

# The successfulness of social housing energy renovation projects

*An exploration into the effects of the project on tenants' satisfaction and their energy consumption*



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# **The successfulness of social housing energy renovation projects**

## *An exploration into the effects of the project on tenants' satisfaction and their energy consumption*

In partially fulfilment of the requirements for the dual degree of Master of Science in Construction Management and Engineering and Architecture, building and planning at Eindhoven University of Technology

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## Summary

Within national and international policies, the residential sector is important in the attempt to tackle climate change. Because of the large share of social housing in the residential sector in the Netherlands, housing corporations are playing an important role to improve the energy efficiency of existing dwellings. Therefore, this thesis focusses on energy renovation projects of housing corporations. Even though housing corporations are motivated to improve their portfolio, current tenants make this process more complicated. Uesaraie (2018) analysed the criteria to judge the successfulness of a renovation project and concluded that aspects such as tenants' satisfaction and energy reduction are important factors. Both factors may be influenced by the approach used during the renovation process. A higher level of participation during the process is assumed to result in a higher satisfaction level (Debusschere, VandeKerckhove, & Van Bortel, 2009; Schoenmakers, 2015), and is assumed to affect the energy consumption behaviour of tenants (Gianfrate, Piccardo, Longo, & Giachetta, 2017). Therefore, the main research question of this thesis is as follows: *How does the renovation process, including the level of participation, affect the satisfaction level of tenants and the energy reduction?*

First literature is reviewed to gain insight into the topics of participation, satisfaction and energy consumption and the relationships between these topics and (energy) renovation projects. The literature review showed that participation concerns the amount of influence given to a certain participant. Tenant participation specifically considers the "involvement in and the influence on the planning and policy-making of housing corporations" (Rus et al., 2010, pp. 5). The higher the level of participation, the more influence tenants have. While there are studies that describe various forms of participation used within (energy) renovation projects, there is little research that considers experiences and point of view of the tenants. Furthermore, there is little research into the effect of participation on the satisfaction level of tenants and the determinants that affect the satisfaction level. Literature is therefore used to identify possible determinants for the satisfaction of tenants which will be studied later. These determinants are 'influence', 'time', 'discomfort and nuisance', 'communication', 'information', 'measures', 'financial consequences' and 'comfort'. The satisfaction is considered to be the result of a gap between the expectations and actual experience or outcome of these aspects (Galster, 1987; Patterson, 1993). Finally, the literature review showed that behaviour has a large impact on the actual energy performance of a dwelling and therefore also in the actual change in energy consumption due to a renovation. The actual savings are often smaller compared to the theoretical savings due to the rebound- and prebound effect (Majcen et al., 2013; Sunikka-Blank et al., 2012). While it's likely that the renovation approach may influence the (unconscious) behaviour change of tenants, there is little research and empirical evidence on the relation between these topics. While the literature review showed insight into the three important topics of this study and the relation with renovation projects, it also showed that there is little research into the effects of the renovation approach on the satisfaction and the energy consumption.

The literature review is used to create a conceptual model. Which is the base for the remainder of this study. To answer the research question, four case studies with different renovation approaches are compared. This study is divided into two parts: satisfaction and energy consumption. A questionnaire is designed to collect data about tenants' expectation, experience and satisfaction with each determinant, their satisfaction with the process, results, and their overall satisfaction. Furthermore, data about the energy consumption before and after renovation is collected for a limited number of households per case.

The satisfaction data (N=118) is used to estimate a path model to understand the relations between observed variables. The path model of this study explains the relationship between the gap between

the expectations and experiences of each determinant, the satisfaction with the determinants, the satisfaction with the process, and results and the overall satisfaction. It shows that the determinants 'financial consequences' and 'information' don't affect the overall satisfaction. Furthermore, the gap between expectations and experiences of the other determinants affect the satisfaction level of that determinant. It is therefore recommended for housing corporations to measure the expectations of the tenants before and the experiences during and after the renovation process. During the process, the gap between the expectations and experiences can be addressed if needed. Because the gap between the expectations and experiences about the measures and comfort cannot be addressed during the renovation, these determinants should be considered afterwards and, if possible, additional adjustments should be made.

Subsequently, the four cases are compared for each determinant, using the results of various ANOVA tests. According to the path model, the end result of the renovation is more important than the process. The satisfaction with the result is mainly influenced by the satisfaction with the comfort improvement and the measures. The satisfaction levels of these determinants decrease if the measures don't fit the wishes/needs of the tenants. It is therefore recommended to evaluate the wishes and needs during the design phase and communicate the differences between these wishes/needs and the actual applied measures. It is furthermore important to clearly communicate the effect of the measures on the level of comfort and/or daily use of the dwellings and prevent from using too general and/or vague descriptions. Furthermore, the satisfaction with the amount of self-invested time is important because it indirectly affects the overall satisfaction through the satisfaction with the discomfort and nuisance, communication with the housing corporation, communication with the contractor and the influence. The amount of self-invested time and the satisfaction with it is partially the result of the relationship between the contractor and the tenant. It is therefore recommended for the housing corporation to monitor the communication between the contractor and tenants and intervene where needed. While it was expected that tenant participation improves the satisfaction level of tenants, this study showed that a higher level of participation doesn't necessarily result in a higher level of satisfaction. Of all determinants, satisfaction with the influence is the least important for the overall satisfaction. However, the gap variable of this determinant has, compared to the other gap variables, quite a large impact because it also affects the satisfaction with the time and the communication with the contractor. The study concluded that tenants experience more influence if there is a more personal approach. It is likely that a personal approach results in all tenants being able to express their feelings, wishes and complaints more easily. When tenants were given the opportunity to have extra work carried out, their gap between expected and actual amount of influence and their satisfaction with it increased. To manage this, work hours/vouchers can be used. Each household receives the same amount and can use them for additional work while regulating the amount of additional work per dwelling.

The second part of this thesis analysed the differences between the theoretical and the actual change in energy consumption. According to literature, two aspects contribute to the difference between the theoretical and actual change. First, the energy label, used to indicate the energy performance of a dwelling, is not able to predict the real energy consumption (Majcen et al., 2013). Therefore, the theoretical consumption is overestimated for dwellings with a poor label and underestimated for dwellings with a better energy label. Second, the rebound- and prebound effect occur because tenants change their consumption behaviour according to their needs and costs. This study indicates that the renovation approach may affect energy consumption behaviour as well. Provided information about the effect of behaviour on energy consumption and tips to change the behaviour may reduce the rebound effect. However, the sample size of this section is too small (N=29) to say this with certainty. Therefore, further research is needed.

## Samenvatting

De gebouwde omgeving, waaronder woningen, wordt in nationaal en internationaal beleidsvorming gezien als een belangrijke sector om klimaatverandering tegen te gaan. Omdat woningcorporaties een groot deel van de huidige woningen bezitten, worden woningcorporaties gezien als belangrijke spelers om de energie-efficiëntie van bestaande woningen te verbeteren en klimaatverandering tegen te gaan. Daarom richt deze scriptie zich op energie renovatieprojecten van woningcorporaties. Hoewel woningcorporaties gemotiveerd zijn om hun portefeuille te verbeteren, spelen andere aspecten (zoals huidige bewoners) ook een belangrijke rol in de besluitvorming rond deze projecten. Uesaraie (2018) analyseerde welke criteria het succes van een energie renovatieproject bepalen en concludeerde dat criteria zoals huurderstevredenheid en energiereductie belangrijk zijn. Beide aspecten kunnen worden beïnvloed door de aanpak die tijdens het renovatieproject wordt gebruikt. In de literatuur wordt vaak verondersteld dat een hoger niveau van participatie resulteert in een hogere tevredenheid (Debusschere et al., 2009; Schoenmakers, 2015) en dat het invloed heeft op het energiegedrag van huurders (Gianfrate et al., 2017). De onderzoeksvraag van deze scriptie is daarom als volgt: *Hoe beïnvloedt het renovatieproces, inclusief het niveau van participatie, de huurderstevredenheid en de energiereductie van een energie renovatieproject?*

Er is eerst een literatuuronderzoek uitgevoerd om meer inzicht te krijgen in de bestaande kennis over participatie, tevredenheid en energieverbruik en de relatie tussen deze drie onderwerpen en energie renovatieprojecten. Hieruit is geconcludeerd dat participatie te maken heeft met de hoeveelheid invloed die een participant heeft. Huurdersparticipatie wordt daarom omschreven als de “betrokkenheid bij en de hoeveelheid invloed op de planning en beleidsvorming van woningcorporaties” (Rus et al., 2010, pp. 5). Hoe hoger het participatieniveau, hoe meer invloed de huurders hebben. Er zijn verschillende onderzoeken die verschillende vormen van participatie in (energie) renovatieprojecten beschreven in de literatuur. Er zijn echter weinig onderzoeken die onderzoek hebben gedaan over de ervaringen van de huurder. Daarnaast is er ook weinig onderzoek gedaan naar de relatie tussen participatie en de huurderstevredenheid en welke factoren de tevredenheid van huurders met de renovatie bepalen. De bestaande literatuur is gebruikt om mogelijke factoren te bepalen, resulterend in de volgende factoren: ‘invloed’, ‘tijd’, ‘ongemak en overlast’, ‘communicatie’, ‘informatie’, ‘maatregelen’, ‘financiële gevolgen’ en ‘comfort’. De tevredenheid is het resultaat van het verschil tussen de verwachtingen en daadwerkelijke ervaringen (Galster, 1987; Patterson, 1993). Het literatuuronderzoek maakte verder duidelijk dat het gedrag van mensen een grote invloed heeft op het daadwerkelijke energiegebruik van een woning en daardoor ook op de verandering van het energieverbruik door de renovatie. Het rebound- en prebound effect zorgen er vaak voor dat de daadwerkelijke verandering kleiner is dan de theoretische verandering (Majcen et al., 2013; Sunikka-Blank et al., 2012). Waarschijnlijk heeft de renovatieaanpak invloed op de gedragsverandering van huurders, maar hier is weinig onderzoek naar gedaan. Het literatuuronderzoek heeft gezorgd voor meer inzicht in de drie belangrijkste onderwerpen van deze scriptie: participatie, tevredenheid en energieverbruik en de relatie met renovatieprojecten. Echter, het laat ook zien dat er een weinig onderzoek gedaan is naar de relatie tussen het renovatieproces en de huurderstevredenheid en het energieverbruik van huishoudens.

Met behulp van het literatuuronderzoek is een conceptueel model opgesteld, dat is gebruikt als basis voor het vervolg van dit onderzoek. Om de onderzoeksvraag te beantwoorden, zijn vier projecten met verschillende aanpakken vergeleken. Het onderzoek is verdeeld in twee delen; tevredenheid en energieverbruik. Een vragenlijst is gemaakt om data te verzamelen over de verwachtingen, ervaringen en tevredenheid met betrekking tot de factoren en de tevredenheid met het proces, het resultaat en

de gehele renovatie. Daarnaast is ook het energieverbruik van voor en na de renovatie verzameld voor een beperkt aantal huishoudens per project.

