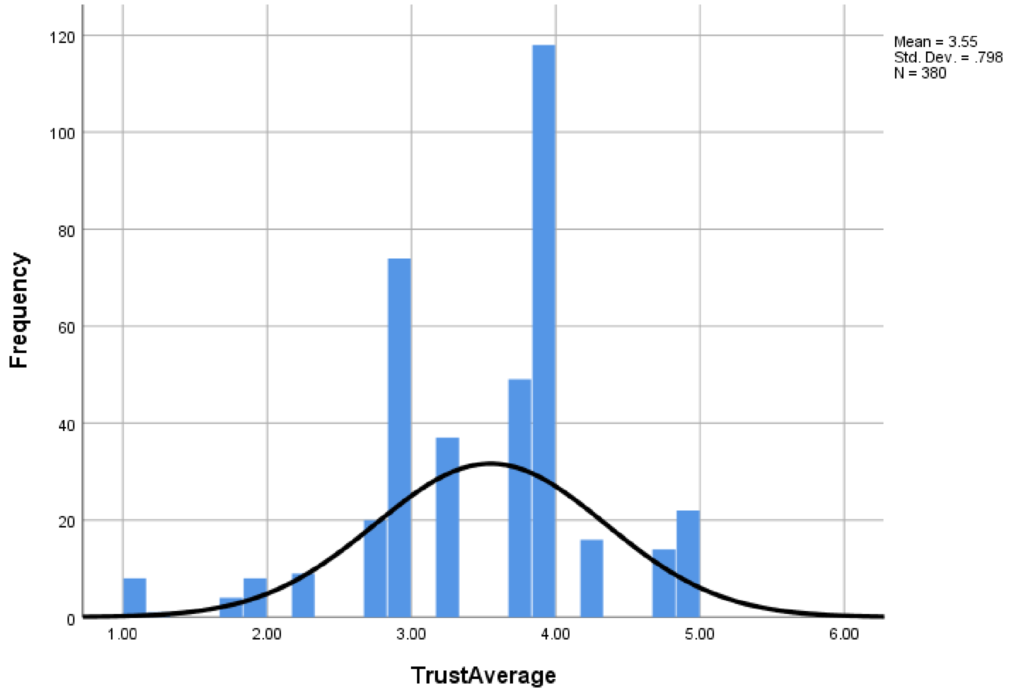
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 31 Histogram containing the respondents' satisfaction with the housing association's communication frequency



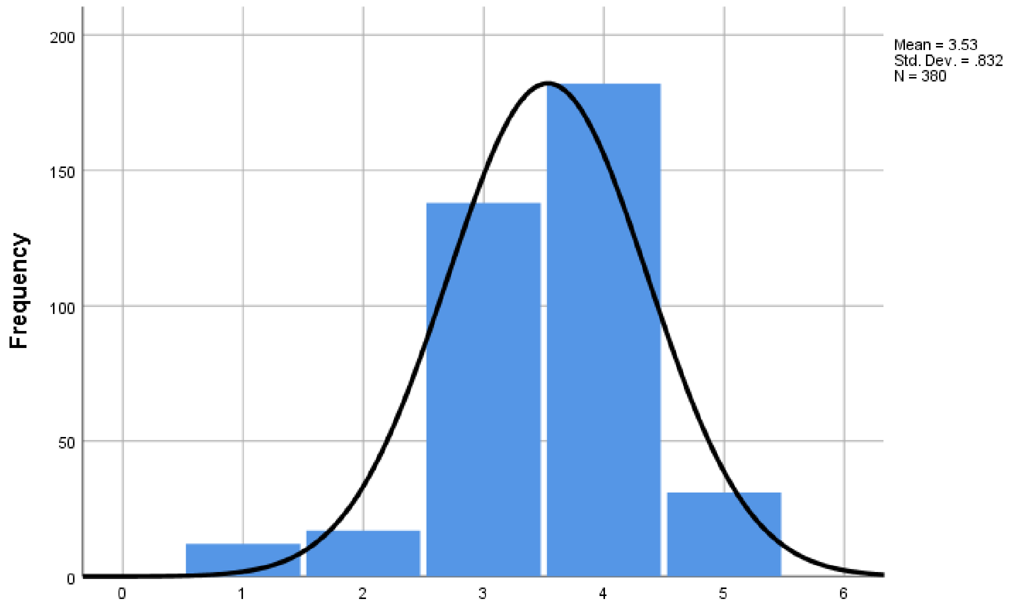
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 32 Histogram containing the respondents' satisfaction with the amount of tenant say they have in relation to the decisions made regarding their dwelling



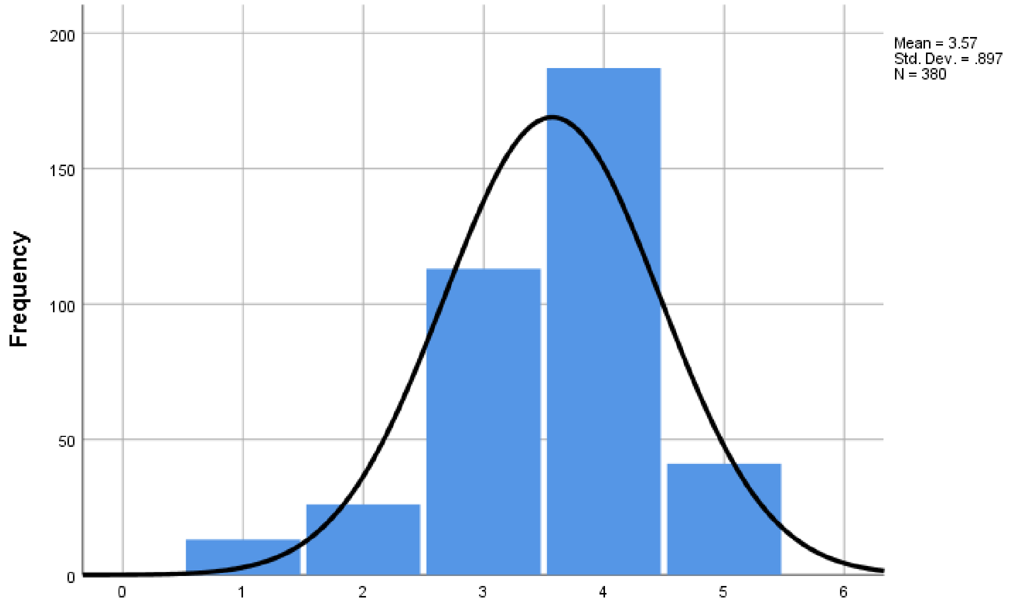
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 33 Histogram containing the respondents' average trust in the housing association



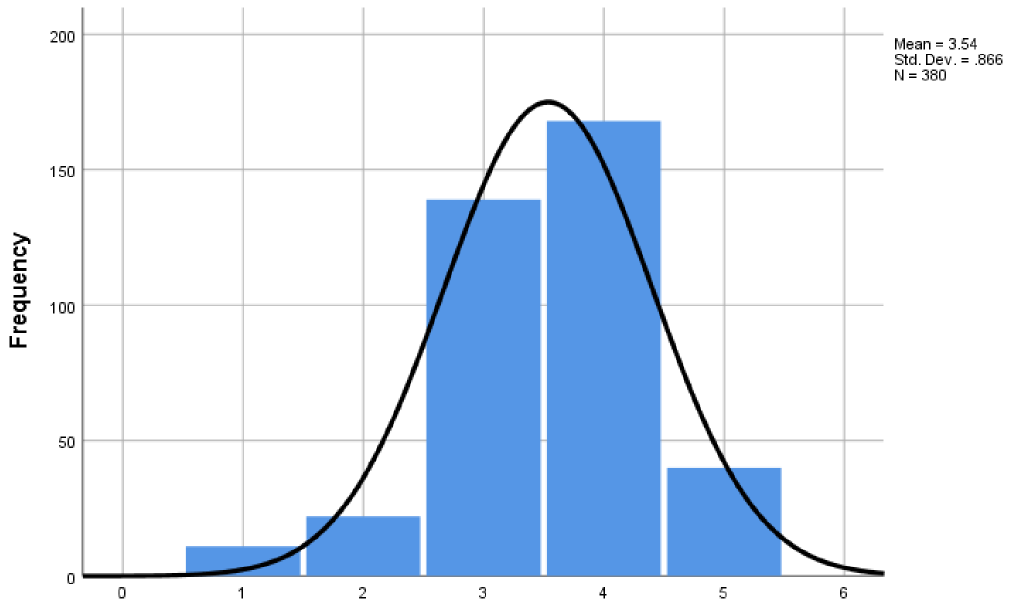
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 34 Histogram containing the respondents' trust in the housing association



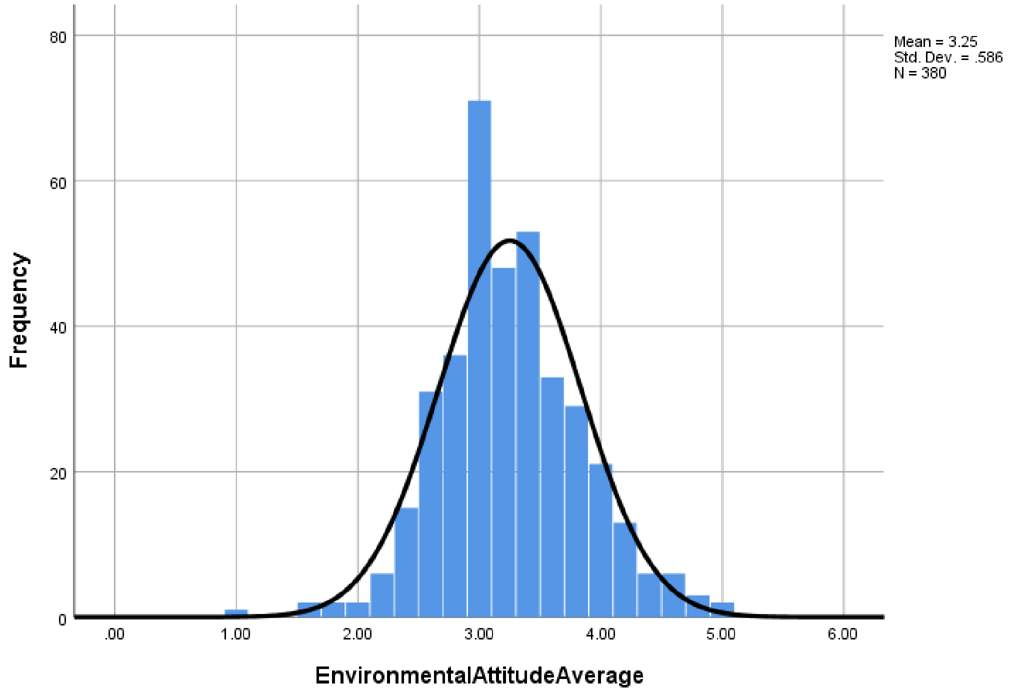
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 35 Histogram containing whether respondents think the housing association meets its agreements



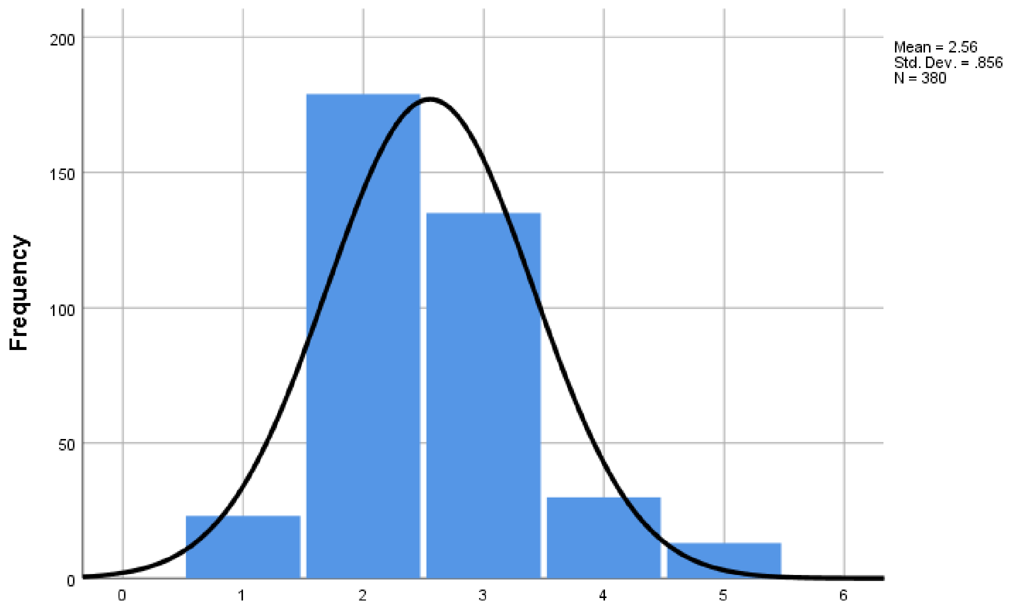
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 36 Histogram containing whether respondents' would recommend their housing association to their family and friends



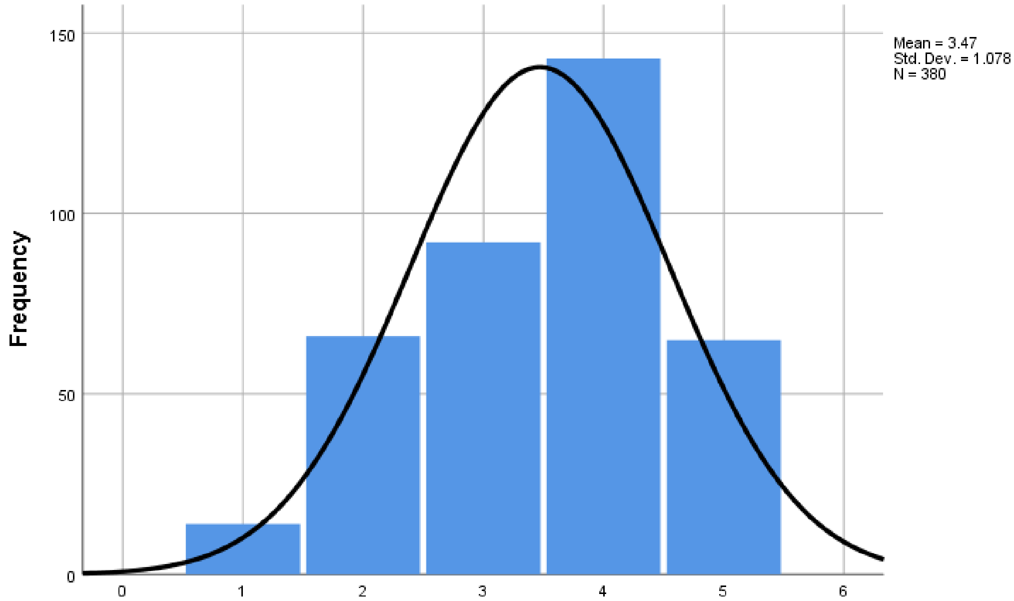
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 37 Histogram containing the respondents' average environmental attitude



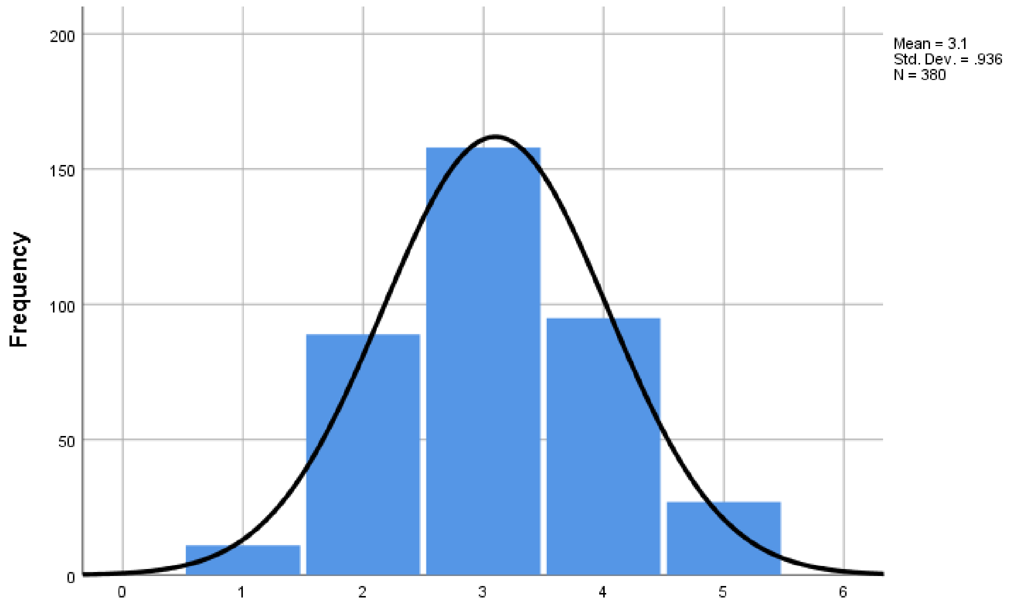
1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree **<u>(reversed)</u>**

Figure 38 Histogram containing whether respondents think that something smart will be invented so that the world will not become uninhabitable



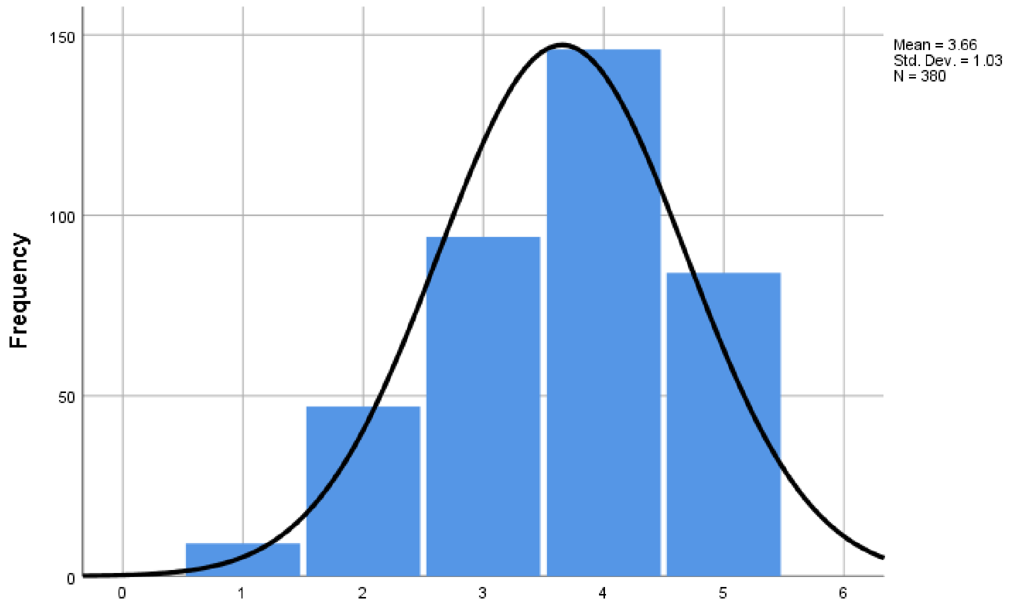
1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree **(reversed)**

Figure 39 Histogram containing whether respondents think nature and the environment is strong enough to survive the modern (industrial) world



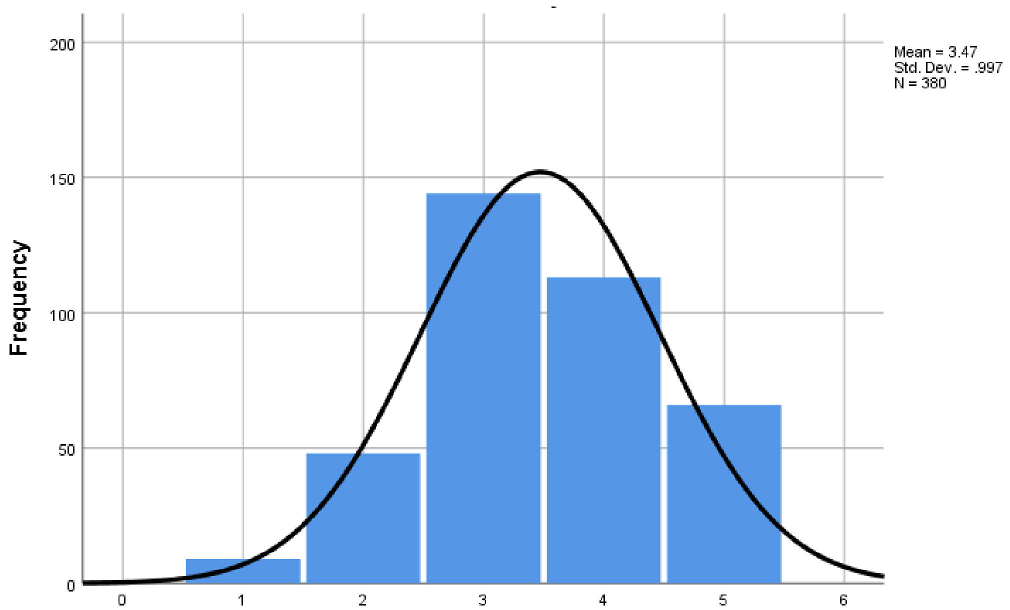
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 40 Histogram containing whether respondents think the earth has limited resources (like food) that we have to share



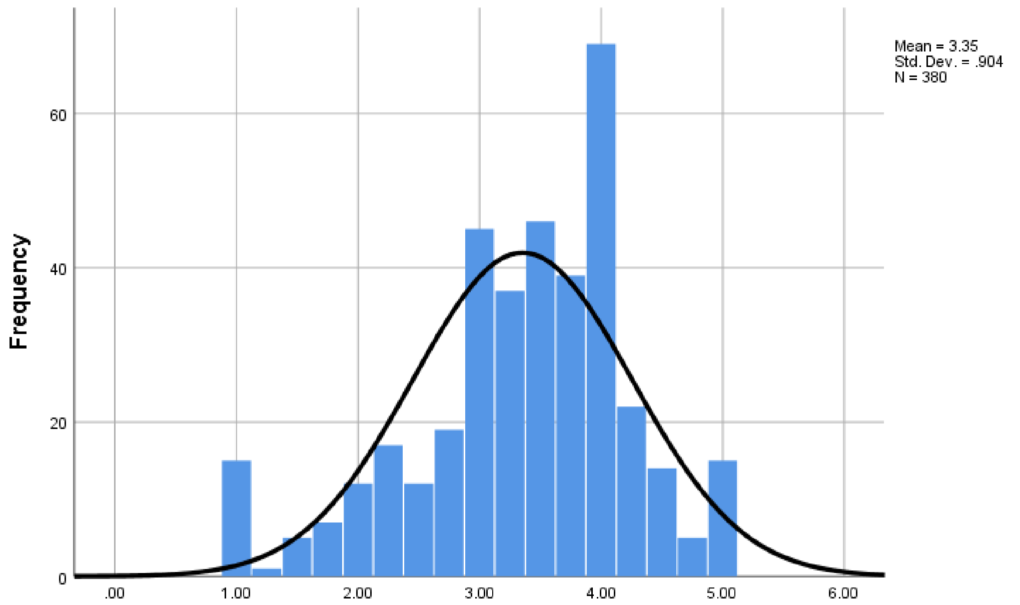
1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree **(reversed)**

Figure 41 Histogram containing whether respondents think humans are meant to rule over the rest of nature



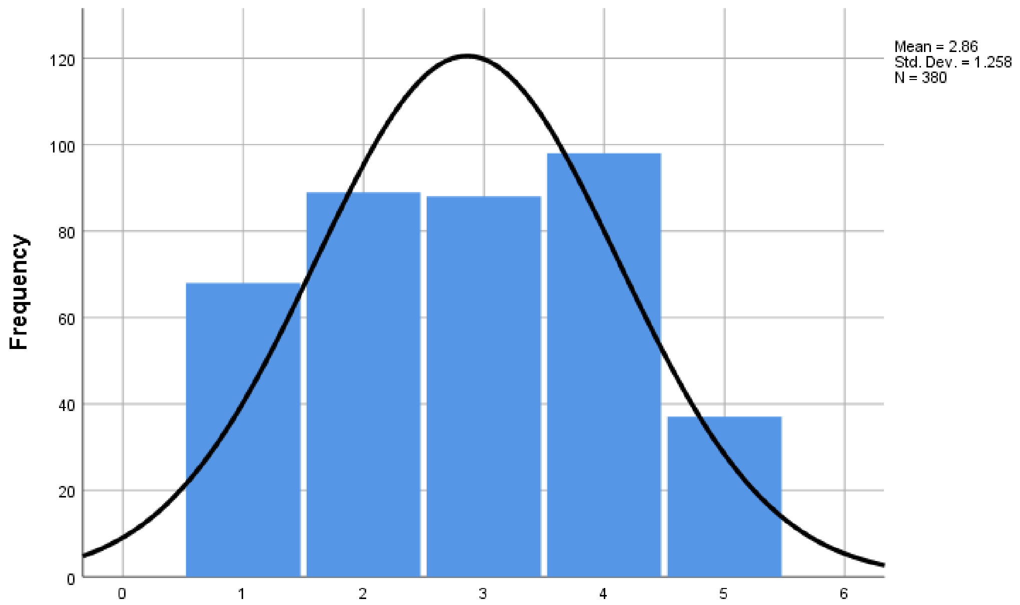
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 42 Histogram containing whether respondents think a major natural disaster will occur when we continue like this



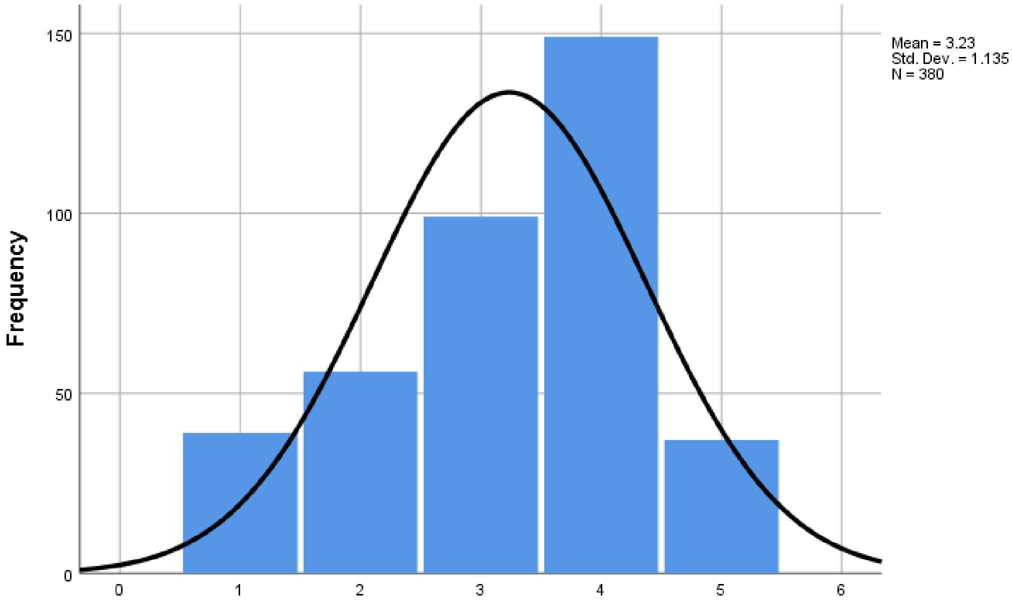
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 43 Histogram containing the respondents' average willingness to pay



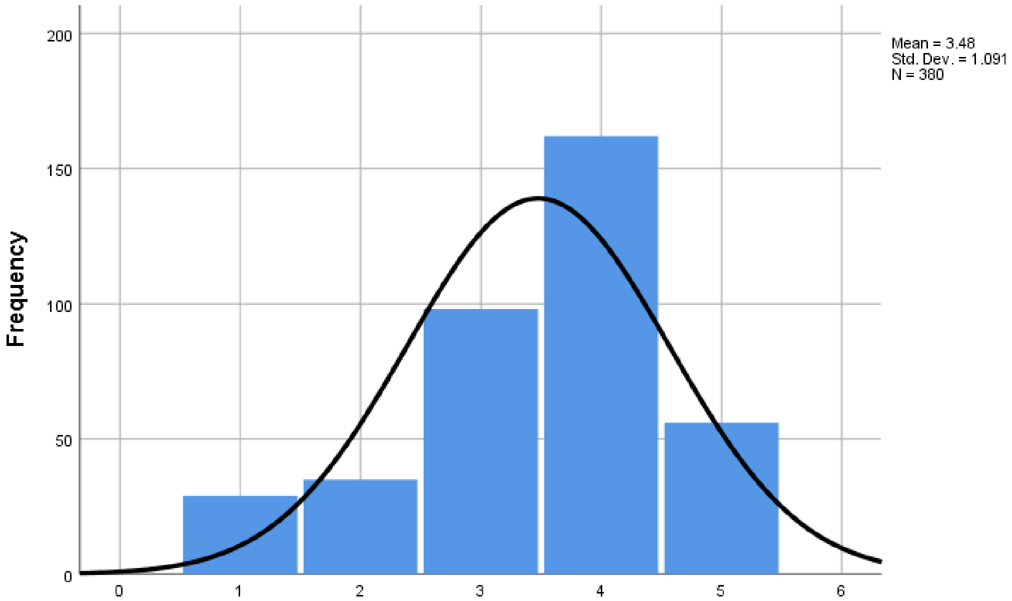
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 44 Histogram containing whether respondents are willing to pay for a new bathroom, kitchen, or toilet



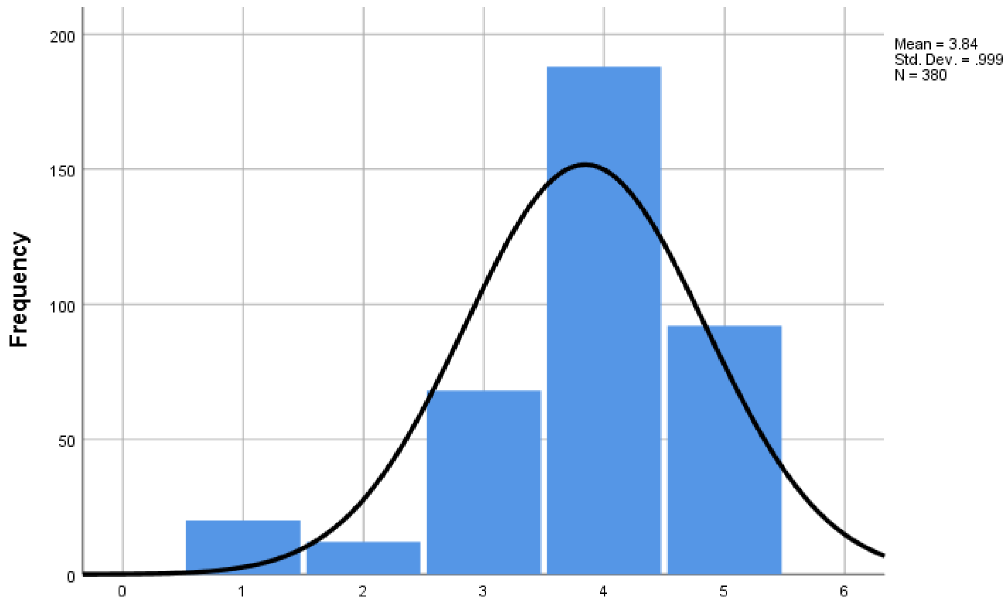
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 45 Histogram containing whether respondents are willing to pay for a comfort improvement



1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 46 Histogram containing whether respondents are willing to pay to improve their dwelling so that it is better for the environment



1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Figure 47 Histogram containing whether respondents are willing to pay for a reduction in energy costs

Cross-tabs

Statement factor regarding average satisfaction of housing association's communication

Table 47 Cross-tabs: statement factor regarding average communication satisfaction