De verzamelde data over de tevredenheid (N=118) is gebruikt om een pad model te maken. Pad analyse is onderdeel van structurele vergelijkingsmodellen, waarin de relatie tussen geobserveerde variabelen wordt geanalyseerd. Het model in deze studie laat de relatie zien tussen de kloof variabelen (verschil tussen ervaring en verwachting) en de tevredenheid met de factoren, proces, resultaat en algehele tevredenheid. De factoren 'financiële gevolgen' en 'informatie' hebben geen invloed op de algehele tevredenheid. Verder laat het model zien dat de variabelen met betrekking tot de kloof tussen verwachting en ervaring invloed hebben op de bijbehorende tevredenheidsvariabelen. Er wordt daarom aangeraden aan woningcorporatie om de verwachting van huurders vooraf te meten en dit te vergelijken met de ervaringen tijdens en na de renovatie. Tijdens het renovatieproces kunnen, naar aanleiding van de kloof, aanpassingen gedaan worden om de tevredenheid van huurders te vergroten. Met betrekking tot de maatregelen en comfort kan achteraf gekeken worden of er verschillen zijn wat kan leiden tot eventuele aanpassingen.

De vier projecten zijn, op basis van de factoren, vergeleken door middel van ANOVA testen. Het pad model laat zien dat het resultaat belangrijker is dan het proces. Dit komt voornamelijk door de tevredenheid met het comfort en de maatregelen. De tevredenheid daalt wanneer de maatregelen niet overeenkomen met de wensen en behoeften van huurders. Het is daarom belangrijk om deze wensen en behoeften te achterhalen en, waar mogelijk, mee te nemen in de daadwerkelijke maatregelen. Het is belangrijk om te communiceren aan welke wensen voldaan kan worden en welke niet. Verder is het belangrijk om de gevolgen van de maatregelen na de renovatie duidelijk te communiceren, zonder vage en/of te algemene omschrijvingen te geven. De tevredenheid met de zelf bestede tijd aan de renovatie is ook belangrijk omdat het invloed heeft op de tevredenheid met het ongemak en overlast, de communicatie met de woningcorporatie en aannemer en de invloed. De zelf bestede tijd is deels het resultaat van de relatie tussen de huurder en de aannemer. Het wordt daarom aanbevolen aan de woningcorporaties om deze relatie te monitoren en in te grijpen wanneer nodig. Er werd verwacht dat de participatie de tevredenheid zou verbeteren. Echter dit onderzoek laat zien dat dit niet per definitie het geval is. Van alle factoren, heeft de tevredenheid met de invloed het minste effect op de algehele tevredenheid, maar de betreffende kloofvariabele heeft een relatief grote invloed. De analyse laat zien dat huurders meer invloed ervaren als de benadering meer persoonlijk is. Waarschijnlijk leidt dit ertoe dat huurders hun gevoelens, wensen en klachten gemakkelijker kunnen uiten. Daarnaast is de tevredenheid hoger als men invloed heeft op extra maatregelen tijdens het proces. Om dit te reguleren, kunnen gratis werkuren/vouchers gebruikt worden. Elke huishouden ontvangt dezelfde hoeveelheid en kan deze inzetten voor extra werkzaamheden.

Het tweede deel van deze scriptie analyseerde de verschillen tussen de verandering in daadwerkelijk en theoretisch energieverbruik. Volgens het literatuuronderzoek zijn er twee aspecten die een rol spelen in het verschil tussen daadwerkelijk en theoretisch energieverbruik; (1) het energie label laat de energieprestatie van de woning zien, maar niet het energieverbruik (Majcen et al., 2013) en (2) de rebound- en prebound effecten treden op omdat huurders hun energiegedrag aanpassen aan hun behoeften en de kosten. De analyse laat zien dat het renovatieproject mogelijk invloed heeft op het gedrag van huurders. Informatie over de invloed van het gedrag op het verbruik en tips kunnen het rebound effect verkleinen. De steekproef van dit deel van de studie is echter klein (N=29), waardoor niet met zekerheid gezegd kan worden of het proces daadwerkelijk invloed heeft. Hiervoor is meer onderzoek nodig.

## Abstract

The improvement of the energy efficiency of dwellings of housing corporations is important to counteract climate change. In addition to energy reduction, satisfaction of tenants with the renovation is an important criterion to judge whether a project is successful (Uesaraie, 2018). While it is assumed that the renovation process, including participation, affects these two criteria, there is little research into these relationships. Therefore, the aim of this study is to explore the relations between the renovation approach and the satisfaction and energy consumption, using four cases. Data about the expectations, experiences and satisfaction of tenants is collected (N=118) and used to estimate a path model describing the relations between several determinants and the overall satisfaction. Path analyses showed that the gap between the expectations and experiences of tenants of several determinants influence the overall satisfaction. Therefore, both the expectations and experiences of tenants should be considered during and after the renovation to improve satisfaction. Furthermore, the determinants comfort and measures are most important for the overall satisfaction. The wishes and needs of tenants should be considered and the effect of the applied measures should be communicated. The level of influence seems to be less important to tenants, but a personal approach is likely to ensure that tenants can express their feelings, wishes and complaints. Influence in additional work will increase satisfaction and can be regulated through e.g. work vouchers. The amount of self-invested time should also be considered, because it affects most of the other determinants. Finally, the communication with the contractor is more important than the communication with the housing corporation. It is therefore important for housing corporations to monitor the communication between contractor and the tenants. The analyses of the energy consumption data show that it is likely that the renovation approach can affect the energy consumption behaviour of tenants. However, the sample size (N=29) is too small to say this for certain.



# List of Abbreviations/Glossary

## Abbreviations

(According to the appearance in the report)

EU	European Union
EPBD	Energy Performance of Building Directive
UN	United Nations
Daeb	Services of general economic interest (in Dutch: diensten van algemeen economisch belang)
WSW	Guarantee fund social housing (in Dutch: Waarborgfonds Sociale Woningbouw)
MIT	Mutual Incentive Theory
EI	Energy index
BEG	Degree on energy performance of buildings (in Dutch: Besluit energieprestatie gebouwen)
UTAUT	Unified theory of acceptance and use of technology
SEM	Structural equation modelling
ML	Maximum likelihood
ULS	Unweighted least squares
GLS	Generalised least squares
AFD	Asymptotically distribution free
RMSEA	Root mean square error of approximation
(S)RMSR	(Standardised) root mean square residual
NFI	Normed-fit index
CFI	Comparative fit index
CBS	Statistics Netherlands (in Dutch: Centraal Bureau voor de Statistiek)
PV	Photovoltaic
PVGIS	Photovoltaic Geographical Information System
KNMI	Royal Dutch Meteorological Institute (in Dutch: Koninklijk Nederlands Meteorologisch Instituut)

## Definitions

(According to the appearance in the report)

Energy renovation	Renovating a dwelling in order to increase the energy efficiency (Ástmarsson, Jensen, & Maslesa, 2013)
Tenant participation	The involvement of tenants during planning and policymaking of housing corporations, where tenants have some level of influence over the decision making.
Rebound effect	The over-consumption of households after renovation due to increased use of the energy services and/or the use of less energy-efficient services/facilities.
Prebound effect	Under-consumption of households before renovation due to a more economical use of the energy services.

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# 1. Introduction

In this chapter, this thesis is introduced. It starts with the problem definition, which results in the main and sub research questions. Subsequently, the research design is explained, and the structure of this report is described.

## 1.1. Problem definition

### 1.1.1. Background information

In 2007, the European Union (EU) formulated climate and energy targets to counteract climate change (European Commission, n.d.-a). All buildings in the EU account for approximately 40% of total energy consumption and 36% of the CO<sub>2</sub> emission (European Commission, n.d.-b) and the residential sector accounts for 25.4% of the total energy consumption in the EU (Eurostat, n.d.). The residential sector can therefore play an important role in reaching the EU goals. In order to reduce the amount of energy consumption of buildings, the EU created the 'Energy Performance of Building Directive' (EPBD) and 'Energy Efficiency Directive' (European Commission, n.d.-b). Each country in the EU must implement the guidelines of the various directives. In the Netherlands, the implementation of the guidelines of the EU can be found in various national legislations, agreements and covenants (RVO, n.d.-a).

To reduce the energy consumption of social housing, the government, Aedes (branch association of housing corporations) and the association for tenants created the Covenant Energy Saving Covenant for the Rented Sector (in Dutch, "Covenant Energiebesparing Huursector") (Spies, Hazeu, Laurier, & Kamminga, 2012). One of the goals is that in 2020, the total housing stock of all housing corporations should have at least an average energy index (EI) of 1.25 (energy label B). A large amount of the existing dwellings of the housing corporation are built before 1975 and have a poor energy efficiency because of missing legislation (Hoppe, 2012). Therefore, social housing can play an important role in the reduction of energy consumption in the Netherlands. Filippidou et al. (2017) analysed the energy performance of Dutch social housing renovations and concluded that improvements have been made but more work needs to be done to reach the Dutch and European goals.

In addition to European legislation, the Netherlands agreed, together with the other countries of the United Nations (UN), to limit the global warming well below 2 °C (Rijksoverheid, n.d.-c) in 2015 during the conference in Paris. In response to the climate agreement of the UN, the Dutch government presented in June 2019 its national climate agreement (Rijksoverheid, n.d.-c). The built environment is seen as one of the sectors who can contribute to achieving the objectives. In 2050, 7 million dwellings should be off the natural gas grid. Housing corporations in the Netherlands have approximately 2.4 million dwellings in possession (Klimaatakkoord, n.d.). Therefore, the housing corporations have to initiate the transition of the climate agreement.

### 1.1.2. Problem statement

From the government, but also the sector itself, there is a desire to improve the energy performance of social housing. Even though the housing corporations are motivated to improve their portfolio, current tenants make this process more complicated. Uesaraie (2018) analysed the criteria to judge the successfulness of a renovation project and concluded that aspects such as tenants' satisfaction and energy reduction are important factors.

When tenants feel they have a say during the renovation process, they are likely to be more satisfied with it, compared to tenants that don't have any influence in the process (Marissing, 2008). Therefore, using a form of tenant participation during the renovation process should improve the tenants' satisfaction. However, little research is done into the aspects that affect the satisfaction level of tenants and the effect of a renovation process approach on it.

Tenant participation is also considered within the energy reduction aspect of the renovation. Literature shows that there is a difference between the expected and the actual energy savings of a renovation (Majcen, Itard, & Visscher, 2013; Sunikka-Blank, Chen, Britnell, & Dantsiou, 2012). Gianfrate et al. (2017) suggested to increase the level of participation to improve the operation of the new measures and improve the actual energy savings. However, whether the renovation approach used can actually affect the energy consumption of tenants after renovation is unclear.

From previous studies, it can be concluded that it is likely that the renovation approach, in particular the level of tenant participation, will affect the satisfaction of tenants and their energy consumption after renovation. Because these two aspects, among other things, determine the successfulness of the renovation projects, the approach has an impact on the successfulness of the project. Because there is little research done into the effect of the approach on the satisfaction level, energy consumption and the overall successfulness, this study will analyse this effect.

## 1.2. Research question

The coming years, housing corporations will carry out a lot of renovation projects to improve the energy performance of the dwellings and decrease CO<sub>2</sub> emissions. To successfully carry out these projects, aspects such as tenants' satisfaction, energy reduction and tenant participation should be considered. More insight into these aspects is needed to construct a more successful renovation approach. Therefore, the main research question proposed in this study is:

*How does the renovation process, including the level of participation, affect the satisfaction level of tenants and the energy reduction?*

In order to answer this question, literature review and case studies are used. Literature review will provide insight into the existing literature about participation, satisfaction and energy reduction in terms of (social) housing renovation projects. Case studies will give insight into the actual implementation of a renovation. Additional sub research questions are formulated to guide the study and answer the main research question.