Crosstab

Count

		Average satisfaction with communication housing association																	
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	Total
Gender	Man	4	0	6	2	6	8	16	13	40	19	19	19	8	2	2	2	2	168
	Woman	4	3	4	5	13	13	15	26	33	21	29	22	18	1	2	1	2	212
Total		8	3	10	7	19	21	31	39	73	40	48	41	26	3	4	3	4	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Year of birth	1941 and older	1	0	1	1	2	1	1	3	1	4	4	3	2	0	0	0	1	25
	1942-1951	2	0	3	1	0	2	8	2	19	8	6	9	5	0	1	0	0	66
	1952-1961	1	0	2	2	9	2	5	12	17	11	11	11	6	0	2	1	1	93
	1962-1971	2	2	2	1	5	6	5	7	14	5	13	8	4	2	0	0	0	76
	1972-1981	1	0	0	0	1	1	5	8	13	8	5	2	5	1	0	2	1	53
	1982-1991	0	1	1	2	2	7	3	6	4	3	8	6	4	0	0	0	1	48
	1992-2001	1	0	1	0	0	2	4	1	5	1	1	2	0	0	1	0	0	19
Total		8	3	10	7	19	21	31	39	73	40	48	41	26	3	4	3	4	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Education	Elementary school	0	0	0	0	1	0	1	2	3	4	3	4	1	0	0	0	1	20
	Havo bovenbouw, vwo, mbo	3	3	3	3	4	10	10	13	29	12	17	18	7	3	1	2	3	141
	Hbo, wo	3	0	1	2	8	4	13	10	11	9	10	7	5	0	0	0	0	83
	Vmbo, mbo1, havo onderbouw	2	0	6	2	6	7	7	14	30	15	18	12	13	0	3	1	0	136
Total		8	3	10	7	19	21	31	39	73	40	48	41	26	3	4	3	4	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Household Composition	Living together	2	0	4	3	4	6	9	9	26	10	13	19	12	0	1	0	1	119
	Living together with children	1	0	2	0	6	1	5	8	6	2	5	4	4	0	1	1	1	47
	Single	4	3	3	2	7	10	15	15	27	24	22	12	7	2	2	2	2	159
	Single parent with children	1	0	1	2	2	4	2	7	14	4	8	6	3	1	0	0	0	55
Total		8	3	10	7	19	21	31	39	73	40	48	41	26	3	4	3	4	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Household Income	1791 - 2212	1	1	1	3	3	5	7	8	13	13	7	15	6	0	1	1	1	86
	Less than 1791	3	1	4	2	8	10	10	12	26	12	22	8	8	2	2	1	2	133
	More than 2212	4	0	4	1	2	6	6	13	21	5	13	12	7	0	1	0	0	95
	No answer	0	1	1	1	6	0	8	6	13	10	6	6	5	1	0	1	1	66
Total		8	3	10	7	19	21	31	39	73	40	48	41	26	3	4	3	4	380

Table 48 Chi-Square test: statement factor regarding average communication satisfaction

Chi-Square Tests

	Chi-Square	df	Asymptotic Significance (2-sided)
Gender	15.521	16	0.487
Year of birth	102.022	96	0.318
Education	51.862	48	0.326
Household composition	47.415	48	0.497
Household income	45.405	48	0.580

Statement factor regarding average trust in housing association

Table 49 Cross-tabs: statement factor regarding average housing association trust

Crosstab

Count

		Average trust in housing association													
		1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	Total
Gender	Man	4	0	3	2	3	7	33	14	22	52	10	7	11	168
	Woman	4	1	1	6	6	13	41	23	27	66	6	7	11	212
Total		8	1	4	8	9	20	74	37	49	118	16	14	22	380
		1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	
Year of birth	1941 and older	1	0	0	0	2	2	5	0	4	8	2	0	1	25
	1942-1951	0	0	0	0	1	6	7	7	10	26	3	3	3	66
	1952-1961	2	1	2	2	0	4	28	3	12	25	4	4	6	93
	1962-1971	4	0	1	2	4	2	14	10	8	25	1	1	4	76
	1972-1981	0	0	1	0	1	1	11	8	9	13	5	2	2	53
	1982-1991	0	0	0	4	1	3	6	7	5	14	0	4	4	48
	1992-2001	1	0	0	0	0	2	3	2	1	7	1	0	2	19
Total		8	1	4	8	9	20	74	37	49	118	16	14	22	380
		1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	
Education	Elementary school	0	0	0	0	1	3	2	1	2	5	4	1	1	20
	Havo bovenbouw , vwo, mbo	3	0	2	4	5	3	26	14	17	47	4	5	11	141
	Hbo, wo	3	0	1	4	2	7	11	11	10	25	5	3	1	83
	Vmbo, mbo1, havo onderbouw	2	1	1	0	1	7	35	11	20	41	3	5	9	136
Total		8	1	4	8	9	20	74	37	49	118	16	14	22	380
		1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	
Household Composition	Living together	1	0	3	1	2	10	20	9	16	41	4	5	7	119
	Living together with children	3	0	0	1	1	3	7	4	9	10	2	3	4	47
	Single	3	1	1	4	2	6	35	17	20	48	6	6	10	159
	Single parent with children	1	0	0	2	4	1	12	7	4	19	4	0	1	55
Total		8	1	4	8	9	20	74	37	49	118	16	14	22	380
		1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	
Household Income	1791 - 2212	1	0	0	1	1	5	16	9	15	27	3	4	4	86
	Less than 1791	1	1	0	4	3	9	34	10	13	40	4	4	10	133
	More than 2212	3	0	3	1	2	3	9	10	15	35	4	6	4	95
	No answer	3	0	1	2	3	3	15	8	6	16	5	0	4	66
Total		8	1	4	8	9	20	74	37	49	118	16	14	22	380

Table 50 Chi-Square test: statement factor regarding average housing association trust

Chi-Square Tests

	Chi-Square	df	Asymptotic Significance (2-sided)
Gender	8.038	12	0.782
Year of birth	82.665	72	0.183
Education	48.348	36	0.082
Household composition	37.379	36	0.406
Household income	40.200	36	0.290

Statement factor regarding average environmental attitude

Table 51 Cross-tabs: statement factor average environmental attitude

Crosstab

Count

		Average environmental attitude																			
		1.00	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	Total
Gender	Man	1	1	2	1	4	7	14	6	32	20	27	20	9	11	6	2	2	1	2	168
	Woman	0	1	0	1	2	8	17	30	39	28	26	13	20	10	7	4	4	2	0	212
Total		1	2	2	2	6	15	31	36	71	48	53	33	29	21	13	6	6	3	2	380
		1.00	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	
Year of birth	1941 and older	0	0	0	0	1	0	3	3	4	3	2	5	2	0	1	1	0	0	0	25
	1942-1951	0	0	0	1	4	4	10	9	8	4	10	1	4	3	5	2	0	0	1	66
	1952-1961	0	1	1	1	0	5	8	6	23	11	9	10	6	7	2	1	1	1	0	93
	1962-1971	1	0	1	0	1	1	5	6	15	13	12	6	5	4	1	0	4	1	0	76
	1972-1981	0	0	0	0	0	3	4	5	7	10	5	5	8	2	2	1	0	0	1	53
	1982-1991	0	1	0	0	0	2	0	6	10	3	13	4	3	2	2	1	0	1	0	48
	1992-2001	0	0	0	0	0	0	1	1	4	4	2	2	1	3	0	0	1	0	0	19
Total		1	2	2	2	6	15	31	36	71	48	53	33	29	21	13	6	6	3	2	380
		1.00	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	
Education	Elementary school	0	0	1	0	0	2	1	3	4	4	0	3	0	2	0	0	0	0	0	20
	Havo bovenbouw, vwo, mbo	0	2	1	1	2	2	11	14	29	14	20	11	13	8	8	1	3	0	1	141
	Hbo, wo	1	0	0	0	2	0	5	5	8	12	14	8	8	7	4	4	2	2	1	83
	Vmbo, mbo1, havo onderbouw	0	0	0	1	2	11	14	14	30	18	19	11	8	4	1	1	1	1	0	136
Total		1	2	2	2	6	15	31	36	71	48	53	33	29	21	13	6	6	3	2	380
		1.00	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	
Household Composition	Living together	0	1	2	1	3	5	13	8	23	13	17	11	11	4	5	1	0	0	1	119
	Living together with children	0	0	0	0	1	2	6	5	8	7	7	4	1	3	1	0	1	0	1	47
	Single	1	1	0	1	2	7	10	14	27	17	25	12	14	12	5	5	4	2	0	159
	Single parent with children	0	0	0	0	0	1	2	9	13	11	4	6	3	2	2	0	1	1	0	55
Total		1	2	2	2	6	15	31	36	71	48	53	33	29	21	13	6	6	3	2	380
		1.00	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	
Household Income	1791 - 2212	0	0	0	0	2	1	9	7	19	11	14	9	8	1	2	1	0	1	1	86
	Less than 1791	1	1	0	1	0	6	8	16	27	18	15	10	9	11	5	2	1	2	0	133
	More than 2212	0	1	2	0	3	6	10	4	12	10	15	11	7	6	4	2	2	0	0	95
	No answer	0	0	0	1	1	2	4	9	13	9	9	3	5	3	2	1	3	0	1	66
Total		1	2	2	2	6	15	31	36	71	48	53	33	29	21	13	6	6	3	2	380

Table 52 Chi-Square test: statement factor regarding average environmental attitude

Chi-Square Tests

	Chi-Square	df	Asymptotic Significance (2-sided)
Gender	26.779	18	0.083
Year of birth	110.895	108	0.405
Education	72.170	54	0.050
Household composition	44.680	54	0.813
Household income	50.670	54	0.604

Table 53 Cross-tabs: statements factor regarding average environmental attitude in percentages and education

Crosstab

Count

		Average environmental attitude																			Total
Education	Elementary school	0	0	1	0	0	2	1	3	4	4	0	3	0	2	0	0	0	0	0	20
		0%	0%	5%	0%	0%	10%	5%	15%	20%	20%	0%	15%	0%	10%	0%	0%	0%	0%	0%	
	Havo bovenbouw, vwo, mbo	0	2	1	1	2	2	11	14	29	14	20	11	13	8	8	1	3	0	1	141
		0%	1%	1%	1%	1%	1%	8%	10%	21%	10%	14%	8%	9%	6%	6%	1%	2%	0%	1%	
	Hbo, wo	1	0	0	0	2	0	5	5	8	12	14	8	8	7	4	4	2	2	1	83
		1%	0%	0%	0%	2%	0%	6%	6%	10%	14%	17%	10%	10%	8%	5%	5%	2%	2%	1%	
	Vmbo, mbo1, havo onderbouw	0	0	0	1	2	11	14	14	30	18	19	11	8	4	1	1	1	1	0	136
		0%	0%	0%	1%	1%	8%	10%	10%	22%	13%	14%	8%	6%	3%	1%	1%	1%	1%	0%	
Total		1	2	2	2	6	15	31	36	71	48	53	33	29	21	13	6	6	3	2	380

Statement factor regarding average willingness to pay

Table 54 Cross-tabs: statement factor regarding average willingness to pay

Crosstab

Count

		Average willingness to pay																	
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	Total
Gender	Man	7	0	2	6	4	8	4	6	21	13	18	18	30	11	8	2	10	168
	Woman	8	1	3	1	8	9	8	13	24	24	28	21	39	11	6	3	5	212
Total		15	1	5	7	12	17	12	19	45	37	46	39	69	22	14	5	15	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Year of birth	1941 and older	1	0	0	0	1	0	2	2	4	2	4	2	4	2	0	1	0	25
	1942-1951	3	0	1	1	1	4	3	1	9	6	10	6	13	3	4	0	1	66
	1952-1961	4	0	1	4	3	5	2	4	8	7	14	12	13	3	6	0	7	93
	1962-1971	2	1	2	1	5	4	4	4	14	9	5	5	14	5	1	0	0	76
	1972-1981	4	0	0	0	0	1	0	5	3	6	7	8	12	3	1	0	3	53
	1982-1991	1	0	1	0	2	3	1	3	6	5	4	3	9	3	1	2	4	48
	1992-2001	0	0	0	1	0	0	0	0	1	2	2	3	4	3	1	2	0	19
Total		15	1	5	7	12	17	12	19	45	37	46	39	69	22	14	5	15	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Education	Elementary school	0	0	0	0	0	3	0	2	4	2	3	3	0	2	0	0	1	20
	Havo bovenbouw , vwo, mbo	7	1	1	1	5	4	4	9	16	15	18	13	27	6	4	3	7	141
	Hbo, wo	4	0	2	3	1	3	6	4	9	7	5	10	15	9	3	2	0	83
	Vmbo, mbo1, havo onderbouw	4	0	2	3	6	7	2	4	16	13	20	13	27	5	7	0	7	136
Total		15	1	5	7	12	17	12	19	45	37	46	39	69	22	14	5	15	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Household Composition	Living together	7	0	0	3	6	5	5	6	13	10	11	16	19	7	7	1	3	119
	Living together with children	0	0	2	0	2	1	0	1	3	4	6	7	10	3	2	2	4	47
	Single	6	1	2	2	3	11	6	6	24	16	23	8	30	9	4	1	7	159
	Single parent with children	2	0	1	2	1	0	1	6	5	7	6	8	10	3	1	1	1	55
Total		15	1	5	7	12	17	12	19	45	37	46	39	69	22	14	5	15	380
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Household Income	1791 - 2212	7	1	0	0	4	0	0	3	12	11	12	7	19	4	4	1	1	86
	Less than 1791	3	0	3	4	4	9	6	9	15	15	21	8	20	6	3	2	5	133
	More than 2212	3	0	0	2	2	2	4	4	8	6	8	13	21	10	4	2	6	95
	No answer	2	0	2	1	2	6	2	3	10	5	5	11	9	2	3	0	3	66
Total		15	1	5	7	12	17	12	19	45	37	46	39	69	22	14	5	15	380

Table 55 Chi-Square test: statement factor regarding average willingness to pay

Chi-Square Tests

	Chi-Square	df	Asymptotic Significance (2-sided)
Gender	14.443	16	0.566
Year of birth	98.098	96	0.421
Education	50.293	48	0.383
Household composition	50.891	48	0.361
Household income	60.416	48	0.108

Appendix 8 – MNL and ML results and figures

MNL Base model

Table 56 Results from MNL base model that includes the attribute variables from the SCE

Attribute	Level	Parameters	Pr(>|z|)
Constant	Constant 1	1.025	0.001
Heating type	Heat network WITH new radiators	0.037	
	Heat network WITHOUT new radiators	0.001	
	Heat pump on electricity	-0.0172	
	Heat pump on electricity and green gas	-0.021	
Housing costs	€0 p/m	0.029	
	€10 p/m LESS	0.289	0.001
	€5 p/m LESS	0.100	0.05
	€10 p/m MORE	-0.417	0.001
Comfort change	Remains the same	0.135	
	Better	0.269	0.001
	A little better	0.125	0.01
	A little worse	-0.530	0.001
Nuisance	Little nuisance	0.312	
	A lot of nuisance	-0.312	0.001
House improvements	None	-0.179	
	New bathroom, kitchen and/or toilet	0.179	0.001
Neighborhood improvements	None	-0.161	
	Your neighbourhood will get better and the (social) problems will be fixed	0.161	0.001
Number of observations	**9120**		
LL(0)	**-3045.5**		
LL(β)	**-2766.0**		
McFadden's Rho²	**0.092**		
Rho² adjusted	**0.086**		

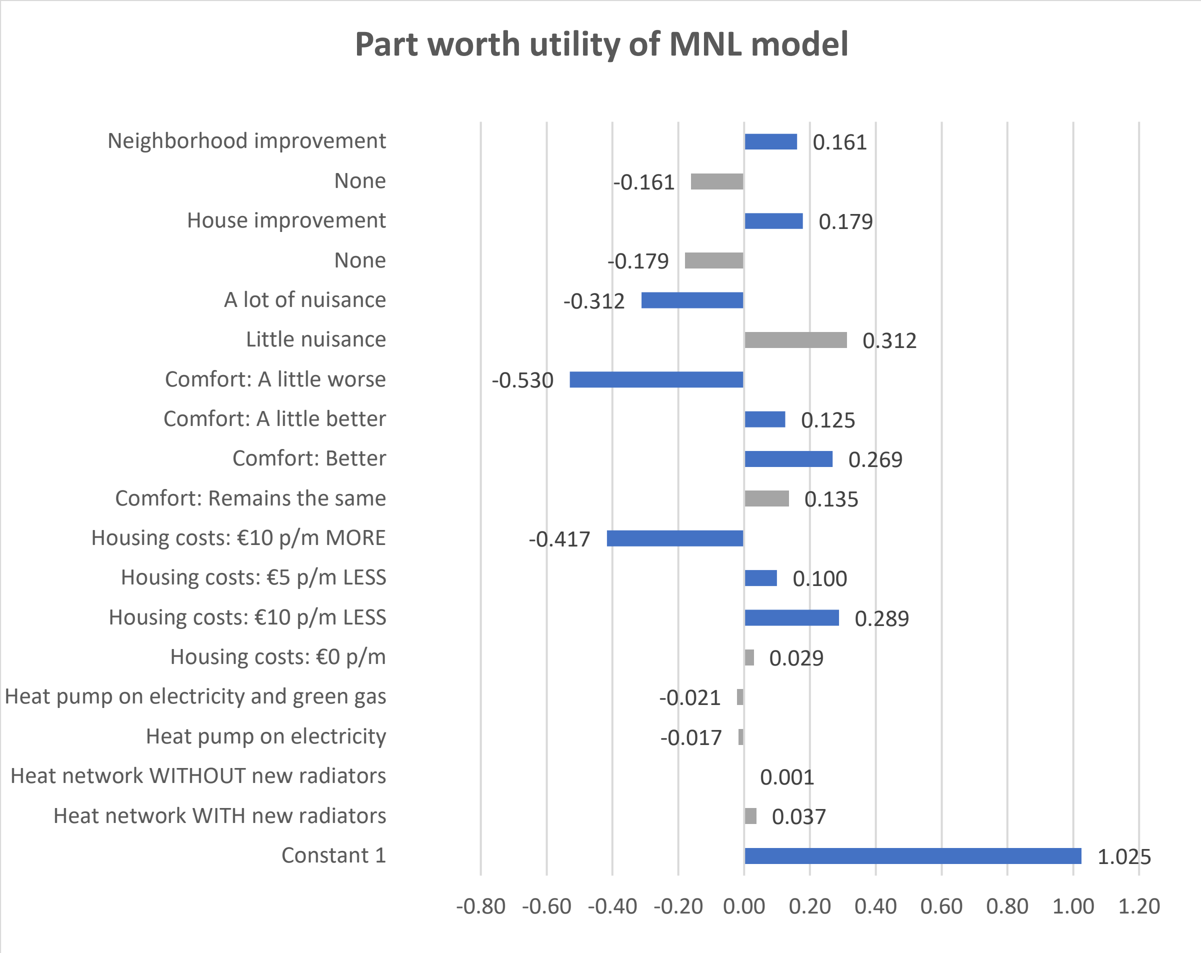


Figure 48 Part worth utility of MNL base model

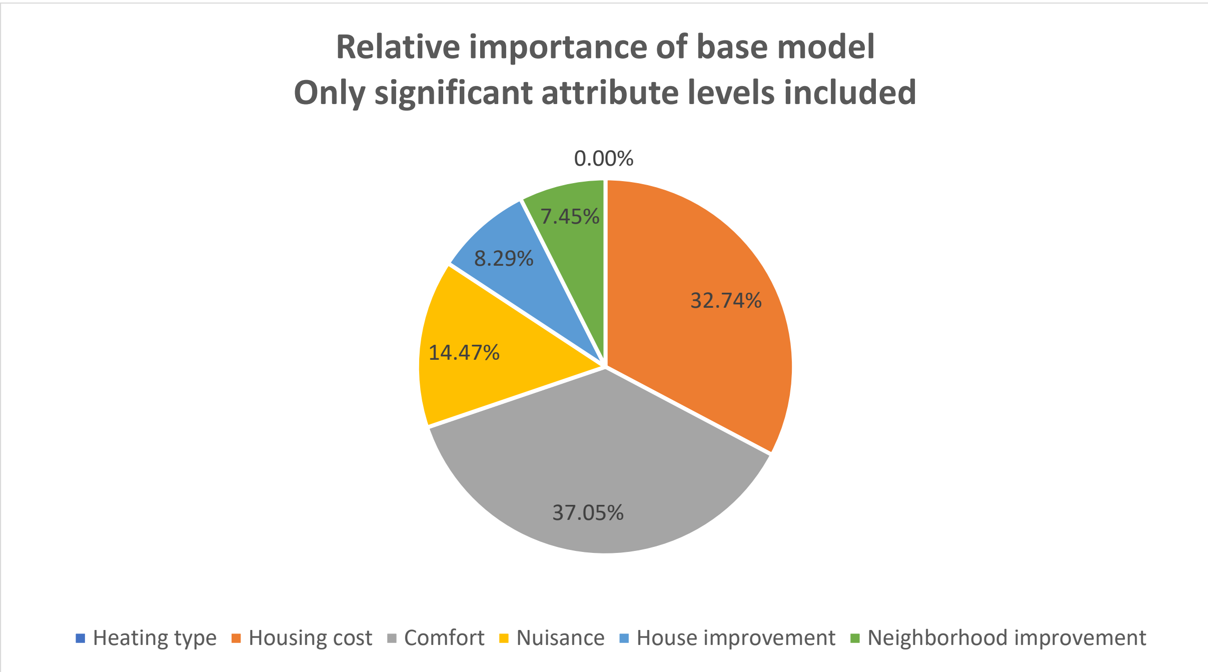


Figure 49 Relative importance of the MNL base model, only significant attribute levels included

MNL model including the socio-demographics

Table 57 Results from MNL model that includes the attribute and socio-demographic variables

Attribute	Level	Parameters	Pr(>|z|)
Constant	Constant 1	1.113	0.001
Heating type	Heat network WITH new radiators	-0.065	
	Heat network WITHOUT new radiators	-0.058	
	Heat pump on electricity	0.066	
	Heat pump on electricity and green gas	0.057	
Housing costs	Housing costs: €0 p/m	0.004	
	Housing costs: €10 p/m LESS	0.264	0.001
	Housing costs: €5 p/m LESS	0.121	0.05
	Housing costs: €10 p/m MORE	-0.389	0.001
Comfort change	Comfort: Remains the same	0.127	
	Comfort: Better	0.315	0.001
	Comfort: A little better	0.145	0.01
	Comfort: A little worse	-0.586	0.001
Nuisance	Little nuisance	0.244	
	A lot of nuisance	-0.244	0.001
House improvements	None	-0.213	
	House improvement	0.213	0.001
Neighborhood improvements	None	-0.189	
	Neighborhood improvement	0.189	0.001
Gender	Women * Comfort: Remains the same	0.068	
	Women * Comfort: Better	0.041	
	Women * Comfort: A little better	0.007	
	Women * Comfort: A little worse	-0.116	0.05
	Women * Little nuisance	0.060	
	Women * A lot of nuisance	-0.060	0.05
No work	No work * Little nuisance	0.058	
	No work * A lot of nuisance	-0.058	0.05
Number of observations	**9120**		
LL(0)	**-3045.5**		
LL(β)	**-2756.6**		
McFadden's Rho²	**0.095**		
Rho² adjusted	**0.091**		

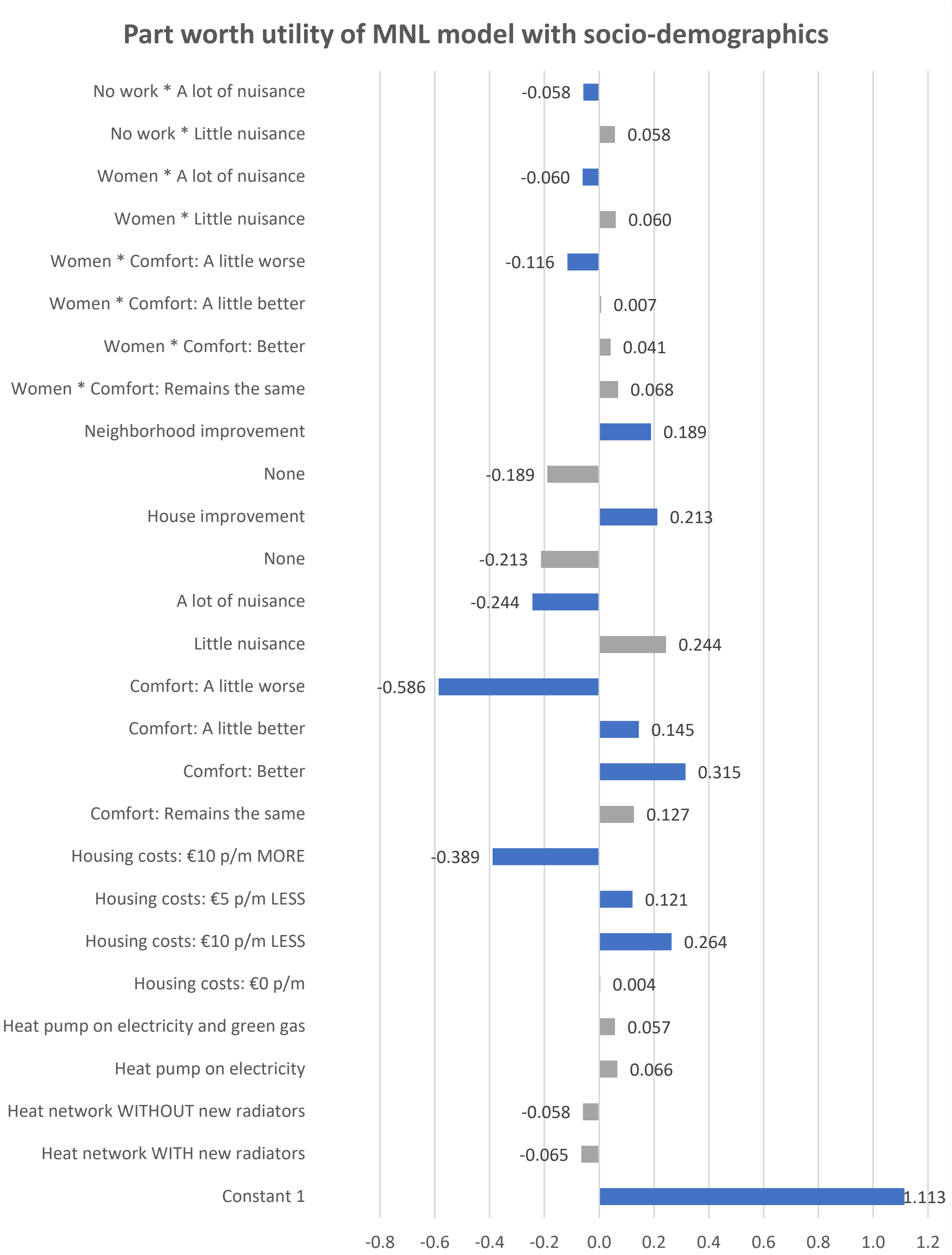


Figure 50 Part worth utility of MNL model with socio-demographic variables

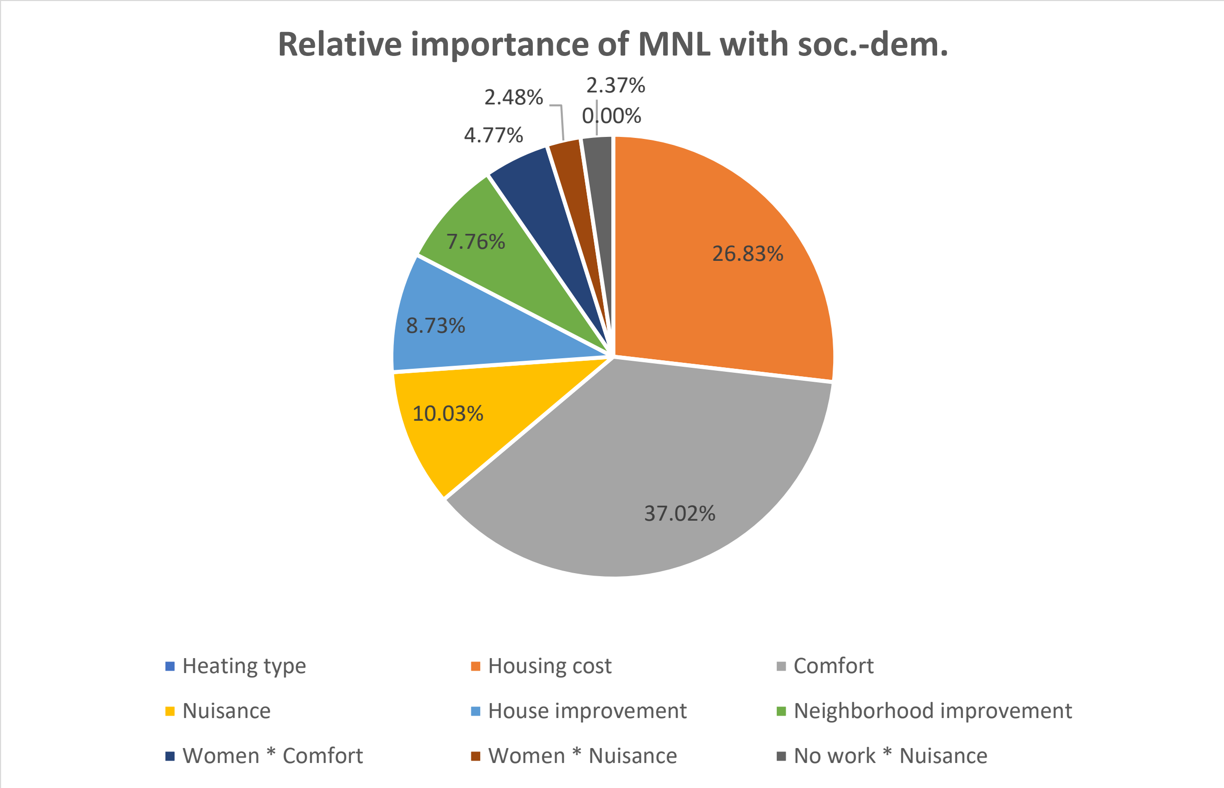


Figure 51 Relative importance of the MNL model with socio-demographic variables, significant attribute levels included

MNL model including the statement factors

Table 58 Results from MNL model that includes the attribute and statement factors

Attribute	Level	Parameters	Pr(>|z|)
Constant	Constant 1	1.021	0.001
Heating type	Heat network WITH new radiators	0.241	
	Heat network WITHOUT new radiators	0.072	
	Heat pump on electricity	-0.162	
	Heat pump on electricity and green gas	-0.152	
Housing costs	Housing costs: €0 p/m	-0.441	
	Housing costs: €10 p/m LESS	0.836	0.05
	Housing costs: €5 p/m LESS	0.605	
	Housing costs: €10 p/m MORE	-1.000	0.05
Comfort change	Comfort: Remains the same	0.138	
	Comfort: Better	0.268	0.001
	Comfort: A little better	0.126	0.01
	Comfort: A little worse	-0.532	0.001
Nuisance	Little nuisance	0.314	
	A lot of nuisance	-0.314	0.001
House improvements	None	-0.180	
	House improvement	0.180	0.001
Neighborhood improvements	None	-0.163	
	Neighborhood improvement	0.163	0.001
WTP	High WTP (>4) * Housing costs: €0 p/m	0.049	
	High WTP (>4) * Housing costs: €10 p/m LESS	-0.109	0.05
	High WTP (>4) * Housing costs: €5 p/m LESS	-0.109	0.05
	High WTP (>4) * Housing costs: €10 p/m MORE	0.169	0.01
Communication and trust	Comm. and trust * Housing costs: €0 p/m	-0.023	
	Comm. and trust * Housing costs: €10 p/m LESS	-0.079	
	Comm. and trust * Housing costs: €5 p/m LESS	0.124	
	Comm. and trust * Housing costs: €10 p/m MORE	-0.022	
Environmental attitude	Env. Att. * Heat network WITH new radiators	-0.063	
	Env. Att. * Heat network WITHOUT new radiators	-0.023	
	Env. Att. * Heat pump on electricity	0.045	
	Env. Att. * Heat pump on electricity and green gas	0.041	
Environmental attitude	Env. Att. * Housing costs: €0 p/m	0.117	
	Env. Att. * Housing costs: €10 p/m LESS	0.024	
	Env. Att. * Housing costs: €5 p/m LESS	-0.168	0.05
	Env. Att. * Housing costs: €10 p/m MORE	0.027	
Number of observations	**9120**		
LL(0)	**-3045.5**		
LL(β)	**-2752.5**		
McFadden's Rho²	**0.096**		
Rho² adjusted	**0.092**		