Sub questions:

1. What is participation in a renovation project?
2. Which determinants affect the satisfaction level of tenants?
3. What are the main differences between the case studies?
4. How can a housing corporation improve the renovation process so that tenants are more satisfied with the renovation?
5. Are there differences between the actual and theoretical energy consumption and how can this be explained?

## 1.3. Research design

This study starts with a literature review. This provides insight into the existing knowledge and the already studied cases. With this, a conceptual framework is made as a guideline for the remainder of the study. Subsequently, the selected four cases are studied. First, background information about the cases is analysed and compared. The theoretical background and background information of the cases result in the next section of the thesis. To answer the research question, the analyses is divided into two parts; (1) satisfaction analyses and (2) energy consumption analyses. For the analyses of satisfaction, a questionnaire is made. These are completed during semi-structured interviews. With the data collected, a path model is identified to define the determinants for overall satisfaction. The cases are compared based on this path model. In addition, energy consumption data of tenants is collected during these interviews for the second part of the analyses. The actual and theoretical energy

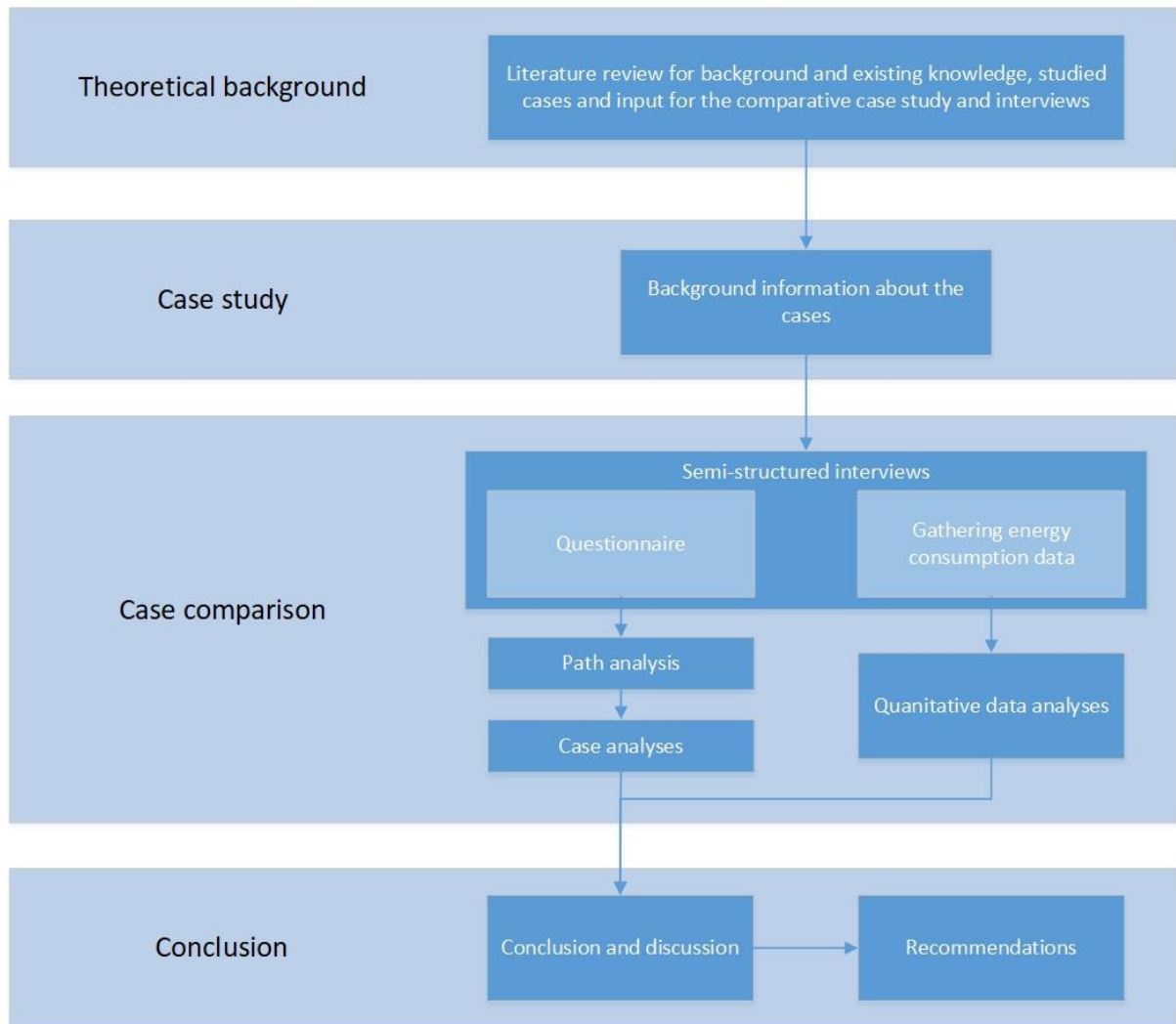


Figure 1.1: Research framework

consumption of the tenants is compared. Finally, a conclusion can be drawn. Resulting in recommendations. An overview of the research framework is given in figure 1.1.

#### 1.4. Reading guide

The structure of this thesis is divided into six chapters. In this first chapter, the problem that is studied is defined resulting in a research question and a research design. Subsequently, literature is reviewed for background information and existing knowledge about the topic. This literature review is presented in the second chapter. A conceptual model that serves as the basis for the analyses is developed using the gained knowledge of the literature review. This is described in chapter 3. Furthermore, the main methods used (comparative case study, interview and structural equation modelling) are explained. Chapter 4 describes the data collection and modification. Four cases are selected and documentation about these cases is collected. Furthermore, a questionnaire is designed and used to collect data about the satisfaction of tenants and their energy consumption. The design, data collection method and the cleaning and processing of the data is described. The analyses and results of the analyses are presented in chapter 5. It is divided into three sections; the case descriptions, analyses of the satisfaction dataset and the analyses of the energy consumption dataset. All four cases are compared in each section. Conclusions are drawn and discussed. Finally, recommendations for the housing corporations and further research will be presented.

## 2. Literature review

The law of supply and demand determines the price of a product or service. The price is the market equilibrium where supply and demand are equal. The principle also applies to the housing market. However, this market price is too high for some groups of people. Therefore, housing corporations provide, rent and maintain housing below the market price for specific target groups (Housing Europe, 2010). The main target group is the households with a low income (in the Netherlands: max € 36.798 in 2018). Special target groups are the elderly, students, people with a physical or mental disability, people with mental disorders, labour migrants, young homeless

people and households that require fast and temporary accommodation (Smits, 2014). In addition, they have to manage social real estate and invest in liveability (Rijksoverheid, n.d.-a). These three activities are daeb-activities (services of general economic interest, in Dutch: diensten van algemeen economisch belang). There are also several non-daeb activities, namely; providing rental housing in the private sector and inexpensive owner-occupied dwellings for households that fall between the social and private sector and commercial real estate. These non-daeb, commercial activities are closely monitored (Rijksoverheid, n.d.-a).

Because housing corporations have to deal with the vulnerable groups of the society, it is laid down in Dutch legislation that housing corporations are “private, non-profit enterprises that pursue social goals within a strict framework of national laws and regulations” (Aedes, 2016, pp.3). Several stakeholders, such as municipalities and tenants, are involved in policymaking. The execution of the tasks is paid through equity and bank loans. The government and housing corporations provide a guarantee for these loans through the Guarantee fund social housing (in Dutch, Waarborgfonds Sociale Woningbouw or WSW) (Smits, 2014). As a result, the WSW manage the risks of the housing corporations to prevent them from getting into financial trouble.

Because of the large share of social housing (approximately 30%) in the Netherlands, the government, Aedes, housing corporations and the association for tenants expressed the need to improve the energy efficiency of social housing. Furthermore, the government stated that the housing corporations have to initiate the transition of the national climate agreement. Renovating a dwelling to increase the energy efficiency is called energy renovation (Ástmarsson et al., 2013). Energy renovation of social housing brings together various aspects. This chapter will discuss the literature of these aspects.

### 2.1. Landlord/tenant dilemma

One of the barriers of energy renovation is the (social) rental sector is the ‘landlord/tenant dilemma’ (Ástmarsson et al., 2013). This dilemma implies that on the one hand the landlord must invest in the renovation. On the other hand, the energy bill of the tenant will be lower because of the decreasing energy consumption and the comfort of the dwelling will increase. The dilemma is also called the ‘split incentives problem’. Ástmarsson et al. (2013) analysed suggested changes and adaptation of tools to solve this dilemma, in the specific situation of Denmark. They concluded that there are three factors that can affect the dilemma, namely; the energy label, compulsory savings and the rent act.

In the Netherlands, a valid energy label is obligated for landlords (including housing corporations) (RVO, n.d.-c). Through the WSW, the housing corporations have the opportunity to increase the rent when the energy label improves, but only when this is reasonable (Oel, Haas, Hal, & Thomsen, 2009). For current tenants, the rent may only be increased in case of a renovation. For a renovation of a housing complex (10 or more dwellings), 70% of the tenants should accept the proposal, including the rent increase (Rijksoverheid, n.d.-d). For a renovation of less than 10 dwellings, the approval of all households is necessary. When the tenants don’t accept the proposal, but it is reasonable, the housing

corporation can enforce the renovation in court. However, the 70% threshold only applies to renovations. In the Netherlands, a distinction is made between (major-)maintenance and renovation. Renovation (or home improvement) is described as “all work carried out that results in an increase of the living comfort” (Huurcommissie, 2018, pp.6). Maintenance is described as “the repair or replacement of parts of the house” (Rijksoverheid, n.d.-e) and major maintenance, or systematic maintenance, is seen as “carrying out urgent maintenance or replacement work at complex level” (Aedes, 2016b, pp.3). In case of (major-)maintenance, measures such as replacing roof constructions may be possible. In case of such replacement, it is likely that used techniques will result in an increase of living comfort. Therefore, even though the maintenance results in an increase of the living comfort and seems to fit within the definition of renovation, housing corporations do not have to reach to 70% approval threshold. In case of maintenance, a rent increase is not possible.

Compulsory savings for the housing corporations are drawn down in the Energy Saving Covenant for the Rented Sector. As a result, housing corporations are motivated to improve their portfolio. Braga and Palvarini (in Filippidou et al., 2017) states that there are three elements in the EU that describe the social housing sector, namely; “mission of general interest, affordable housing for the low-income population and realization of specific targets, defined in terms of socio-economic status or the presence of vulnerabilities” (pp.489). Because housing corporations have to provide affordable housing for low-income population, the government, Aedes and the association for tenants agreed in the Energy Saving Covenant for the Rented Sector that the energy renovation results in a decrease in housing costs (rent and electricity and gas costs) for the tenants (Spies et al., 2012).

## 2.2. Participation

While there are legislation, agreements and covenants in place in the Netherlands to stimulate housing corporations to improve the energy efficiency of their portfolio, there is also legislation in place to protect the tenant from unreasonable renovation. As discussed before, legislation states that, in case of a renovation of complexes, 70% of the tenants should agree with the proposal to continue with the renovation (Atriensis, 2016). Therefore, it is important for housing corporations to involve tenants in the renovation project. Within literature, there are different types of participation mentioned; for example citizen participation (Arnstein, 1969), resident participation (Agentschap NL, 2012a; Bexkens, 2010; Rus et al., 2010) and tenant participation (Glumac, Reuvekamp, Han, & Schaefer, 2013; Simmons & Birchall, 2007). This section will first consider participation in the broadest sense and will subsequently narrow down to tenants’ participation in the housing corporation and participation in a project. Finally, literature will be analysed about the willingness of tenants to participate.