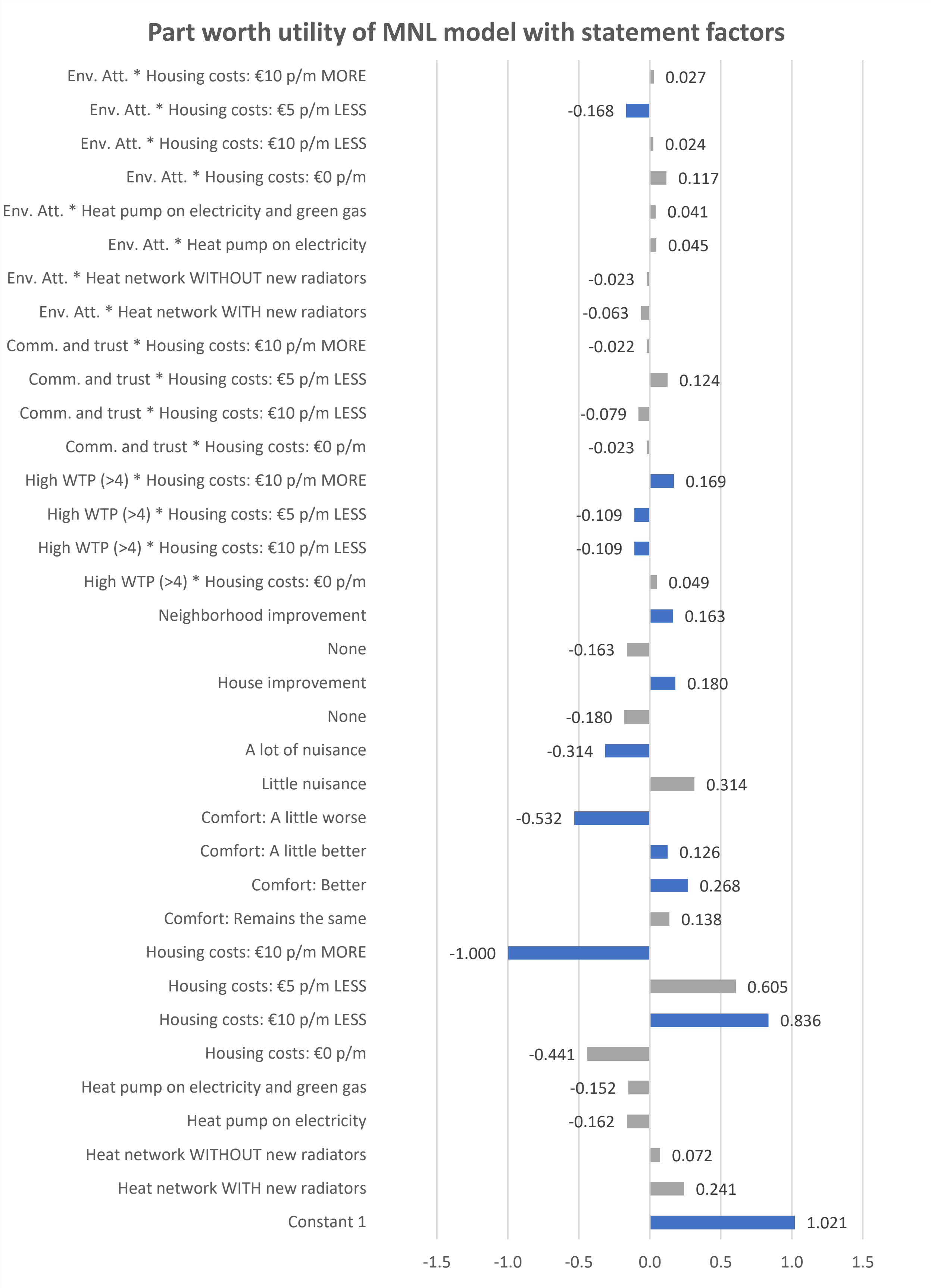


Figure 52 Part worth utility of MNL model with statement factors

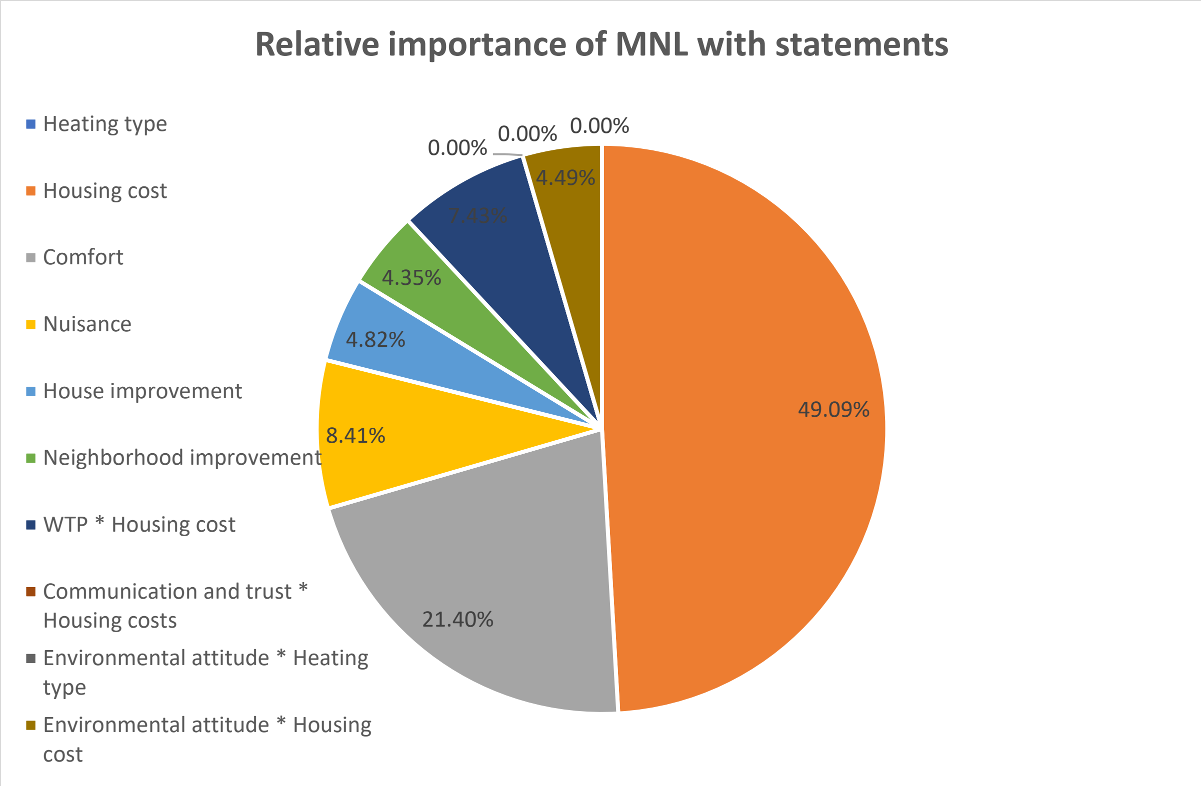


Figure 53 Relative importance of the MNL model with statement factors, significant attribute levels included

ML model

Table 59 Mixed Logit model performance based on the number of Halton draws

Halton draws	25	50	125	500	1000
LL(β)	-2168.297	-2162.279	-2158.712	-2158.391	-2160.685
McFadden's Rho²	.204	.206	.208	.208	.207
Significant parameters	10	10	10	10	10
Significant standard dev.	6	7	7	7	6

Table 60 Results of the Mixed Logit model with 1000 Halton draws

Attribute	Level	Parameters	Pr(>|z|)	St. dev.	Pr(>|z|)
Constant	Constant 1	0.944	0.001		
Heating type	Heat network WITH new radiators	-0.002		0.003	
	Heat network WITHOUT new radiators	0.017		0.468	0.001
	Heat pump on electricity	-0.017		0.444	0.001
	Heat pump on electricity and green gas	0.002			
Housing costs	Housing costs: €0 p/m	-0.008			
	Housing costs: €10 p/m LESS	0.413	0.001	0.043	
	Housing costs: €5 p/m LESS	0.175	0.01	0.396	0.001
	Housing costs: €10 p/m MORE	-0.580	0.001	0.458	0.001
Comfort change	Comfort: Remains the same	0.145			
	Comfort: Better	0.435	0.001	0.179	
	Comfort: A little better	0.202	0.001	0.006	
	Comfort: A little worse	-0.783	0.001	0.120	
Nuisance	Little nuisance	0.436			
	A lot of nuisance	-0.436	0.001	0.310	0.001
House improvements	None	-0.232			
	House improvement	0.232	0.001	0.548	0.001
Neighborhood improvements	None	-0.209			
	Neighborhood improvement	0.209	0.001	0.016	
Log-Likelihood:	**-2160.68**				
Mc Fadden's Rho²	**0.207**				

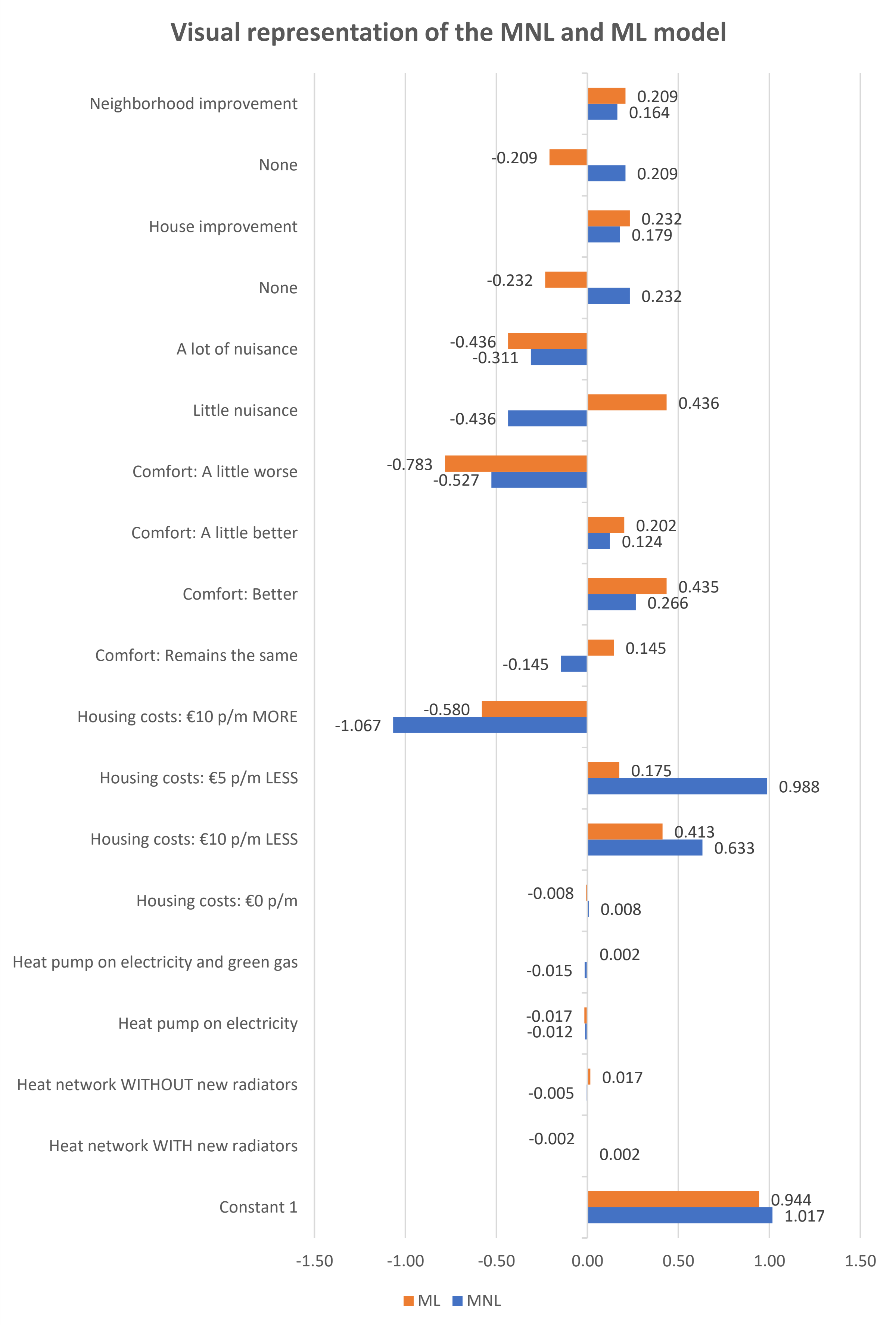


Figure 54 Visual representation of the MNL base and ML (1000 Halton draws) model

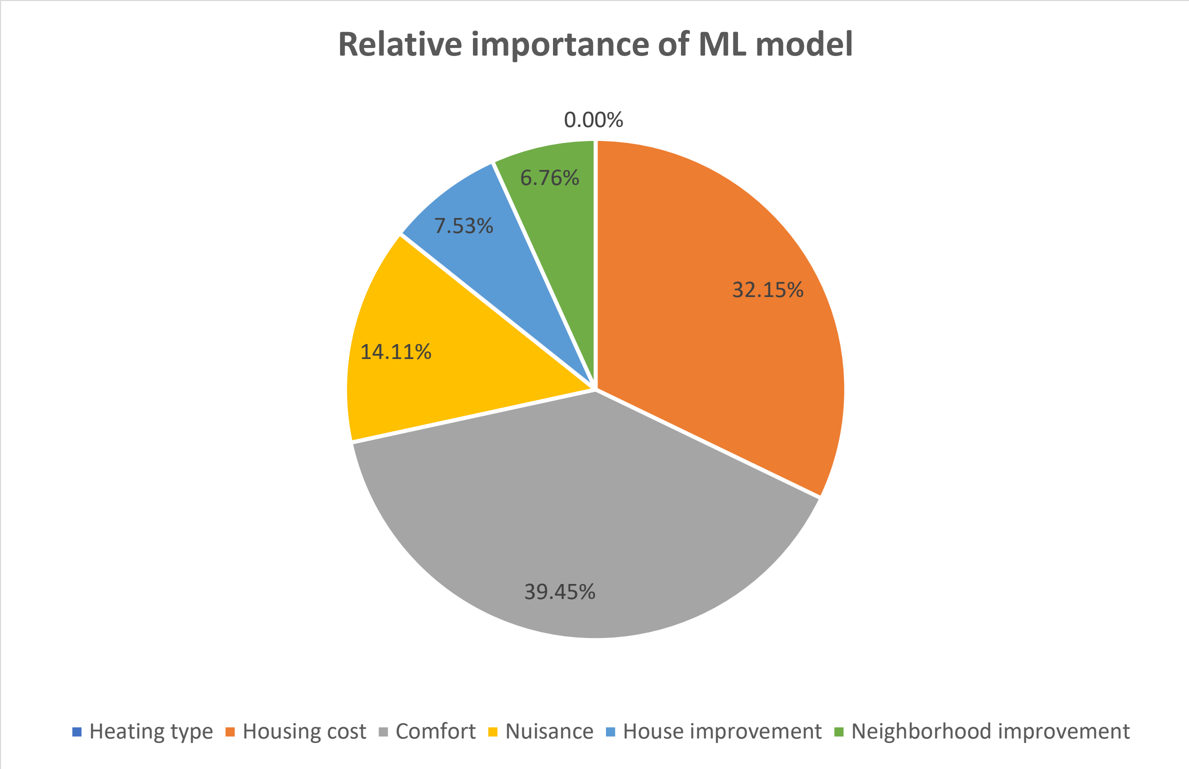


Figure 55 Relative importance of the ML model, significant attribute levels included

Appendix 9 – MNL and Latent Class model

Multinomial Logit model Base

```
> nrow(Data1)
[1] 9120

> Data1 <- mlogit.data (Data1, shape="long", id.var="PersonID", alt.var="Alt", choice="Choice")
> mnlbase <- mlogit(Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 + Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hous1
 + Neig1, data=Data1)
> summary(mnlbase)


Call:
mlogit(formula = Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 +
    Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hous1 +
    Neig1, data = Data1, method = "nr")

Frequencies of alternatives:choice
      1       2       3
0.44408 0.41480 0.14112

nr method
4 iterations, 0h:0m:0s
g'(-H)^-1g = 7.72E-08
gradient close to zero

Coefficients :
         Estimate  Std. Error  z-value  Pr(>|z|)
Con    1.02490028  0.05298243  19.3442 < 2.2e-16 ***
Heat1  0.00097807  0.04619957   0.0212  0.983110
Heat2 -0.01716154  0.04522568  -0.3795  0.704343
Heat3 -0.02060688  0.04439424  -0.4642  0.642519
Cost1  0.28852467  0.04406537   6.5477 5.845e-11 ***
Cost2  0.09981407  0.04646871   2.1480  0.031715 *
Cost3 -0.41722879  0.04635480  -9.0008 < 2.2e-16 ***
Comf1  0.26902576  0.04540959   5.9244 3.134e-09 ***
Comf2  0.12537790  0.04472422   2.8034  0.005057 **
Comf3 -0.52967336  0.04770400 -11.1033 < 2.2e-16 ***
Nuis1 -0.31201752  0.02194850 -14.2159 < 2.2e-16 ***
Hous1  0.17870050  0.02174488   8.2181 2.220e-16 ***
Neig1  0.16063699  0.02170522   7.4008 1.352e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log-Likelihood: -2766
```