### 2.3.1. Participation models

A well-known description of the concept participation is the description of Arnstein (1969). She describes citizen participation as citizen power. Citizens receive power to contribute to an ongoing process or product. To explain this, Arnstein uses the ‘ladder of citizen participation’ (figure 2.1). The ladder contains eight levels of participation. The higher up in the ladder, the more power citizens have. The first two levels, manipulation and therapy, are ‘nonparticipation’ levels. In these levels, the citizens do not have any power. The goal of the powerholder (e.g. authorities or housing corporation) in these levels is merely to change the views or minds of the citizens. The third to fifth level is described as ‘tokenism’. In these levels, citizens do not have the power to influence but their opinions will be heard by the powerholders. In the third level, ‘informing’, the citizens are informed. They have little opportunity to state their views, but do not have the power to change anything. On the other hand, in the placation level, citizens have some degree of influence. Citizens can make their own plans, but the

power to carry out the plan lies with the powerholder. In the last three levels, citizens have, depending on the level, some degree of power. Within the level partnership, the citizens and powerholders share the power and must negotiate to come to an agreement. In the levels 'delegated power' and 'citizen control', citizens become the main powerholders. In the level 'citizen control' the citizens have the full power.

While Arnstein (1969) created the first participation model, various models of participation exist nowadays. Similar to the ladder of Citizen Participation of Arnstein, Pretty (1995) created a model containing seven levels of participation (table 2.1). He states that participation is seen in two different ways, namely; (1) people will tend to agree earlier when they are involved and (2) participation to "initiate mobilization for collective action, empowerment and institution building" (Pretty, 1995, pp. 1251). Similar to Arnstein, the first four levels can be defined as 'nonparticipation' (Pretty, 1995). People have no influence on the process or outcome. From level five till seven, the influence of the people on the process or outcome increases. In the final level, 'self-mobilization', participants take their own initiatives and have full control over it.

Arnstein (1969) and Pretty (1995) mainly focus on different levels of participation, White (1996) considers the interests of stakeholders at different forms of participation (table 2.2). In the ideal situation, the top-down- and bottom-up interests are the same and executed form of participation. However, this will often not be the case. Therefore, this model can be used to consider opposing views in the participation process (Cornwall, 2008). While the model tries to create uniform groups, White (1996) agrees that this is often not the case in reality. People within the same group (top-down or bottom-up) have often different interests and have therefore a different expectation of the participation.

Arnstein (1969) and Pretty (1995) focus on the role of the participant and White (1996) focusses on the interests of both the participant and the organisation. From the point of view of the organisation, government, company etc, it is important to consider a certain management style that should be implemented to promote the level of participation that is of interest of them. The management style determines how these organizations, governments, companies etc. deal with participants (Rimmelzwaan, 2012) and the space that is given to them (Schoenmakers, 2015). Pröpper (in Rimmelzwaan, 2012) created a ladder of management styles linked to different forms of participation. The seven management styles are:

1. Facilitating style
2. Cooperating style
3. Delegating style
4. Participative style
5. Consultative style
6. Open authoritarian style
7. Closed authoritarian style

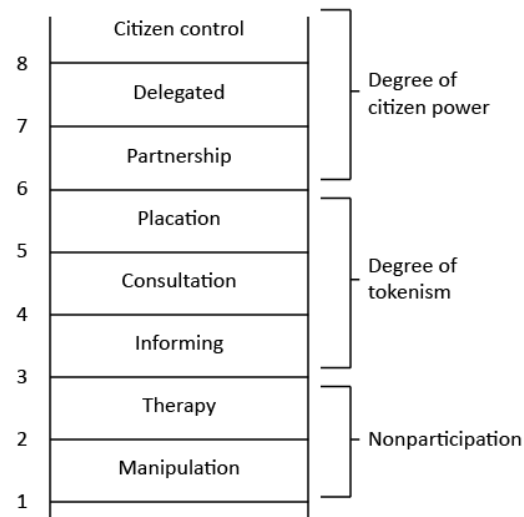


Figure 2.1: Ladder of Citizen Participation (adapted from Arnstein, 1969)



Table 2.1: A typology of participation: how people participate in development programmes and projects (adapted from Pretty, 1995, pp.1252).

Typology	Characteristics of each type
Manipulative participation	Participation is simply a pretence, with “people’s” representatives on official boards, but who are un-elected and have no power.
Passive participation	People participate by being told what has been decided or has already happened. It involves unilateral announcements by an administration or project management without any listening to people’s responses. The information being shared belongs only to external professionals.
Participation by consultation	People participate by being consulted or by answering questions. External agents define problems and information-gathering processes, and so control analysis. Such a consultative process does not concede any share in decision-making, and professionals are under no obligation to take on board people’s views.
Participation for material	People participate by contributing resources, for example, labour, return for food, cash or other material incentives. Farmers may provide the fields and labour but are involved in neither experimentation nor the process of learning. It is very common to see this called participation, yet people have no stake in prolonging technologies or practices when the incentives end.
Functional participation	Participation seen by external agencies to achieve project goals, especially reduced costs. People may participate by forming groups to meet predetermined objectives related to the project. Such involvement may be interactive and involve shared decision-making but tends to arise only after major decisions have already been made by external agents. At worst, local people may still only be co-opted to serve external goals.
Interactive participation	People participate in joint analysis, development of action plans and formation or strengthening of local institutions. Participation is seen as a right, not just the means to achieve project goals. The process involves interdisciplinary methodologies that seek multiple perspectives and make use of systemic and structured learning processes. As groups take control over local decisions and determine how available resources are used, so they have a stake in maintaining structures or practices.
Self-mobilization	People participate by taking initiatives independently of external institutions to change systems. They develop contacts with external institutions for resources and technical advice they need but retain control over how resources are used. Self-mobilization can spread if government and NGOs provide an enabling framework of support. Such self-initiated mobilization may or may not challenge existing distributions of wealth and power.

Table 2.2: Interests in participation (adapted from White, 1996, pp.7)

<b>Form</b>	<b>Top-down*</b>	<b>Bottom-up**</b>	<b>Function***</b>
Nominal	Legitimation	Inclusion	Display
Instrumental	Efficiency	Cost	Means
Representative	Sustainability	Leverage	Voice
Transformative	Empowerment	Empowerment	Means/End

\* interest that those who design and implement development programmes have in the participation of others, \*\*how the participants themselves see their participation and what they expect to get out of it, \*\*\*overall function of each type of participation.

Table 2.3: Degree of participation and styles of management (adapted from Edelenbos et al., 2006, pp.21)

<b>Participation ladder</b>	<b>Management styles</b>	<b>Role of citizen</b>	<b>Role of management</b>
Participant is not involved	Closed authoritarian style	None	Conducts independent policy and provides no information
Inform	Open authoritarian style	Target group of research/information, does not provide input	Conducts independent policy and provides information about this
Consult	Consultative style	Consulted conversation partner	determines policy and gives the opportunity for comment, but does not have to link any consequences
Advise	Participative style	Advisor	Determines policy, but is open to other ideas and solutions
Coproductio	Delegating style	Co-decision maker: within boundary conditions	Management decides on the policy considering the proposed boundary conditions
	Cooperating style	Cooperation partner based on equality	Management works and decides based on equality with participations
Co-decision	Facilitating style	Initiator	Offers support and leaves policy making to participants

In the management styles four till seven, the policies of the organisation are the focus (Rimmelzwaan, 2012). In the closed authoritarian style, the participants will only be informed about the policies, while in the participative style, the participants can give advice. In the management styles one till three, the management gives the participant more space. In the delegating style, the management provides guidelines and participants can make decisions within these guidelines. Using the cooperation style, management and participant will work together. The most open management style, facilitating style, the participant take the initiative and management will offer support (Rimmelzwaan, 2012). Edelenbos, Domingo, Klok, & Tatenhove (2006) combines the participation ladder of Edelenbos (2000), management styles of Pröpper and Steenbeek (1999) with the role of the participant and management to create a clearer picture of the roles of the stakeholders (table 2.3). The participation levels of Edelenbos (2000) are largely in line with the third till seventh levels of participation of Arnstein (1969). It shows that as the role of the participant increases, the role of the management decreases.

### *2.3.2. Conditions of participation*

The models discussed above provide insight into the various levels of participation and the role of the actors. In addition to these models, literature also discusses conditions that should be considered before and during a participation process. First of all, it should be clear for all actors what their influence level (Edelenbos, 2000; Edelenbos, Teisman, & Reuding, 2001) and their role or contribution in the process are (Rimmelzwaan, 2012). The above analysis shows that there are various levels of participation, which result in different types of influence and roles. Participation also involves investment. The budget for the participation project should be clear from the start of the process (Debusschere et al., 2009). Clarity about the framework of the process will prevent a wrong expectation pattern (Rimmelzwaan, 2012).

In addition, clarity about the content of the project is also important. However, whether an actor understands the information and is able to use it, depends on the type of actor. Therefore, equivalence is seen as a condition of the participation process (Edelenbos et al., 2001). Equality arises when actors are dependent on each other because of their knowledge and resources needed for reaching the common goal (Edelenbos et al., 2001). In many cases, there is a difference between actors concerning, for example, their knowledge about the situation, availability of time and certain skills. Additional support of those actors who have a shortage of knowledge and skills will improve the process (Debusschere et al., 2009). It is important that all actors have the same knowledge and skills because a participation process works towards a common goal. Through persuasion, conviction, negotiation and exchange, actors will reach to a common goal and they should understand and agree with it (Edelenbos, 2000).

Another condition of participation is the relationship between the actors. According to Rimmelzwaan (2012), there should be a constructive relationship between the parties involved. Debusschere et al. (2009) state that trust is one of the conditions of participation. The parties involved should trust one another. Often, there will be no or little trust at the start of the participation process because parties have not often worked together. Therefore, it is important that the level of trust increases during the process. This can be done by open and full communication (Debusschere et al., 2009). Edelenbos, Teisman, & Reuding (2001) describe openness in terms of content, process and actors. Content openness is about the space for new ideas, plans and actions and the space to deviate from views, assumptions and action frameworks of the initiator. Openness of the process means that the process should be transparent for all actors, participation should be possible for all stakeholders and all participants should have access to the information needed. The fair exchange of information is necessary (Debusschere et al., 2009). Finally, openness of actors can be described as the degree of susceptibility of actors, the extent to which actors are able to adopt an open and unobtrusive attitude

in the process and are prepared to modify their perspectives, interests and ideas or at least consider the perspectives, interests and ideas of others. Bexkens (2010) also states that transparent cooperation between actors is important.

It is likely that clarity about the framework, equivalence and a good relationship between actors will result in good and qualitative communication between actors. According to Debusschere et al. (2009) both formal and informal consultation between actors is needed for continuity, additional information and a more efficient and faster way to respond to the situation.

### *2.3.3. Tenant participation*

The analysis of various models of participation and management shows that the level of participation determines who has the control (or power) over the decisions that need to be made. When taking participation in decisions making within housing corporations, it is called tenant participation. The reason behind the importance of tenant participation lies partly by various laws. In 2013 and 2014, the parliamentary inquiry committee housing corporations studied the design and the functioning of the housing corporation system and concluded that the position of tenants had to be strengthened and the legitimacy of corporations had to be increased (Terlingen, 2016). As a result, the position of tenant organizations is anchored in the 2015 Housing Act (in Dutch, Woningwet 2015). In addition, the law in the consultation tenants-landlord (in Dutch Wet op het overleg huurders verhuurder) explains the rights of tenant organizations and residents' committees.

The law in the consultation tenants-landlord defines tenant participation as “the involvement in and the influence on the planning and policy-making of housing corporations” (Rus et al., 2010, pp. 5). This largely corresponds with the definitions and models of participation discussed above. There are various reasons for housing corporations to let tenants participate, for example; participation improves the social cohesion in a neighbourhood (Debusschere et al., 2009; Marissing, 2008), use the experiential expertise of tenants (Marissing, 2008), to gain insight into the opinions, ideas and wishes of tenants to be able to respond to this (Schoenmakers, 2015), improve the relation between housing corporation and the tenants (Schoenmakers, 2015) and to increase the satisfaction of tenants (Debusschere et al., 2009; Schoenmakers, 2015). Dutch regulation states that to be able to carry out a project, 70% of the tenants should accept the proposal (Atriensis, 2016). It is therefore important for housing corporations to gain support from the tenants. The reasons mentioned above will help by creating more support. In addition, participation can result in an increasing democratic legitimacy of the housing corporation (Edelenbos et al., 2006; Marissing, 2008; Rimmelzwaan, 2012; Schoenmakers, 2015).

There are various ways of participation. Participation can be divided into two main categories, namely; formal and informal participation. Participation through tenant organizations and residents' committees laid down in legislation is also called formal participation (Rus et al., 2010). A residents' committee can be described as a “group of active tenants who represent the interests of all tenants of one or more, closely situated, housing complexes” (Cüsters, 2011, pp.8). A housing corporation is obligated to inform the residents' committee and discuss all matters concerning the housing complexes. In return, the residents' committee is obligated to inform all tenants, involve them in determining their point of view, organise an annual meeting for all tenants and enable tenants to join the committee (Cüsters, 2011). The residents' committees fall under the tenant organization. These tenant organizations work on the higher housing corporation level and have qualified advisory rights for corporation-wide subjects (Rus et al., 2010).

One of the shortcomings of formal participation is the lack of representativeness (Rus et al., 2010). Tenant organizations and residents' committees primarily consist of autochthonous seniors and mainly young people and immigrants are underrepresented. Rus et al. (2010) refer to four strategies that

housing corporations apply to improve shortcomings. On the one hand, housing corporations try to change the formal structure by changing the role or invest in the quality to improve the existing structure. In addition, the formal structure is also changed or supplemented by new, more informal, structures. Informal participation is described as both contribute to decisions-making as active citizenship, the tenants taking responsibilities. It includes all kind of experimental, fruitful participation moments and they are often low-threshold, theme-oriented and temporary. However, there is no clear line between formal and informal participation. For example, Rus et al. (2010) concluded that housing corporations differ in the opinion whether sounding board groups, customer panels, working groups and residential teams belong to formal or informal participation.

#### *2.3.4. Participation in practice*

In practice, housing corporations use both formal and informal participation. The exact interpretation of participation depends on various aspects such as the housing corporation, their experience with participation, the goal of the participation process. Schoenmakers (2015) analysed in her thesis the presence and interpretation of tenant participation in three housing corporations. Using five conditions of participation, the presence and interpretation of these housing corporations were compared at the business, neighbourhood and local level. The five conditions of participation used are; being able, motifs, space, invitation and response. The study concluded that all three housing corporations are open for participation on all three levels. They make it possible for tenants to participate and try to motivate them. Depending on the type of tenants they want to reach, other types of communication methods are used.

Schoenmakers (2015) considers tenant participation at the policy and planning making level of housing corporation. However, there is a difference between participation at a more general level, compared to participation in renovation projects. In a renovation project, the housing corporation works towards a certain goal. Therefore, the way of involving tenants is different. To gain more insight into tenant participation at a renovation level, examples of participation in social housing projects are analysed. The first example of a project that involves tenants is described by Agentschap NL (2012b). After failed plans to renovate the complex, the housing corporation decided to involve the tenants in making new plans. The housing corporation wanted to use the knowledge of the users to create a better plan. During a meeting with some tenants, a sounding board was created with eight tenants. The purpose of the sounding board was to help the housing corporation by making an inventory of problems, react to possible solutions and being present during construction meetings. In addition, it should also provide a lower threshold for tenants to discuss possible problems. The changed plans involved energy saving measures. The housing corporation wanted a rent increase and presented a housing costs guarantee. The tenants did not accept this increase, probably because previously it was told that there would be no rent increase. The level of participation of the project can be described as consultation or advice. The sounding board had the opportunity to communicate their wishes and complaints. Often, the housing corporation took these in consideration.

Hoppe (2009, 2012) studied energy renovation projects of housing corporations in the Netherlands. While the studies focus on decision-making processes in these projects (Hoppe, 2009) and the factors that influence the adoption of innovative energy systems (Hoppe, 2012), the role of tenants in these projects is briefly described. In one of the cases, the municipality and the housing corporations created a plan for the neighbourhood. The plan was to demolish the dwellings and replace them. The tenants did not accept this plan and the housing corporation decided to renovate two-thirds of the dwellings. A plan was created for passive renovation, renovating the dwellings into passive housing. As a result, the rent of the tenants would increase. To create support for the plan, among other, some tenants and the Woonbond (interest representation on behalf of the tenants) participated in an excursion to an

example project of passive housing. They had the opportunity to talk with residents of those dwellings to gain more insight. This excursion, together with conversations with tenants convinced just over 70% of the tenants to agree with the plans and the threshold of approval was made. In this case, the only influence tenants had in the plan was to accept it or not. Considering the participation levels discussed before, this project can be seen as nonparticipation or another low level of participation. Tenants are informed about the plans and when they disagree, they are convinced (manipulated) to change their view.

Crone & Noorman (2004) describes the concept of control (in Dutch 'zeggenschap') in a project and make recommendations for successful projects. They state that control is an active form of participation, where residents actually have a say in the essential parts of the plan. Control is divided into 'individual- and collective private commissioning' (the individual or collective of citizens execute their own project) and 'consumer-oriented project development' (providing residents with predetermined choices). The study analysed cases to provide sufficient insight into various levels and ways of control to form the recommendations. In one of these cases, the housing corporation wanted to involve the tenants. A project group was set up with people from the housing corporation, municipalities and a resident committee. This project group was responsible for the development of the plan. A description of the structure of the process and a letter of intent was created to control the process of the project. The municipality and housing corporation only set the budget and that the result should be a series-based development as preconditions. In addition, promises towards the tenants were made to create trust and to make the process more flexible. Experts were hired to support the resident committee, both process and content related. Due to the project group, this case can be placed in the partnership or coproduction level of the participation levels. Furthermore, conditions such as trust and equivalence were considered. In another case, tenants had the opportunity to have some control over the demands of the renovation and the choice of the architect out of a preselection. The housing corporation determined the basic package of renovation measures and the tenants determined improvement options that could be implemented for a certain rent increase or price. As with the previous case, the level of participation can be described as coproduction. The difference between the cases is that in this case, the tenants had only the opportunity to make additional options. The housing corporation was the main decision-maker and the tenants are co-decision makers, making decisions within boundaries (rent increase or price) set by the housing corporation. In these two cases described by Crone & Noorman (2004), the initiative of the project lies with the housing corporations. They also described a case where the former squatters asked the housing corporation to buy the building and renovate it. The condition of the housing corporation was that the building should be renovated to meet rules and quality requirements. The residents were closely involved in the decision-making of the architect. Important in this project was the fact that the residents were obligated to work for minimal 8 hours per week on the renovation. After the renovation, the tenants had to mainly manage the complex themselves, by doing the housing assignment and the corresponding administration, the rent collection and a part of the maintenance. In this case, the initiative of the project lies with the residents. However, the housing corporation takes some control over the project by drawing up conditions. Also, after the renovation, tenants have a great deal of control over the complex.

#### *2.3.5. Willingness to participate*

The previous section showed that there are various levels of participation and different ways to involve tenants during a renovation project. A housing corporation can decide to let tenants participate. However, the tenants should be willing to participate. This section will study literature about the motivation of people to participate. Birchall & Simmons (2004) and Simmons & Birchall (2005) developed the 'Mutual Incentive Theory' (MIT). The theory combines the individualistic and

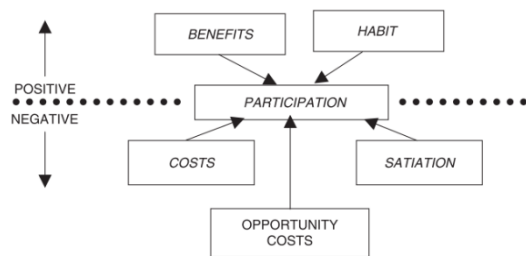


Figure 2.2: Individualistic incentives  
(adapted from Birchall & Simmons, 2004)

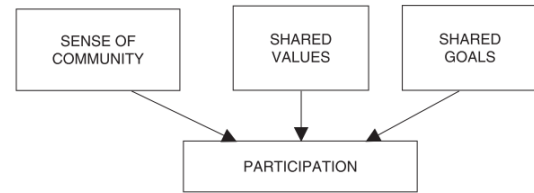


Figure 2.3: Collectivistic Incentives (adapted  
from Birchall & Simmons, 2004)

collectivistic approach to describe the motivation to participate. In the individualistic approach (figure 2.2), the motivation of people to participate depends on individual positive and negative incentives. Examples of these incentives are the opportunity to acquire more knowledge or skills, fulfilment and pleasure (Birchall & Simmons, 2004). On the other hand, the collectivistic approach assumes that the motivation depends on shared goals and values and the sense of community (figure 2.3). The more these incentives are present, the more likely someone will participate.

The MIT theory resulted in the participation chain shown in figure 2.4. The motivation level is described by the MIT. Both individualistic- and collectivistic incentives determine the motivation of a person to participate. The resource level is about the resources and capacities of potential participants such as time, money, skills and confidence (Birchall & Simmons, 2004). As discussed above, actors should be dependent on each other during a participation process due to their specific knowledge and resources. People will analyse their resources and capacities to determine to participate. The last level, mobilisation, has to do with relative deprivation and dissatisfaction, facilitating conditions and recruitment efforts (Simmons & Birchall, 2007). The three levels of the participation chain are linked to each other and determine together the likelihood that someone will participate (Birchall & Simmons, 2004).

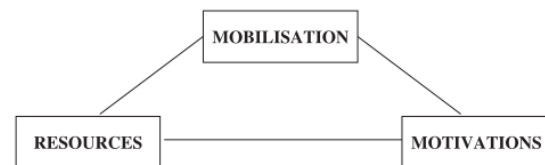


Figure 2.4: The participation chain (adapted  
from Simmons & Birchall, 2005)

Simmons & Birchall (2007) use the participation chain to examine whether tenants are willing to participate. They interviewed participants and non-participants of tenants' associations and tenant's management organisations. Considering the three levels of the participation chain, the study concluded that for the level resources 'skills' such as "educational qualifications, previous experience and training (pp. 581) and 'confidence' are main aspects for both starting with participating and increase the level of participation. Another aspect of resources is 'time', tenants with more spare time are more likely to start participating but once someone started, time became less important. Finally, the study concluded that the level of income did not influence the willingness to participate. For the level of mobilisation Simmons & Birchall (2007) found that the opportunity to participate, especially the "attractiveness, timeliness and relevance" (pp.583) was important to mobilise tenants. In addition, more active forms of recruitment, for example being asked instead of receiving a letter, and the connectedness to the recruiter influence the likelihood of participation. Also, the presence of issues may mobilise tenants to participate. Finally, for the motivation level of the chain, individualistic and collectivistic incentives are examined. Simmons & Birchall (2007) concluded that for the individualistic incentives, the costs of participation did not keep tenants from participating. Considering the benefits, mainly the internal benefits are important for tenants, while the external benefits are less important. While individualistic incentives influence the tenants, the study found that for many tenants, the

collectivistic incentives were more important. Participants had a higher sense of communication and shared values compared to non-participants. The study placed a side note to these findings, “some types of people are more likely to come forward to participate than others” (pp. 590).