Multinomial Logit model with socio-demographic variables

```
> nrow(DataSoc)
[1] 9120
> Data1 <- mlogit.data (Data1, shape="long", id.var="PersonID", alt.var="Alt", choice="Choice")
> mnlsocdem <- mlogit(Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 + Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hou
s1 + Neig1 + Gender.Comf1 + Gender.Comf2 + Gender.Comf3 + Gender.Nuis1 + Gender.Heat1 + Gender.Heat2 + Gender.Heat3 + Born.7
0.Nuis1 + EducationHigh.Heat1 + EducationHigh.Heat2 + EducationHigh.Heat3 + ChildYesNo.Neig1 + AgeChildYoung.Neig1 + WorkOrN
o.Nuis1 + DwelSingleFam.Comf1 + DwelSingleFam.Comf2 + DwelSingleFam.Comf3 + DwelSingleFam.Hous1 + DwelSingleFam.Neig1 + TimeL
ived1..Hous1 + TimeLived1..Nuis1 + Rent600..Cost1 + Rent600..Cost2 + Rent600..Cost3 + AllowanceYesNo.Cost1 + AllowanceYesNo.C
ost2 + AllowanceYesNo.Cost3 + Income2212..Cost1 + Income2212..Cost2 + Income2212..Cost3, data=Data1)
> summary(mnlsocdem)

Call:
mlogit(formula = Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 +
    Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hous1 +
    Neig1 + Gender.Comf1 + Gender.Comf2 + Gender.Comf3 + Gender.Nuis1 +
    Gender.Heat1 + Gender.Heat2 + Gender.Heat3 + Born.70.Nuis1 +
    EducationHigh.Heat1 + EducationHigh.Heat2 + EducationHigh.Heat3 +
    ChildYesNo.Neig1 + AgeChildYoung.Neig1 + WorkOrNo.Nuis1 +
    DwelSingleFam.Comf1 + DwelSingleFam.Comf2 + DwelSingleFam.Comf3 +
    DwelSingleFam.Hous1 + DwelSingleFam.Neig1 + TimeLived1..Hous1 +
    TimeLived1..Nuis1 + Rent600..Cost1 + Rent600..Cost2 + Rent600..Cost3 +
    AllowanceYesNo.Cost1 + AllowanceYesNo.Cost2 + AllowanceYesNo.Cost3 +
    Income2212..Cost1 + Income2212..Cost2 + Income2212..Cost3,
    data = Data1, method = "nr")
```

```
Frequencies of alternatives:choice
      1       2       3
0.44408 0.41480 0.14112

nr method
4 iterations, 0h:0m:0s
g'(-H)^-1g = 5.6E-08
gradient close to zero

Coefficients :
                         Estimate  Std. Error  z-value  Pr(>|z|)
Con                    1.01480079  0.05309889  19.1115 < 2.2e-16 ***
Heat1                 -0.03802740  0.05634968  -0.6748   0.49977
Heat2                  0.02338324  0.05504802   0.4248   0.67100
Heat3                  0.02043919  0.05406875   0.3780   0.70541
Cost1                  0.24984235  0.04958730   5.0384 4.694e-07 ***
Cost2                  0.12725035  0.05215310   2.4399   0.01469 *
Cost3                 -0.43164922  0.05221039  -8.2675 2.220e-16 ***
Comf1                  0.26116832  0.04957578   5.2681 1.379e-07 ***
Comf2                  0.12328020  0.04876142   2.5282   0.01146 *
Comf3                 -0.54193468  0.05214836 -10.3922 < 2.2e-16 ***
Nuis1                 -0.26377987  0.04136832  -6.3764 1.813e-10 ***
Hous1                  0.21866549  0.03673933   5.9518 2.652e-09 ***
Neig1                  0.19904552  0.03500775   5.6858 1.302e-08 ***
Gender.Comf1           0.02786838  0.04615757   0.6038   0.54600
Gender.Comf2           0.03231893  0.04545687   0.7110   0.47710
Gender.Comf3          -0.11409064  0.04817877  -2.3681   0.01788 *
Gender.Nuis1          -0.06312332  0.02234013  -2.8256   0.00472 **
Gender.Heat1           0.03094391  0.04678351   0.6614   0.50834
Gender.Heat2          -0.06369192  0.04550130  -1.3998   0.16158
Gender.Heat3           0.03060789  0.04489900   0.6817   0.49543
Born.70.Nuis1         -0.00183079  0.03171918  -0.0577   0.95397
EducationHigh.Heat1   -0.05037297  0.05603283  -0.8990   0.36866
EducationHigh.Heat2    0.05014732  0.05446595   0.9207   0.35720
EducationHigh.Heat3    0.06402918  0.05354122   1.1959   0.23174
ChildYesNo.Neig1       0.05533127  0.03414707   1.6204   0.10515
AgeChildYoung.Neig1    0.00645906  0.04280818   0.1509   0.88007
WorkOrNo.Nuis1        -0.05227246  0.02675656  -1.9536   0.05074 .
DwelSingleFam.Comf1   -0.01127115  0.04927244  -0.2288   0.81906
DwelSingleFam.Comf2   -0.00477877  0.04869124  -0.0981   0.92182
DwelSingleFam.Comf2   -0.00477877  0.04869124  -0.0981   0.92182
DwelSingleFam.Comf3   -0.03010727  0.05127989  -0.5871   0.55713
DwelSingleFam.Hous1   -0.02303132  0.02401091  -0.9592   0.33746
DwelSingleFam.Neig1    0.03245575  0.02450218   1.3246   0.18530
TimeLived1..Hous1      0.05935053  0.03720797   1.5951   0.11069
TimeLived1..Nuis1      0.06447774  0.03675270   1.7544   0.07937 .
Rent600..Cost1        -0.09078475  0.04633397  -1.9594   0.05007 .
Rent600..Cost2        -0.00020257  0.04883439  -0.0041   0.99669
Rent600..Cost3        -0.00085434  0.04836101  -0.0177   0.98591
AllowanceYesNo.Cost1   0.05123287  0.05115365   1.0015   0.31656
AllowanceYesNo.Cost2  -0.16652018  0.05418989  -3.0729   0.00212 **
AllowanceYesNo.Cost3   0.01040222  0.05433098   0.1915   0.84817
Income2212..Cost1     -0.06021718  0.05884335  -1.0233   0.30614
Income2212..Cost2      0.03991782  0.06212565   0.6425   0.52053
Income2212..Cost3     -0.02318274  0.06251870  -0.3708   0.71078
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log-Likelihood: -2737.6
```

Multinomial Logit model with statement factors

```
> nrow(DataSoc)
[1] 9120
> Data1 <- mlogit.data (Data1, shape="long", id.var="PersonID", alt.var="Alt", choice="Choice")
> mnlsdstat <- mlogit(Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 + Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hou
s1 + Neig1 + WTP.Cost1 + WTP.Cost2 + WTP.Cost3 + CommTrust.Cost1 + CommTrust.Cost2 + CommTrust.Cost3 + EnvAttitude.Heat1 + En
vAttitude.Heat2 + EnvAttitude.Heat3 + EnvAttitude.Cost1 + EnvAttitude.Cost2 + EnvAttitude.Cost3, data=Data1)
> summary(mnlsdstat)

Call:
mlogit(formula = Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 +
    Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hous1 +
    Neig1 + WTP.Cost1 + WTP.Cost2 + WTP.Cost3 + CommTrust.Cost1 +
    CommTrust.Cost2 + CommTrust.Cost3 + EnvAttitude.Heat1 + EnvAttitude.Heat2 +
    EnvAttitude.Heat3 + EnvAttitude.Cost1 + EnvAttitude.Cost2 +
    EnvAttitude.Cost3, data = Data1, method = "nr")

Frequencies of alternatives:choice
      1       2       3
0.44408 0.41480 0.14112

nr method
4 iterations, 0h:0m:0s
g'(-H)^-1g = 6.74E-08
gradient close to zero

Coefficients :
                    Estimate Std. Error  z-value  Pr(>|z|)
Con                 1.020823   0.053035  19.2483 < 2.2e-16 ***
Heat1               0.072482   0.261886   0.2768  0.781956
Heat2              -0.161830   0.254665  -0.6355  0.525128
Heat3              -0.151814   0.250179  -0.6068  0.543970
Cost1               0.835845   0.364142   2.2954  0.021711 *
Cost2               0.604581   0.385272   1.5692  0.116594
Cost3              -0.999578   0.390151  -2.5620  0.010406 *
Comf1               0.268358   0.045587   5.8867  3.94e-09 ***
Comf2               0.125618   0.044893   2.7981  0.005140 **
Comf3              -0.531972   0.047901 -11.1057 < 2.2e-16 ***
Comf1               0.268358   0.045587   5.8867  3.94e-09 ***
Comf2               0.125618   0.044893   2.7981  0.005140 **
Comf3              -0.531972   0.047901 -11.1057 < 2.2e-16 ***
Nuis1              -0.314301   0.022060 -14.2478 < 2.2e-16 ***
Hous1               0.180211   0.021846   8.2493  2.22e-16 ***
Neig1               0.162728   0.021814   7.4597  8.66e-14 ***
WTP.Cost1          -0.108597   0.050808  -2.1374  0.032566 *
WTP.Cost2          -0.109211   0.053555  -2.0392  0.041427 *
WTP.Cost3           0.168739   0.052632   3.2060  0.001346 **
CommTrust.Cost1    -0.078972   0.065134  -1.2125  0.225340
CommTrust.Cost2     0.124175   0.068869   1.8031  0.071378 .
CommTrust.Cost3    -0.022100   0.066465  -0.3325  0.739512
EnvAttitude.Heat1 -0.022600   0.079193  -0.2854  0.775352
EnvAttitude.Heat2  0.044803   0.077205   0.5803  0.561703
EnvAttitude.Heat3  0.040608   0.075809   0.5357  0.592193
EnvAttitude.Cost1  0.024436   0.075023   0.3257  0.744635
EnvAttitude.Cost2 -0.168063   0.079444  -2.1155  0.034388 *
EnvAttitude.Cost3  0.026500   0.081142   0.3266  0.743979
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log-Likelihood: -2752.5
```

Multinomial Logit model with socio-demographic variables and statement factors

```
> nrow(Data1)
[1] 9120
> library("dfidx")
> library("mlogit")
> Data1 <- mlogit.data (Data1, shape="long", id.var="PersonID", alt.var="Alt", choice="Choice")
> mnlsdstat <- mlogit(Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 + Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hou
s1 + Neig1 + Gender.Comf1 + Gender.Comf2 + Gender.Comf3 + Gender.Nuis1 + WorkOrNo.Nuis1 + TimeLived1..Nuis1 + Rent600..Cost1
 + Rent600..Cost2 + Rent600..Cost3 + AllowanceYesNo.Cost1 + AllowanceYesNo.Cost2 + AllowanceYesNo.Cost3 + CommTrustHighLow.Co
st1 + CommTrustHighLow.Cost2 + CommTrustHighLow.Cost3, data=Data1)
> summary(mnlsdstat)

Call:
mlogit(formula = Choice ~ -1 + Con + Heat1 + Heat2 + Heat3 + 
    Cost1 + Cost2 + Cost3 + Comf1 + Comf2 + Comf3 + Nuis1 + Hous1 + 
    Neig1 + Gender.Comf1 + Gender.Comf2 + Gender.Comf3 + Gender.Nuis1 + 
    WorkOrNo.Nuis1 + TimeLived1..Nuis1 + Rent600..Cost1 + Rent600..Cost2 + 
    Rent600..Cost3 + AllowanceYesNo.Cost1 + AllowanceYesNo.Cost2 + 
    AllowanceYesNo.Cost3 + CommTrustHighLow.Cost1 + CommTrustHighLow.Cost2 + 
    CommTrustHighLow.Cost3, data = Data1, method = "nr")

Frequencies of alternatives:choice
      1       2       3 
0.44408 0.41480 0.14112 

nr method
4 iterations, 0h:0m:0s 
g'(-H)^-1g = 5.95E-08 
gradient close to zero 

Coefficients :
                          Estimate  Std. Error  z-value  Pr(>|z|)    
Con                     1.0163e+00  5.3079e-02  19.1476 < 2.2e-16 ***
Heat1                  -3.4262e-03  4.6612e-02  -0.0735 0.9414036    
Heat2                  -1.0425e-02  4.5530e-02  -0.2290 0.8188828    
Heat3                  -1.5214e-02  4.4752e-02  -0.3400 0.7338822    
Cost1                   2.2713e-01  6.4257e-02   3.5347 0.0004082 ***
Cost2                   1.8302e-01  6.7399e-02   2.7155 0.0066174 ** 
Cost3                  -4.2100e-01  6.6150e-02  -6.3643 1.962e-10 ***
Comf1                   2.6858e-01  4.6080e-02   5.8285 5.593e-09 ***
Comf2                   1.2361e-01  4.5415e-02   2.7219 0.0064906 ** 
Comf3                  -5.3226e-01  4.8283e-02 -11.0237 < 2.2e-16 ***
Nuis1                  -2.5403e-01  3.5578e-02  -7.1400 9.335e-13 ***
Hous1                   1.8045e-01  2.1986e-02   8.2078 2.220e-16 ***
Neig1                   1.6580e-01  2.1906e-02   7.5689 3.775e-14 ***
Gender.Comf1            2.9057e-02  4.5825e-02   0.6341 0.5260166    
Gender.Comf2            3.2340e-02  4.5216e-02   0.7152 0.4744690    
Gender.Comf3           -1.0966e-01  4.7464e-02  -2.3104 0.0208686 *  
Gender.Nuis1           -6.5371e-02  2.2078e-02  -2.9609 0.0030672 ** 
WorkOrNo.Nuis1         -5.2885e-02  2.1928e-02  -2.4117 0.0158766 *  
TimeLived1..Nuis1       7.1149e-02  3.5284e-02   2.0164 0.0437538 *  
Rent600..Cost1         -8.8473e-02  4.6181e-02  -1.9158 0.0553933 .  
Rent600..Cost2          2.1584e-03  4.8656e-02   0.0444 0.9646168    
Rent600..Cost3          7.6657e-05  4.8349e-02   0.0016 0.9987350    
AllowanceYesNo.Cost1    1.8114e-02  4.5680e-02   0.3966 0.6916992    
AllowanceYesNo.Cost2   -1.3698e-01  4.8340e-02  -2.8337 0.0046011 ** 
AllowanceYesNo.Cost3    2.7088e-03  4.8231e-02   0.0562 0.9552118    
CommTrustHighLow.Cost1 -6.1974e-02  6.3266e-02  -0.9796 0.3272927    
CommTrustHighLow.Cost2  1.0033e-01  6.6409e-02   1.5108 0.1308496    
CommTrustHighLow.Cost3  1.6500e-03  6.5425e-02   0.0252 0.9798804    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -2743.5
```

Mixed Logit model with 1000 Halton draws

(Bad observations are due to missing values. Respondents who did not want to answer whether they received rent allowance are coded as missing value.)

```
|-> RPLOGIT;
    Lhs=CHOICE;
    Choices=1,2,none;
    RHS=CON,HEAT1,HEAT2,HEAT3,COST1,COST2,COST3,COMF1,COMF2,COMF3,NUIS1,HOUS1,NEIG1;
    Fcn=HEAT1(n),HEAT2(n),HEAT3(n),COST1(n),COST2(n),COST3(n),COMF1(n),COMF2(n),COMF3(n),NUIS1(n),HOUS1(n),NEIG1(n);
    Pts=1000;Halton;Pds=8$

+---------------------------------------------------+
|WARNING:   Bad observations were found in the sample. |
|Found  120 bad observations among   3040 individuals. |
|You can use ;CheckData to get a list of these points. |
+---------------------------------------------------+

Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .2647166D+04

-----------------------------------------------------------------------------
Start values obtained using MNL model
Dependent variable                 Choice
Log likelihood function     -2647.16591
Estimation based on N =    2920, K =  13
Inf.Cr.AIC  =   5320.3 AIC/N =    1.822
----------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -2918.7612  .0931 .0892
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
----------------------------------------
Response data are given as ind. choices
Number of obs.=  3040, skipped  120 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.       95% Confidence
  CHOICE|  Coefficient     Error       z    |z|>Z*          Interval
--------+--------------------------------------------------------------------
   HEAT1|    -.01610       .04722     -.34  .7331     -.10865     .07644
   HEAT2|     .00303       .04616      .07  .9477     -.08744     .09350
   HEAT3|    -.02054       .04529     -.45  .6502     -.10932     .06823
   COST1|     .29399***    .04508     6.52  .0000      .20564     .38234
   COST2|     .09237*      .04749     1.94  .0518     -.00072     .18546
   COST3|    -.41136***    .04728    -8.70  .0000     -.50402    -.31870
   COMF1|     .28673***    .04624     6.20  .0000      .19609     .37736
   COMF2|     .12011***    .04558     2.64  .0084      .03078     .20944
   COMF3|    -.54992***    .04897   -11.23  .0000     -.64589    -.45394
   NUIS1|    -.31541***    .02242   -14.07  .0000     -.35935    -.27147
   HOUS1|     .17573***    .02219     7.92  .0000      .13224     .21921
   NEIG1|     .15748***    .02216     7.11  .0000      .11405     .20092
     CON|    1.04111***    .05440    19.14  .0000      .93450    1.14773
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 30, 2021 at 00:43:55 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  42 iterations. Status=0, F=    .2575951D+04

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable                CHOICE
Log likelihood function     -2575.95086
Restricted log likelihood   -3207.94788
Chi squared [ 25](P= .000)   1263.99405
Significance level              .00000
McFadden Pseudo R-squared     .1970098
Estimation based on N =    2920, K =  25
Inf.Cr.AIC  =   5201.9 AIC/N =    1.781
----------------------------------------
```

```
               Log likelihood R-sqrd R2Adj
No coefficients -3207.9479  .1970 .1936
Constants only  -2918.7612  .1175 .1137
At start values -2647.1659  .0269 .0227
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has     380 groups
Fixed number of obsrvs./group=        8
Number of obs.=  3040, skipped  120 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random parameters in utility functions...........................					
HEAT1	-.01261	.05846	-.22	.8292	-.12718	.10196
HEAT2	-.00883	.06216	-.14	.8870	-.13066	.11299
HEAT3	-.01452	.05966	-.24	.8077	-.13146	.10242
COST1	.39873***	.06122	6.51	.0000	.27874	.51872
COST2	.13396**	.06480	2.07	.0387	.00694	.26097
COST3	-.58493***	.06829	-8.57	.0000	-.71878	-.45109
COMF1	.37058***	.05997	6.18	.0000	.25303	.48812
COMF2	.16810***	.05623	2.99	.0028	.05790	.27830
COMF3	-.73552***	.06633	-11.09	.0000	-.86553	-.60551
NUIS1	-.44407***	.04065	-10.93	.0000	-.52373	-.36441
HOUS1	.24111***	.04219	5.72	.0000	.15843	.32380
NEIG1	.21617***	.02994	7.22	.0000	.15748	.27485
	Nonrandom parameters in utility functions........................					
CON	.84845***	.06139	13.82	.0000	.72813	.96876
	Distns. of RPs. Std.Devs or limits of triangular.................					
NsHEAT1	.00025	.10171	.00	.9981	-.19910	.19960
NsHEAT2	.48064***	.09027	5.32	.0000	.30371	.65756
NsHEAT3	.36944***	.11318	3.26	.0011	.14762	.59127
NsCOST1	.02519	.17069	.15	.8827	-.30935	.35973
NsCOST2	.37117***	.10896	3.41	.0007	.15761	.58473
NsCOST3	.43085***	.10011	4.30	.0000	.23463	.62707
NsCOMF1	.31475***	.10468	3.01	.0026	.10958	.51991
NsCOMF2	.02232	.11690	.19	.8486	-.20679	.25143
NsCOMF3	.08572	.20445	.42	.6750	-.31499	.48644
NsNUIS1	.33532***	.05859	5.72	.0000	.22048	.45016
NsHOUS1	.56269***	.05459	10.31	.0000	.45569	.66969
NsNEIG1	.09351	.11654	.80	.4223	-.13490	.32192

```
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 30, 2021 at 01:52:41 PM
```

Latent Class model without LCM variables

```
|-> NLOGIT;
    Lhs=CHOICE;
    Choices=1,2,none;
    RHS=CON,HEAT1,HEAT2,HEAT3,COST1,COST2,COST3,COMF1,COMF2,COMF3,NUIS1,HOUS1,NEIG1;
    LCM;
    Pds=8;Pts=2$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .2766001D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable              Choice
Log likelihood function     -2766.00091
Estimation based on N =   3040, K =  13
Inf.Cr.AIC  =   5558.0 AIC/N =    1.828
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -3045.5354  .0918 .0877
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=  3040, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
CON|1|	1.02490***	.05298	19.34	.0000	.92106	1.12874
HEAT1|1|	.00098	.04620	.02	.9831	-.08957	.09153
HEAT2|1|	-.01716	.04523	-.38	.7043	-.10580	.07148
HEAT3|1|	-.02061	.04439	-.46	.6425	-.10762	.06640
COST1|1|	.28852***	.04407	6.55	.0000	.20216	.37489
COST2|1|	.09981**	.04647	2.15	.0317	.00874	.19089
COST3|1|	-.41723***	.04635	-9.00	.0000	-.50808	-.32638
COMF1|1|	.26903***	.04541	5.92	.0000	.18002	.35803
COMF2|1|	.12538***	.04472	2.80	.0051	.03772	.21304
COMF3|1|	-.52967***	.04770	-11.10	.0000	-.62317	-.43618
NUIS1|1|	-.31202***	.02195	-14.22	.0000	-.35504	-.26900
HOUS1|1|	.17870***	.02174	8.22	.0000	.13608	.22132
NEIG1|1|	.16064***	.02171	7.40	.0000	.11810	.20318

```
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 27, 2021 at 08:22:07 PM
```

```
Iterative procedure has converged
Normal exit:  38 iterations. Status=0, F=     .2451893D+04
-----------------------------------------------------------------------------
Latent Class Logit Model
Dependent variable                 CHOICE
Log likelihood function       -2451.89310
Restricted log likelihood     -3339.78136
Chi squared [ 27](P= .000)     1775.77652
Significance level                 .00000
McFadden Pseudo R-squared        .2658522
Estimation based on N =   3040, K =  27
Inf.Cr.AIC  =   4957.8 AIC/N =    1.631
---------------------------------------
            Log likelihood R-sqrd R2Adj
No coefficients -3339.7814  .2659 .2626
Constants only  -3045.5354  .1949 .1913
At start values -2765.9724  .1136 .1096
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of latent classes =            2
Average Class Probabilities
     .759  .241
LCM model with panel has     380 groups
Fixed number of obsrvs./group=        8
Number of obs.=  3040, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random utility parameters in latent class -->> 1					
CON|1	2.96760***	.23094	12.85	.0000	2.51497	3.42024
HEAT1|1	.00765	.05473	.14	.8888	-.09962	.11492
HEAT2|1	-.03714	.05439	-.68	.4947	-.14375	.06946
HEAT3|1	-.04581	.05197	-.88	.3781	-.14768	.05605
COST1|1	.30647***	.05194	5.90	.0000	.20466	.40828
COST2|1	.15432***	.05536	2.79	.0053	.04582	.26282
COST3|1	-.41191***	.05294	-7.78	.0000	-.51567	-.30816
COMF1|1	.32416***	.05425	5.98	.0000	.21784	.43048
COMF2|1	.16159***	.05295	3.05	.0023	.05781	.26537
COMF3|1	-.53692***	.05339	-10.06	.0000	-.64155	-.43228
NUIS1|1	-.29605***	.02466	-12.01	.0000	-.34437	-.24772
HOUS1|1	.20063***	.02444	8.21	.0000	.15272	.24853
NEIG1|1	.16218***	.02372	6.84	.0000	.11570	.20867
	Random utility parameters in latent class -->> 2					
CON|2	-.99700***	.13246	-7.53	.0000	-1.25662	-.73737
HEAT1|2	-.09056	.12334	-.73	.4628	-.33231	.15119
HEAT2|2	.12127	.13432	.90	.3666	-.14199	.38452
HEAT3|2	.04615	.12779	.36	.7180	-.20432	.29662
COST1|2	.38331***	.11708	3.27	.0011	.15384	.61277
COST2|2	.15007	.11620	1.29	.1965	-.07767	.37781
COST3|2	-.78830***	.16940	-4.65	.0000	-1.12031	-.45628
COMF1|2	.32386***	.11693	2.77	.0056	.09468	.55305
COMF2|2	.12390	.11789	1.05	.2933	-.10717	.35496
COMF3|2	-.82206***	.16648	-4.94	.0000	-1.14836	-.49577
NUIS1|2	-.51447***	.07206	-7.14	.0000	-.65570	-.37323
HOUS1|2	.08092	.07078	1.14	.2529	-.05780	.21964
NEIG1|2	.14795**	.06393	2.31	.0206	.02266	.27324
	Estimated latent class probabilities					
PrbCls1	.75903***	.02710	28.00	.0000	.70590	.81215
PrbCls2	.24097***	.02710	8.89	.0000	.18785	.29410

```
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 27, 2021 at 08:22:10 PM
-----------------------------------------------------------------------------
```

Latent Class model including LCM variables

(Bad observations are due to missing values. Respondents who did not want to answer whether they received rent allowance are coded as missing value.)

```
|-> NLOGIT;
    Lhs=CHOICE;
    Choices=1,2,none;
    RHS=CON,HEAT1,HEAT2,HEAT3,COST1,COST2,COST3,COMF1,COMF2,COMF3,NUIS1,HOUS1,NEIG1;
    Pds=8;
    LCM=WTPAVE,NOALLOWA,DWELSFAM,CHILDYES,LIVINGCO;
    Pts=2;
    Parameters
    $

+---------------------------------------------------+
|WARNING:   Bad observations were found in the sample. |
|Found  120 bad observations among   3040 individuals. |
|You can use ;CheckData to get a list of these points. |
+---------------------------------------------------+

Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .2647166D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -2647.16591
Estimation based on N =    2920, K =  13
Inf.Cr.AIC  =   5320.3 AIC/N =    1.822
---------------------------------------
               Log likelihood R-sqrd R2Adj
Constants only  -2918.7612  .0931  .0881
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=   3040, skipped  120 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.       95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   CON|1|   1.04111***      .05440    19.14  .0000      .93450   1.14773
 HEAT1|1|   -.01610         .04722     -.34  .7331    -.10865    .07644
 HEAT2|1|    .00303         .04616      .07  .9477    -.08744    .09350
 HEAT3|1|   -.02054         .04529     -.45  .6502    -.10932    .06823
 COST1|1|    .29399***      .04508     6.52  .0000     .20564    .38234
 COST2|1|    .09237*        .04749     1.94  .0518    -.00072    .18546
 COST3|1|   -.41136***      .04728    -8.70  .0000    -.50402   -.31870
 COMF1|1|    .28673***      .04624     6.20  .0000     .19609    .37736
 COMF2|1|    .12011***      .04558     2.64  .0084     .03078    .20944
 COMF3|1|   -.54992***      .04897   -11.23  .0000    -.64589   -.45394
 NUIS1|1|   -.31541***      .02242   -14.07  .0000    -.35935   -.27147
 HOUS1|1|    .17573***      .02219     7.92  .0000     .13224    .21921
 NEIG1|1|    .15748***      .02216     7.11  .0000     .11405    .20092
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 30, 2021 at 00:27:06 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  54 iterations. Status=0, F=    .2453365D+04

-----------------------------------------------------------------------------
```