Rimmelzwaan (2012) studied which factors influence the participation of residents during the decision-making process of restructuring. Personal characteristics such as the length of residence and level of education influence the level of participation. Another factor that influences participation is social cohesion. Residents that are attached and those who are not attached to the neighbourhood are more likely to participate in the decision-making than more neutral residents. A likely reason for this effect is that tenants that are attached and those who are not attached benefit the most of participating during the decision-making. In addition, the study concluded that the way of participation determines which residents participate.

## 2.3. Satisfaction

In previous section discussed the levels of participation and the willingness to participate. Experiences within housing corporations show that intensive involvement of tenants results in great satisfaction, reinforcement of the social bond and the feeling of responsibility for their home and living environment (Crone & Noorman, 2004). Uesaraie (2018) analysed the criteria that need to be judged to determine whether an energy renovation project is successful or not. One of these criteria is the satisfaction of tenants with the project. Therefore, this section will study the concept of satisfaction and satisfaction in renovation projects.

### 2.3.1. Satisfaction theory

A common and widely adopted description of satisfaction is that it comes from some form of comparison between expected and the actual outcome. According to the expectancy disconfirmation paradigm (or disconfirmation paradigm), satisfaction is the result of the aspirations/expectations and the outcome (Oliver, Balkrishan, & Barry, 1994). Prior, someone has aspirations about and/or expectations of the outcome. The actual outcome will trigger a comparison between the aspired and/or expected outcome and the actual outcome. This comparison results in a negative or positive disconfirmation. Satisfaction is the confirmation of the results. Positive disconfirmation (outcome is higher/better than aspirations/expectations) increases satisfaction, negative disconfirmation decreases it and confirmation doesn't have an impact on the satisfaction. The paradigm is given in figure 2.5. While Patterson (1993) uses the paradigm to describe customer satisfaction, it can also be applied to residential satisfaction of renovation projects. An important side note to this paradigm is that it is likely that there is a range in

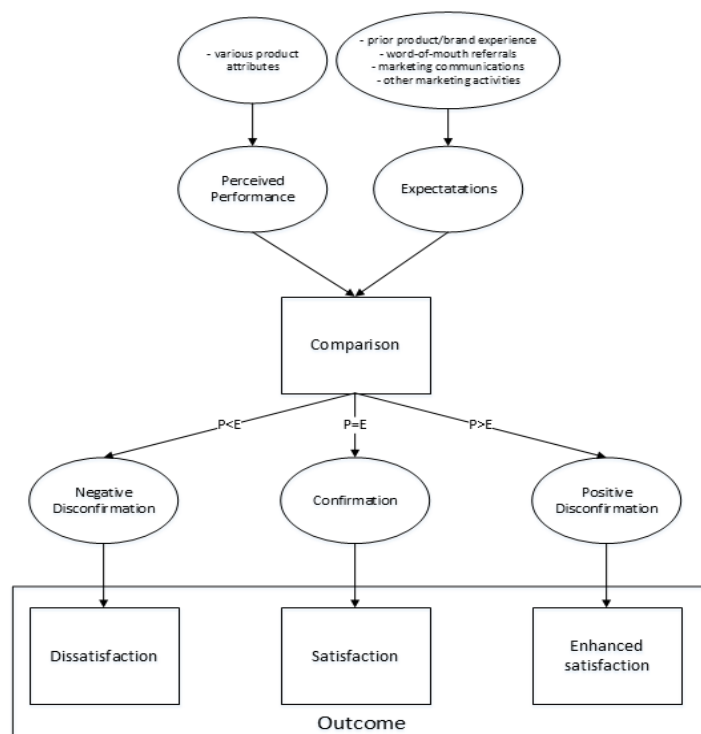


Figure 2.5: Disconfirmation of expectations paradigm (adapted from Patterson, 1993)



which the satisfaction is not affected (Patterson, 1993). The performance within this range is seen as equal to the confirmation.

To study residential satisfaction, Galster (1987) uses the actual-aspirational gap approach. This approach is similar to the disconfirmation paradigm discussed above. The actual physical environment is compared to the standards someone thinks he/she can aspire to. The gap between the actual and aspired environment determines satisfaction. Three components are important: the actual environment, the characteristics of the resident and its beliefs, perceptions and aspirations (Weidemann & Anderson, 1985). The gap approach is also used for service quality, where determinants for both the process and the outcome are being used (Patterson, 1993). Jiang (2018) used this gap theory to study residential satisfaction and the intention to move. The actual and aspired characteristics of the dwellings were asked in a questionnaire.

In case of participation in a renovation process, it may be possible that negotiation is used to come to a solution (e.g. with a sounding board). Oliver, Balkrishan, & Barry (1994) studied the satisfaction in negotiation using the expectancy disconfirmation paradigm. They assume that the parties involved have three internally aspiration levels: best profit outcome, most likely outcome and worst acceptable outcome. The aspiration/expectations, and probably other factors such as experience and motivation, will also influence the outcome. In addition, the desire to negotiate again in the future, depends on the satisfaction of this negotiation process.

The factor theory of customer satisfaction assumes that there is a relationship between the performance of an attribute and satisfaction (Busacca & Padula, 2005). According to this theory, there are three types of attributes, namely:

- Basic attributes, dissatisfaction always occurs because someone assumes it to be necessary and takes it for granted
- One-dimensional performance attributes, the outcome fully determines the satisfaction
- Exciting attributes, someone will always be satisfied because the attributes are unexpected

### *2.3.2. Satisfaction in (energy) renovation projects*

Despite of the little literature about the satisfaction of tenants with the energy renovation project, this section will discuss some literature. Knudsen & Jensen (2015) evaluated the experiences and satisfaction of tenants of a social housing energy renovation projects in Copenhagen. In both projects, there was communication between the housing corporations and tenants throughout the whole project. In one case, tenants had the opportunity to buy additional measures (e.g. underfloor heating). Both the satisfaction with the renovation process and the results of the renovation were studied. They concluded that most of the tenants were positive about the renovation. Despite the limited amount of data, rent increase may be one of the aspects which decreases satisfaction, but most of the tenants stated that the rent increase was reasonable for the improved conditions. Another interesting conclusion is the satisfaction in relation to discomfort/inconvenience during renovation. While most tenants experienced discomfort and inconvenience during renovation, the majority was satisfied with it. It is likely that the amount of communication between tenants and the housing corporation ensured this. Finally, the study showed that tenants experienced improvements concerning the indoor climate. Similar conclusions were found by Thomsen et al. (2016). Thomsen et al. (2016) studied the energy consumption and satisfaction with the process and the result of a case in Denmark. Most of the tenants were satisfied with the renovation, it happened as expected and they would recommend it. They concluded that it is important that the outcome of the renovation is equal to the expectations of the tenants.

Knudsen & Jensen (2015) and Thomsen et al. (2016) focus on satisfaction after the renovation. Hauge, Thomsen, & Löfström (2013) analysed which factors improve the chance that tenants accept the renovation before renovation. They came up with a list of factors that should be considered, namely:

- Openness about the project
- Invest time
- Seek advice
- Joint proposal
- Enthusiasm
- Involve tenants
- Use tenants' suggestions
- Gradually spread information using various methods
- Financial consequences for the tenants
- Tenants should be sufficiently informed before a vote

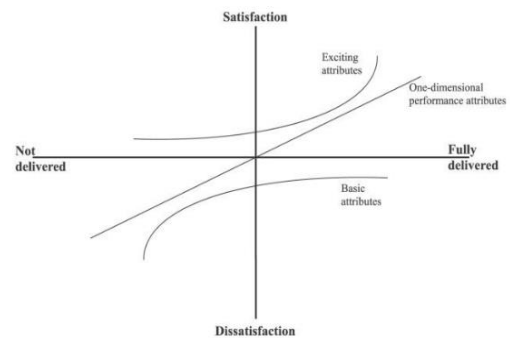


Figure 2.6: The factor theory of customer satisfaction (adapted from Busacca & Padula, 2005)

Hauge, Löfström, & Mellegård (2014) analysed these factors in their case study. They concluded that visiting the tenants had a positive outcome and visualization and illustration resulted in a conversation and created enthusiasm. In terms of the expectancy disconfirmation paradigm, it is more likely that tenants will be satisfied with the renovation if their aspirations are considered before and during the process. It can be said that, when taking the aspirations into account, it becomes more likely that the outcome is similar to this, resulting in confirmation or positive disconfirmation. In addition, communicating with the tenants before and during the process will adjust their expectations, having the same results. It is therefore important that tenants agree with the renovation and its process.

## 2.4. Energy consumption

One of the goals of an energy renovation project is to decrease the energy consumption of the household. Energy efficient measures are taken to decrease the energy consumption. The theoretical energy performance of a dwelling is calculated using the energy index (EI). However, literature shows that the theoretical energy performance may deviate from the actual energy performance. This section will consider the theoretical energy performance but will also analyse what affects the deviation.

### 2.4.1. Energy performance measures

Dutch legislation about the energy performance of buildings is laid down in the 'Degree on energy performance of buildings' (in Dutch: Besluit energieprestatie gebouwen or BEG) and the 'Regulation on energy performance of buildings' (in Dutch: Regeling energieprestatie gebouwen or REG) (RVO, n.d.-d). These legislations are based on the 'European Energy Performance of Buildings Directive' (EPBD). There are two methods in the Netherlands to calculate the energy performance of existing dwellings, namely; the energy label and EI. The difference between the two methods is the way the energy performance is calculated, the EI is calculated using 150 characteristics of the dwelling and the energy label methods only uses 10 characteristics (RVO, n.d.-b). Housing corporations were obligated to use both methods (AEDES vereniging van woningcorporaties, 2018). The EI was used to calculate the rent using a point system. The lower the energy index (better energy performance) the higher the rental points resulting in a higher maximum rent. Because of this point system, a housing corporation is allowed to increase the rent after renovation. However, it should consider the maximum rent of social housing. On the other hand, a housing corporation is obliged to share the energy label when renting the dwelling. Due to the use of two different methods, differences appeared between the energy label and EI. Therefore, from March 29, 2018, the EI is used to determine the energy performance of the

Table 2.4: Assessment table for energy performance indicators (Rijksoverheid, n.d.-b)

Energy label	Energy index	Mean theoretical primary energy consumption (kWh/m <sup>2</sup> /year) (Filippidou et al., 2017)
A++	< 0.6	
A+	0.61 – 0.8	
A	0.81 - 1.20	96.8
B	1.21 - 1.4	132.5
C	1.41 - 1.8	161.6
D	1.81 - 2.1	207.8
E	2.11 - 2.4	265.0
F	2.41 - 2.7	328.0
G	> 2.71	426.9

dwelling and the corresponding energy label is obtained from this value (table 2.4) (AEDES vereniging van woningcorporaties, 2018).

To calculate the EI, the total theoretical energy consumption ( $Q_{total}$ ), heated floor areas ( $A_{floor}$ ) and the not heated areas ( $A_{loss}$ ) are taken into account. The EI is calculated using the following formula (Filippidou et al., 2017):

$$EI = \frac{Q_{total}}{155A_{floor} + 106A_{loss} + 9560}$$

To determine the EI, four components need to be addressed, namely (ISSO, 2015):

- the calculation zone: that part of the dwelling that is considered heated for the energy index and that serves as the basis for the calculation
- general property characteristics
- characteristics of the thermal shell
- characteristics of the installations

Energy saving measures are taken into account, e.g. solar water heater, PV panels, insulation and HR++ glazing. However, due to the complexity of measuring existing dwellings, many assumptions will be made to determine the energy performance of the dwelling. For example, to determine the Rc-value of insulation, a quality declaration or equivalence declaration is needed. If this is not available, the insulation thickness or year of construction/ renovation is used (ISSO, 2015). Furthermore, in case of PV panels, the photovoltaic cell type, surface area, slope and orientation are considered. However, the peak power (Wp) of the installed PV panels is not taken into account. This may result in a difference between the theoretical energy consumption and actual energy consumption.

Majcen, Itard, & Visscher (2013) compared the energy labels and theoretical energy consumption with the actual energy consumption of approximately 200,000 households in the Netherlands. Figure 2.7 shows the differences between the theoretical primary

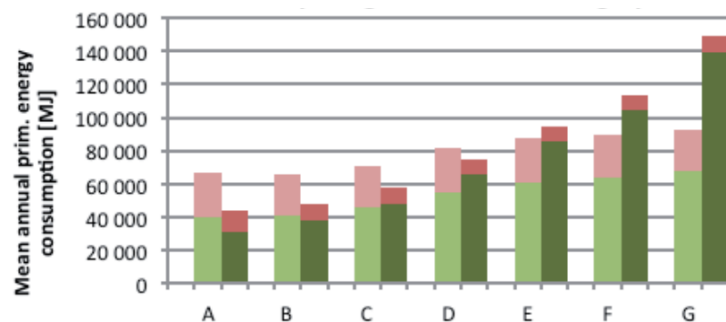


Figure 2.7: actual and theoretical primary energy consumption by energy label (adapted from Majcen et al., 2013)

energy consumption (dark green and pink) and actual primary energy consumption (light green and pink) per energy label, where green is the primary gas consumption and pink the primary electricity consumption. They found that, concerning the gas consumption, the theoretical consumption often overestimates the actual consumption. Dwellings with a better energy label can exceed their theoretical calculated consumption, while those with a worse energy label consume less gas. The differences between the theoretical and actual electricity consumption are the same for each energy label. Therefore, they state that “the energy label gives an approximate indication of the thermal quality of the dwelling but cannot predict the real energy consumption” (Majcen et al., 2013, p.1951).

#### *2.4.2. Rebound and prebound effect*

In addition to the difference between the theoretical and actual energy consumption due to the measuring methods, the energy consumption behaviour of tenants also affects the difference. While the difference due to the building or the measuring method can be tested and improved, the difference due to the household is less easy to predict and avoid (Keyson, Guerra-Santin, & Lockton, 2016). Keyson et al. (2016) identified four ways in which the household can influence the energy performance, namely; rebound effect, prebound effect, differences between households and user—building technology interaction and building control. According to this study, the household factors that influence the energy consumption are; demographics, background, lifestyle and schedules, socio-economic factors and other issues such as habits, attitudes and preferences.

The measures implemented during the renovation will reduce the energy consumption, while a part of this reduction is used to increase consumption of energy services (e.g. warmer house) or other services (Galvin & Sunikka-Blank, 2016). The difference between the calculated energy consumption and the actual energy consumption is called the ‘rebound effect’. Sorrell (2007) makes a distinction between the direct-, indirect- and economy-wide rebound effect. The direct rebound effect occurs when, due to the decreasing costs of energy services, the use of these services increases. The indirect rebound effect occurs when the savings, that occur from the energy efficiency improvements, are used in other ways, increasing the total energy consumption. The sum of the direct- and indirect rebound effect is called the economy-wide rebound effect. Sorrell (2007) gives an example to explain this:

*Someone buys a more fuel-efficient vehicle thus making traveling cheaper. As a result, this person may change his behaviour and travel more often or further than before. The savings of buying a more fuel-efficient vehicle are neutralised by the increased energy consumption of the extra distance travelled (direct rebound effect). On the other hand, this person may also choose to use the savings to buy flight tickets to travel. This more energy-intensive service will reduce the energy consumption savings of the more fuel-efficient vehicle (indirect rebound effect).*

The “normal” rebound effect results in a higher energy consumption than calculated. It may also be the case that the actual energy consumption is lower than the calculated, this is called the negative rebound effect (Ehrhardt-Martinez & Laitner, 2010). This can occur when, e.g., a household is motivated to save energy by the renovation and tries to save more by shorter shower times. The back-fire effect occurs when the actual energy saving is negative (Ehrhardt-Martinez & Laitner, 2010), the energy consumption before the renovation is lower than after. While the rebound and back-fire effect consider the situation after renovation, the prebound effect considers the situation before renovation. It occurs when the actual energy consumption before the renovation is less than the theoretical energy consumption (Sunikka-Blank & Galvin, 2012). Energy that isn’t used before the renovation cannot be

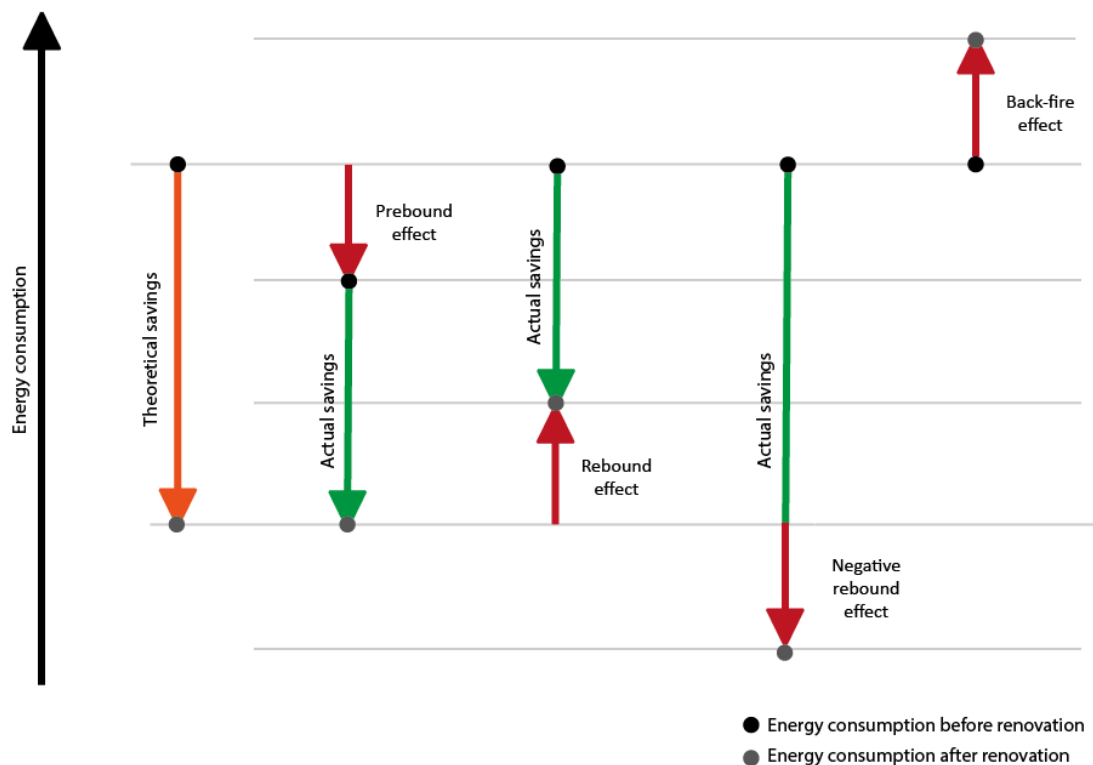


Figure 2.8: Prebound-, rebound- and back-fire effect

saved. Therefore, it can be concluded that the prebound effect is the under-consumption before renovation, the rebound effect is the over-consumption after renovation (Galvin & Sunikka-Blank, 2016), the negative rebound effect is the under-consumption after renovation and the back-fire effect is also the over-consumption resulting in a negative saving. Figure 2.8 provides a schematic representation of these effects.

In literature, mainly the prebound- and rebound effect are studied. Sorrell (2007) stated that the back-fire effect is unlikely because “it is unlikely that all energy efficiency improvements will lead to backfire” (pp. 86). Galvin & Sunikka-Blank (2013) studied the prebound effect of households in Germany and concluded that their heating energy consumption was on average 30% lower than the theoretical consumption. Especially, poor thermal houses deviated because the households behaved more economically. They concluded that the same appears in other countries such as the Netherlands, France, Belgium and the UK. A study of the actual and theoretical energy consumption in the Netherlands showed that dwellings with a low energy label actually use less energy than theoretical calculated, while dwellings with a better energy label use more energy than calculated (Majcen et al., 2013). Guerra Santin (2013) found the rebound effect in the heating behaviour of households. A higher indoor temperature is preferred by households in more energy efficient dwellings. This direct rebound effect is called “comfort taking” (Maxwell & McAndrew, 2011). Due to, e.g. insulation, the costs of a higher indoor temperature lower and therefore households will use higher temperatures.

#### 2.4.3. Behaviour theories

According to Gram-Hanssen (2014), behaviour and norms of residents change simultaneously with the renovation of the dwelling, resulting in the rebound effect. Because behaviour has such an impact on energy consumption and the effectiveness of the renovation, this section will study behavioural theories to gain insight into behaviour.

The theory of Planned Behaviour is an attitude behaviour model and which states that behaviour is determined by intention (figure 2.11). The factors 'attitudes toward the behaviour', 'subjective norm' and 'perceived behavioural control' determine this intention. The factor subjective norm is described as "how socially acceptable an individual believes their behaviour to be" and perceived behavioural control is the "ease of performing the behaviour in question" (Lowery, 2012, pp. 73). The unified theory of acceptance and use of technology (UTAUT) uses the theory of Planned Behaviour, together with other theories (Sovacool & Hess, 2017). In this model, the acceptance and use of technology is determined by the intention. In contrast to the theory of planned behaviour, the intention is determined by the seven factors (figure 2.12). Performance expectancy, effort expectancy, social influence and facilitating conditions are the primary factors of the model and the factors hedonic motivation, price value and habit are added later on (Sovacool & Hess, 2017). Aspects such as age, gender and experience affect these factors. A similar theory is the theory of Interpersonal Behaviour (figure 2.9). It also states that behaviour is determined by intention. However, it also includes habits as a factor that influences the behaviour of an individual. The Needs, Opportunity and Ability (NOA) model mainly focuses on the environmental factors rather than individual factors (Lowery, 2012). Environmental factors determine the needs, opportunities and abilities (figure 2.10). The individual motivation and behavioural control are influenced by these needs, opportunities and abilities. Like the other theories, behaviour is determined by the intention which, in this theory, arises from the motivation and behavioural control.