```
Latent Class Logit Model
Dependent variable                  CHOICE
Log likelihood function        -2453.36452
Restricted log likelihood      -3207.94788
Chi squared [ 32](P= .000)      1509.16673
Significance level                  .00000
McFadden Pseudo R-squared         .2352231
Estimation based on N =    2920, K =    32
Inf.Cr.AIC  =    4970.7 AIC/N =      1.702
------------------------------------------
             Log likelihood R-sqrd R2Adj
No coefficients -3207.9479  .2352  .2310
Constants only  -2918.7612  .1595  .1548
At start values -2653.0458  .0753  .0702
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
------------------------------------------
Response data are given as ind. choices
Number of latent classes =               2
Average Class Probabilities
     .771   .229
LCM model with panel has      380 groups
Fixed number of obsrvs./group=           8
Number of obs.=  3040, skipped  120 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
        |Random utility parameters in latent class -->> 1...................
   CON|1|     2.18902***      .12230    17.90  .0000     1.94931   2.42874
 HEAT1|1|      .00222         .05488      .04  .9677     -.10534    .10978
 HEAT2|1|     -.03625         .05381     -.67  .5005     -.14171    .06921
 HEAT3|1|     -.06596         .05291    -1.25  .2125     -.16965    .03773
 COST1|1|      .27921***      .05265     5.30  .0000      .17602    .38239
 COST2|1|      .14462***      .05608     2.58  .0099      .03470    .25454
 COST3|1|     -.41260***      .05388    -7.66  .0000     -.51821   -.30699
 COMF1|1|      .38475***      .05432     7.08  .0000      .27828    .49122
 COMF2|1|      .17868***      .05323     3.36  .0008      .07436    .28301
 COMF3|1|     -.62462***      .05474   -11.41  .0000     -.73190   -.51734
 NUIS1|1|     -.31398***      .02576   -12.19  .0000     -.36447   -.26349
 HOUS1|1|      .20514***      .02551     8.04  .0000      .15514    .25514
 NEIG1|1|      .16751***      .02443     6.86  .0000      .11963    .21539
        |Random utility parameters in latent class -->> 2...................
   CON|2|     -.78919***      .11511    -6.86  .0000    -1.01481   -.56357
 HEAT1|2|     -.06527         .13513     -.48  .6291     -.33012    .19959
 HEAT2|2|      .16650         .14194     1.17  .2408     -.11170    .44470
 HEAT3|2|     -.01666         .15135     -.11  .9123     -.31330    .27997
 COST1|2|      .38917***      .12565     3.10  .0020      .14290    .63544
 COST2|2|      .14588         .13034     1.12  .2631     -.10959    .40135
 COST3|2|     -.66683***      .16072    -4.15  .0000     -.98183   -.35183
 COMF1|2|      .02659         .13319      .20  .8418     -.23446    .28764
 COMF2|2|     -.15518         .13635    -1.14  .2551     -.42241    .11205
 COMF3|2|     -.32169**       .14323    -2.25  .0247     -.60242   -.04096
 NUIS1|2|     -.39521***      .08896    -4.44  .0000     -.56957   -.22085
 HOUS1|2|      .04834         .08217      .59  .5563     -.11271    .20940
 NEIG1|2|      .10974         .07600     1.44  .1487     -.03920    .25869
        |This is THETA(01) in class probability model.......................
  _ONE|1|     1.84548*       1.04108     1.77  .0763     -.19499   3.88596
 _WTPAV|1|     .61973***      .16678     3.72  .0002      .29286    .94661
 _NOALL|1|     .29575*        .17394     1.70  .0891     -.04516    .63666
 _DWELS|1|    -.13090         .16006     -.82  .4135     -.44460    .18281
 _CHILD|1|    -.08363         .16822     -.50  .6191     -.41334    .24608
 _LIVIN|1|    -.70480***      .22833    -3.09  .0020    -1.15232   -.25729
        |This is THETA(02) in class probability model.......................
  _ONE|2|       0.0        .....(Fixed Parameter).....
 _WTPAV|2|      0.0        .....(Fixed Parameter).....
 _NOALL|2|      0.0        .....(Fixed Parameter).....
 _DWELS|2|      0.0        .....(Fixed Parameter).....
 _CHILD|2|      0.0        .....(Fixed Parameter).....
 _LIVIN|2|      0.0        .....(Fixed Parameter).....
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
Model was estimated on Apr 30, 2021 at 00:27:12 PM
-----------------------------------------------------------------------------
```

Appendix 10 – Factor analysis

Factor analysis of all statement variables

Table 61 Descriptive statistics of all statement variables

Correlation matrix

		WTP 1	WTP 2	WTP 3	WTP 4	Sat1	Sat2	Sat3	Sat4	Trust 1	Trust 2	Trust 3	Envatt1	Envatt2	Envatt3	Envatt4	Envatt5
Correlation	WTP 1	1.000	.648	.456	.388	.179	.097	.132	.126	.139	.106	.076	-.102	-.088	.101	-.049	-.006
	WTP 2	.648	1.000	.645	.498	.121	.104	.157	.153	.152	.083	.097	-.121	-.077	.077	-.021	.023
	WTP 3	.456	.645	1.000	.553	.142	.144	.196	.188	.231	.158	.153	-.151	.035	.144	.104	.191
	WTP 4	.388	.498	.553	1.000	.052	.094	.095	.028	.146	.101	.119	-.132	.035	.034	.019	.088
	Sat1	.179	.121	.142	.052	1.000	.532	.509	.534	.452	.415	.413	-.102	-.315	.079	-.127	-.084
	Sat2	.097	.104	.144	.094	.532	1.000	.822	.539	.611	.581	.596	-.102	-.150	.104	-.069	-.004
	Sat3	.132	.157	.196	.095	.509	.822	1.000	.561	.597	.549	.558	-.162	-.150	.057	-.083	-.079
	Sat4	.126	.153	.188	.028	.534	.539	.561	1.000	.525	.461	.495	-.155	-.200	.081	-.112	-.079
	Trust 1	.139	.152	.231	.146	.452	.611	.597	.525	1.000	.778	.783	-.158	-.169	.046	-.114	-.027
	Trust 2	.106	.083	.158	.101	.415	.581	.549	.461	.778	1.000	.769	-.064	-.102	.133	-.058	-.007
	Trust 3	.076	.097	.153	.119	.413	.596	.558	.495	.783	.769	1.000	-.172	-.150	.087	-.129	-.055
	Envatt1	-.102	-.121	-.151	-.132	-.102	-.102	-.162	-.155	-.158	-.064	-.172	1.000	.225	.036	.164	.098
	Envatt2	-.088	-.077	.035	.035	-.315	-.150	-.150	-.200	-.169	-.102	-.150	.225	1.000	.118	.249	.426
	Envatt3	.101	.077	.144	.034	.079	.104	.057	.081	.046	.133	.087	.036	.118	1.000	-.024	.274
	Envatt4	-.049	-.021	.104	.019	-.127	-.069	-.083	-.112	-.114	-.058	-.129	.164	.249	-.024	1.000	.315
	Envatt5	-.006	.023	.191	.088	-.084	-.004	-.079	-.079	-.027	-.007	-.055	.098	.426	.274	.315	1.000

Factor analysis – Eigenvalue = 1

Table 62 KMO and Bartlett's Test regarding the Factor analysis with Eigenvalue = 1

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.822
Bartlett's Test of Sphericity	Approx. Chi-Square	65994.234
	df	120
	Sig.	.000

Table 63 Communalities (r-square values) of the Factor analysis with Eigenvalue = 1

Communalities

	Initial	Extraction
WTP1	1.000	.613
WTP2	1.000	.764
WTP3	1.000	.721
WTP4	1.000	.582
Sat1	1.000	.497
Sat2	1.000	.711
Sat3	1.000	.679
Sat4	1.000	.535
Trust1	1.000	.755
Trust2	1.000	.706
Trust3	1.000	.711
Envatt1	1.000	.215
Envatt2	1.000	.576
Envatt3	1.000	.850
Envatt4	1.000	.566
Envatt5	1.000	.641

Extraction Method: Principal Component Analysis.

Table 64 Total variance explained of the Factor analysis with Eigenvalue = 1

Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.845	30.280	30.280	4.845	30.280	30.280	4.471	27.946	27.946
2	2.470	15.438	45.719	2.470	15.438	45.719	2.661	16.631	44.578
3	1.788	11.176	56.894	1.788	11.176	56.894	1.877	11.732	56.309
4	1.020	6.377	63.272	1.020	6.377	63.272	1.114	6.962	63.272
5	.945	5.908	69.180						
6	.874	5.463	74.643						
7	.694	4.341	78.983						
8	.595	3.717	82.701						
9	.570	3.561	86.262						
10	.519	3.241	89.503						
11	.453	2.833	92.336						
12	.375	2.343	94.680						
13	.273	1.706	96.386						
14	.216	1.351	97.737						
15	.200	1.250	98.987						
16	.162	1.013	100.000						

Extraction Method: Principal Component Analysis

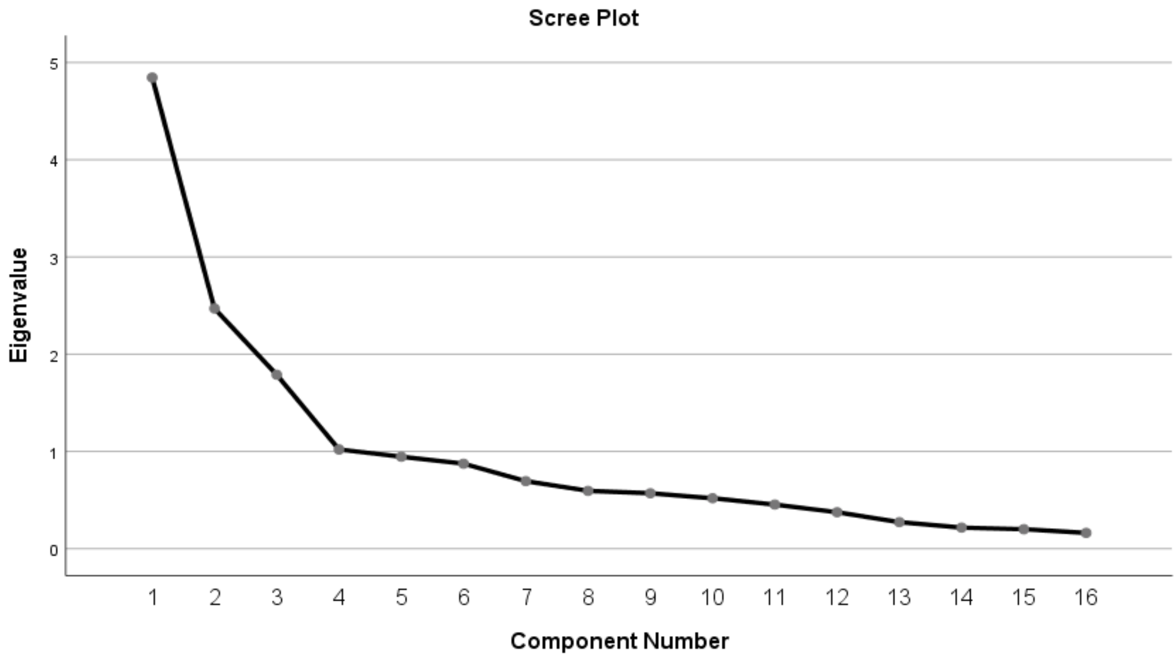


Figure 56 Scree plot of the Factor analysis with Eigenvalue = 1

Table 65 Component matrix showing the Pearson correlations between items and components of the Factor analysis with Eigenvalue = 1

Component Matrix[a]

	Component			
	1	2	3	4
Trust1	.839			
Sat2	.804			
Trust3	.803			
Sat3	.803			
Trust2	.782			
Sat4	.714			
Sat1	.670			
WTP2	.344	.768		
WTP3	.383	.755		
WTP4		.685		
WTP1	.320	.659		
Envatt5		.318	.719	
Envatt2			.666	
Envatt4			.518	-.479
Envatt1			.380	
Envatt3			.379	.810

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Table 66 Rotated component matrix showing the Pearson correlations between items and components of the Factor analysis with Eigenvalue = 1

Rotated Component Matrix[a]

	Component 1	2	3	4
Trust1	.858			
Sat2	.840			
Trust3	.840			
Trust2	.838			
Sat3	.813			
Sat4	.695			
Sat1	.626			
WTP2		.865		
WTP3		.821		
WTP1		.752		
WTP4		.750		
Envatt2			.732	
Envatt5			.709	.352
Envatt4			.686	
Envatt1			.393	
Envatt3				.905

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 67 Component transformation matrix of the Factor analysis with Eigenvalue = 1

Component Transformation Matrix

Component	1	2	3	4
1	.929	.309	-.193	.059
2	-.268	.927	.231	.122
3	.236	-.195	.911	.277
4	-.092	-.081	-.282	.951

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Factor analysis – Fixed number of factors = 3

Table 68 Component matrix showing the Pearson correlations between items and components of the Factor analysis with 3 fixed factors

Component Matrix[a]

	Component		
	1	2	3
Trust1	.839		
Sat2	.804		
Trust3	.803		
Sat3	.803		
Trust2	.782		
Sat4	.714		
Sat1	.670		
WTP2	.344	.768	
WTP3	.383	.755	
WTP4		.685	
WTP1	.320	.659	
Envatt5		.318	.719
Envatt2			.666
Envatt4			.518
Envatt1			.380
Envatt3			.379

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Table 69 Rotated component matrix showing Pearson correlations between items and components of the Factor analysis with 3 fixed factors

Rotated Component Matrix[a]

	Component		
	1	2	3
Trust1	.851		
Sat2	.842		
Trust3	.837		
Trust2	.832		
Sat3	.813		
Sat4	.709		
Sat1	.648		
WTP2		.870	
WTP3		.813	
WTP1		.767	
WTP4		.735	
Envatt5			.784
Envatt2			.732
Envatt4			.571
Envatt3			.393
Envatt1			.375

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Table 70 Component transformation matrix of the Factor analysis with 3 fixed factors

Component Transformation Matrix

Component	1	2	3
1	.939	.318	-.133
2	-.272	.920	.283
3	.212	-.229	.950

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Random Eigenvalue

Parallel Analysis

Number of Variables in Your Dataset to be Factor Analyzed (Please change)

16

Sample Size of Your Dataset (Please change)

9120

Type of Analysis

Principal Components

Number of Random Correlation Matrices to Generate (default of 100 currently set)

500

Percentile of Eigenvalues (default of 95th percentile currently set)

95

Seed

1000

Citing this Application:

Patil Vivek H, Surendra N. Singh, Sanjay Mishra, and D. Todd Donavan (2017). Parallel Analysis Engine to Aid in Determining Number of Factors to Retain using R [Computer software], available from https://analytics.gonzaga.edu/parallelengine/.

Using this Application

Based on parameters provided by the researcher, this engine calculates eigenvalues from randomly generated correlation matrices. These can be then compared with eigenvalues extracted from the researcher's dataset. The number of factors to retain will be the number of eigenvalues (generated from the researcher's dataset) that are larger than the corresponding random eigenvalues (Horn 1965).

The default (and recommended) values for number of random correlation matrices and percentile of eigenvalues are 100 and 95 respectively (see Cota et al. 1993; Glorfeld 1995; Turner 1998; Velicer et al. 2000). Based on the nature of their particular dataset, researchers, can override these default options. Higher (lower) values of number of correlation matrices generated increase (decrease) computation time but provide more (fewer) data points in the distribution of different eigenvalues. The percentile determines the desired eigenvalue from this distribution, which is then used for comparison purposes. Lower values of the percentile tend to lead to over extraction (extraction of more factors than necessary).

Component or Factor	Mean Eigenvalue	Percentile Eigenvalue
1	1.071589	1.084465
2	1.057384	1.067801
3	1.045891	1.054364
4	1.036352	1.043824
5	1.027416	1.034549
6	1.019206	1.025701
7	1.011324	1.017720

Figure 57 Random Eigenvalue generator with the specifics of this research study

Reliability test - Cronbach's Alpha

Table 71 Reliability test showing the Cronbach's Alpha of all the statement variables

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.730	.741	16

Factor analysis and Cronbach's Alpha tests of statement factors

Table 72 Correlation matrix from a factor analysis

Correlation Matrix[a]

		WTPAverage	SatAverage	EnvironmentalAttitudeAverage	TrustAverage
Correlation	WTPAverage	1.000	.191	.012	.173
	SatAverage	.191	1.000	-.174	.679
	EnvironmentalAttitudeAverage	.012	-.174	1.000	-.115
	TrustAverage	.173	.679	-.115	1.000
Sig. (1-tailed)	WTPAverage		.000	.125	.000
	SatAverage	.000		.000	.000
	EnvironmentalAttitudeAverage	.125	.000		.000
	TrustAverage	.000	.000	.000	

a. Determinant = ,500

Table 73 KMO and Bartlett's test from a factor analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.546
Bartlett's Test of Sphericity	Approx. Chi-Square	6311.459
	df	6
	Sig.	.000

Table 74 Total variance explained table from factor analysis

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	1.810	45.260	45.260	1.810	45.260	45.260	1.809
2	1.013	25.317	70.576	1.013	25.317	70.576	1.013
3	.859	21.482	92.058				
4	.318	7.942	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

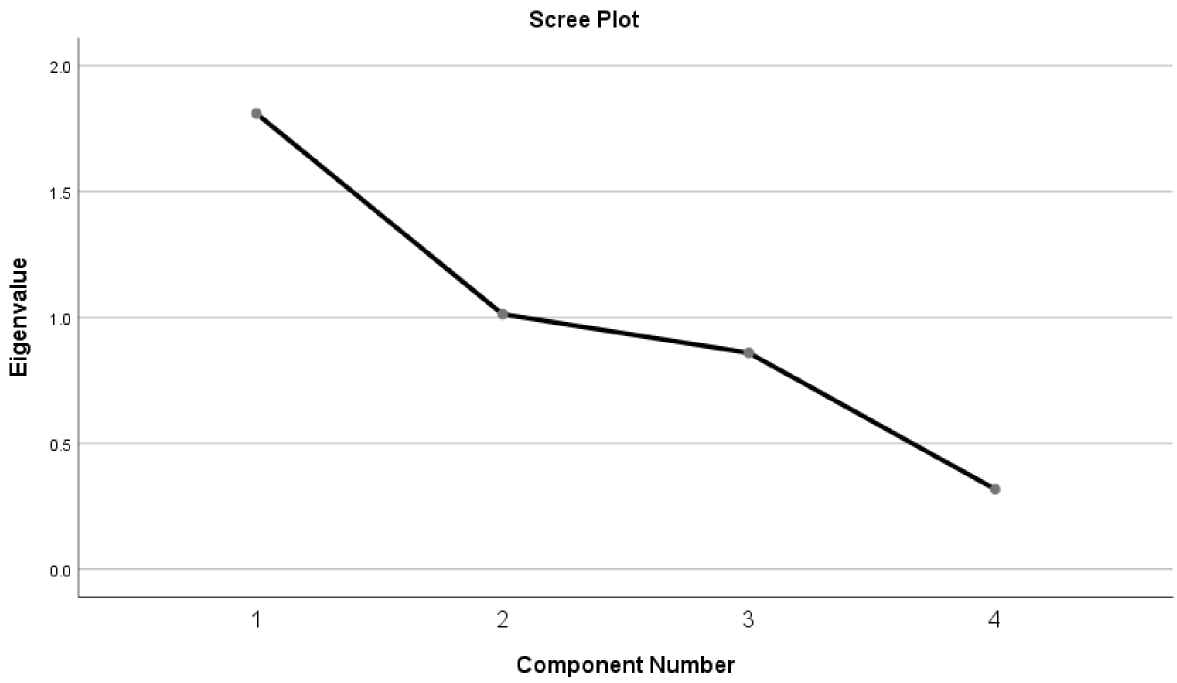


Figure 58 Scree plot from factor analysis

Table 75 Pattern matrix from factor analysis

Pattern Matrix[a]

	Component	
	1	2
WTPAverage	.399	.618
SatAverage	.892	-.060
EnvironmentalAttitudeAverage	-.301	.793
TrustAverage	.875	-.008

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Table 76 Component correlation matrix from factor analysis

Component Correlation Matrix

Component	1	2
1	1.000	.024
2	.024	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Reliability test 1

Table 77 Reliability table including Cronbach's Alpha from reliability test 1

Reliability Statistics

Cronbach's Alpha	N of Items
.418	4

Table 78 Inter-Item Correlation matrix from reliability test 1

Inter-Item Correlation Matrix

	WTPAverage	SatAverage	TrustAverage	EnvironmentalAttitudeAverage
WTPAverage	1.000	.191	.173	.012
SatAverage	.191	1.000	.679	-.174
TrustAverage	.173	.679	1.000	-.115
EnvironmentalAttitudeAverage	.012	-.174	-.115	1.000

Table 79 Item-Total statistic table from reliability test 1

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
WTPAverage	9.82092105265	2.110	.199	.397
SatAverage	10.15118421055	1.947	.438	.119
TrustAverage	9.62684210526	1.849	.444	.096
EnvironmentalAttitudeAverage	9.92368421055	3.353	-.116	.595

Reliability test 2

Table 80 Reliability table including Cronbach's Alpha from reliability test 2

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.595	.615	3

Table 81 Inter-Item Correlation matrix from reliability test 2

Inter-Item Correlation Matrix

	WTPAverage	SatAverage	TrustAverage
WTPAverage	1.000	.191	.173
SatAverage	.191	1.000	.679
TrustAverage	.173	.679	1.000

Table 82 Item-Total statistic table from reliability test 2

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
WTPAverage	6.57039473686	2.029	.198	.040	.808
SatAverage	6.90065789476	1.699	.547	.467	.293
TrustAverage	6.37631578947	1.648	.522	.463	.316

Reliability test 3

Table 83 Reliability statistic including Cronbach's Alpha from reliability test 3

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.022	.024	2

Table 84 Inter-Item Correlation matrix from reliability test 3

Inter-Item Correlation Matrix

	WTPAverage	EnvironmentalAttitudeAverage
WTPAverage	1.000	.012
EnvironmentalAttitudeAverage	.012	1.000

Table 85 Item-Total statistic table from reliability test 3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
WTPAverage	3.2505	.342	.012	.000	.
EnvironmentalAttitudeAverage	3.3533	.815	.012	.000	.