In contrast to the theories described above, the practice theory does not consider the individual and its motivational mechanisms (Lowery, 2012). The theory considers behaviour as a result of the social context instead of someone's intention. According to this theory, behaviour arises from the interaction between 'discursive and realistic awareness' and 'structure' (Spaargaren and van Vliet, 2000 in Lowery, 2012). From the practice theory, the social practice theory is created. According to this theory, behaviour can be described using four elements; materials, competences, meanings and connections. Sovacool & Hess (2017) gave the example of driving a car. For someone to be able to drive a car (material), knowledge and skills are needed (competences). Using a car to commute to work is socially accepted (meanings) and will appear over time when someone must go to work or back (connections).

In case of a renovation, measures are implemented in the dwelling creating a new situation. Above discussed theories describe how behaviour is formed, but there are also theories that focus on the implementation of new technologies in someone's life. One of these theories is the domestication theory (Sovacool & Hess, 2017). It tries to describe how someone comes to possess (appropriation), use (objectification), customise (incorporation) and apply (conversion) a technology. Three activities are important, namely; cognitive work (knowledge and skills), symbolic work, and practical work (change behaviour).

#### *2.4.4. Influencing behaviour*

Changing behaviour of tenants after renovation will temper the energy savings, called the rebound effect. The behaviour is determined by intentions and the habits of tenants. Lowery (2012) studied energy use behaviour of tenants in relation to a renovation project in social housing in the UK. After renovation, behaviour of the tenants can change due to direct- and/or indirect interaction. According to Lowery (2012), the effectiveness of a renovation can be restrained by several aspects, namely: restricted knowledge and skills, habits, quality of installation and function of the measure, convenience and the need or desire for thermal comfort. Similar aspects were found by Walker et al. (2014) and Gianfrate, Piccardo, Longo, & Giachetta (2017). According to their studies, energy related behaviour was influenced by the aspects; access to knowledge and skills, technical intervention, habit, external

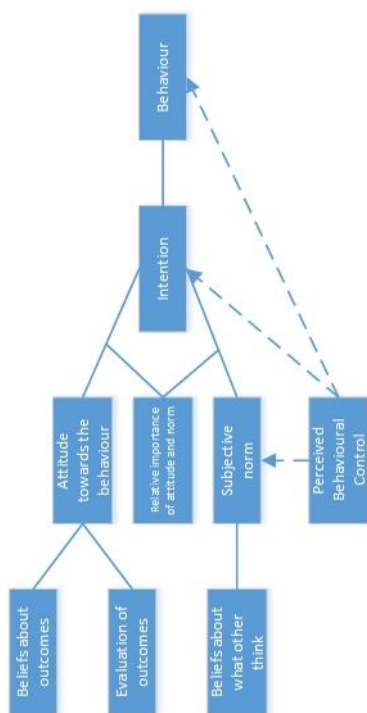


Figure 2.11: Theory of Planned Behaviour (adapted from Jackson, 2005 in Lowery, 2012)

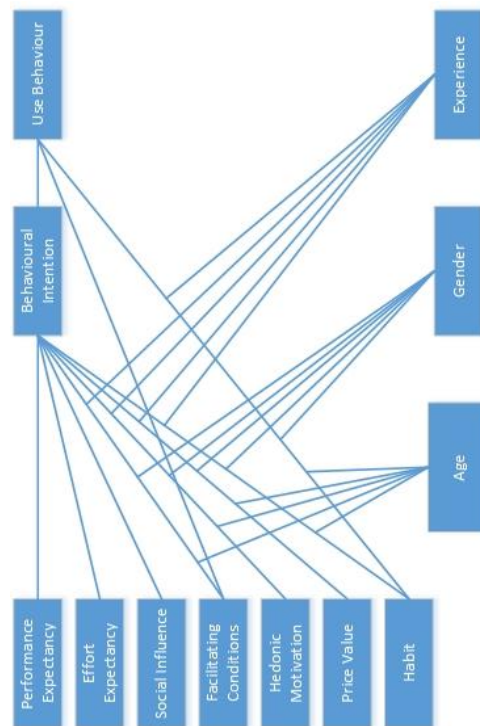


Figure 2.12: Modified Unified Theory of Acceptance and Use of Technology (adapted from Venkatesh et al., 2012 in Sovacool & Hess, 2017)

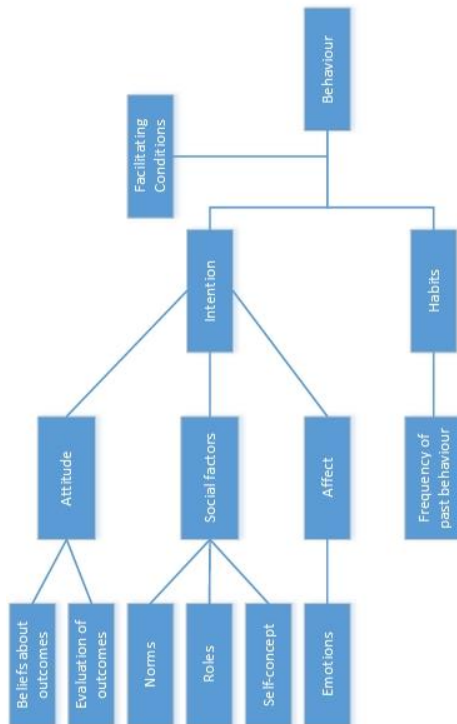


Figure 2.9: Theory of Interpersonal Behaviour (adapted from Jackson, 2005 in Lowery, 2012)

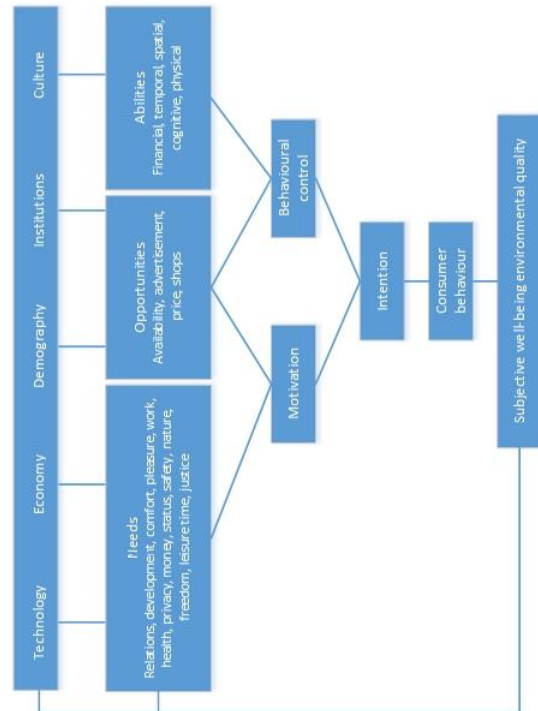


Figure 2.10: Needs, Opportunity, Abilities Model (adapted from Gatersleben and Vlek, 1998 in Lowery, 2012)

circumstances, quality of technical intervention, convenience and thermal comfort. Brown, Swan, & Chahal (2014) support the findings presented above. They analysed how the adoption and living with energy efficient measures affected tenants in England. They concluded that the tenants lacked information about the measures. As a result, the transfer of the measures to the tenants was insufficient. In addition, tenants were suspicious whether there would be extra costs involved. This study demonstrates the importance of communication, knowledge and skills.



Possible reasons why the rebound effect occurs are restricted knowledge and skills, habits, convenience, the need or desire for thermal comfort, habit and external circumstances. To counteract the rebound effect, literature proposes several strategies. Often, these strategies are people-oriented initiatives, “programmes and policies that identify and address the many social, cultural, psychological and environmental factors that shape and constrain energy-related behaviours and practices” (Ehrhardt-Martinez & Laitner, 2010, pp.7-82). A commonly used strategy is information sharing and awareness raising (Bergh, 2011; Font Vivanco, Kemp, & Voet, 2016; Maxwell & McAndrew, 2011). Often, households are unaware of the impact of their behaviour on energy consumption and ultimately on the energy bill. Raising awareness and information is one of the possible strategies. More information about, e.g., the temperature may result in a lower indoor temperature, counteracting this direct rebound effect (Guerra Santin, 2013).

Because the operation of a measure is highly dependent on the behaviour of the user, Gianfrate et al. (2017) suggest using a multidisciplinary approach to gain insight into the relation between user and measure and recommended to increase tenant participation. According to their study, acceptability and adjustment are needed for the comfort and efficiency of the measure. Tenants are more likely to accept a renovation when there is a good relationship between them and other stakeholders, especially the housing corporation (Blomsterberg & Pedersen, 2015). On the other hand, it is also important that the measure fits within the behaviour of the tenants (Gianfrate et al., 2017).

## 2.5. Conclusion

This literature review showed that role of housing corporations is to provide, rent and maintain housing below market price for specific target groups. Even though one of the goals of these housing corporations is good quality housing, they also have to consider their financial situation. This results in the ‘landlord/tenant dilemma’. The housing corporations invest in the renovation and the tenants receive the benefits (Ástmarsson et al., 2013). A rent increase is not always possible or desirable. Despite this dilemma, the government, Aedes (branch association of housing corporations) and the association for tenants expressed the need for energy renovation through the Energy Saving Covenant for the Rented Sector (Spies et al., 2012). In case of a renovation project, legislation states that 70% of the tenants should accept the plans (Atrienis, 2016). To ensure that tenants are satisfied with the renovation and, in some cases, accept the plans, housing corporation involve tenants in the decision-making process.

There are several models and theories that try to describe the levels of participation (for example Arnstein, 1969; Edelenbos et al., 2006; Pretty, 1995; White, 1996). It can be concluded that a higher level of participation means that the participating party is more involved and has more power in decision-making. To create a successful participation process, several conditions should be considered. The framework of the process, including the role (Rimmelzwaan, 2012) and level of influence of each party (Edelenbos, 2000; Edelenbos et al., 2001), the budget (Debusschere et al., 2009) and the content of the project should be clear for each party. The parties should have some level of equivalence between the parties in relation to their knowledge, skills and time. Furthermore, the relationship between them is important. This can be reached by open and full communication and transparent cooperation.

Letting tenants participate in the decision-making of housing corporations is called ‘tenant participation’. There are two types of tenant participation; formal and informal. Formal participation arises from legislation in the form of residents’ committees and tenant organizations. Due to the shortcomings of formal participation, housing corporations also use informal ways of participation. Literature showed the various ways of participation used by housing corporations. The level and way



of participation depend, among other things, on the willingness of tenants to participate. The willingness of tenants to participate depends on the resources (skills, confidence and available time), mobilisation (opportunity to participate in relation to attractiveness, timeline and relevance and the presence of issues) and motivation (individualistic incentives such as benefits but more importantly collectivistic incentives such as sense of communication, shared values and social cohesion). In the literature, there is no participation model or explanation of participation levels for tenants. Therefore, using the information gained from literature, a participation model is created (table 2.5). This model will be used in this study to describe the various levels of participation.

It is likely that the renovation approach, including participation, influences the satisfaction of tenants with the renovation. Therefore, the concept of satisfaction and the satisfaction with projects discussed in the literature was studied. Satisfaction in general is considered as the result of a comparison between expected and actual outcome. Studies focussing on the satisfaction of tenants with the renovation concluded that tenants were satisfied, and the renovation happened as expected. Furthermore, the level of communication most likely influenced the satisfaction of tenants. In the Netherlands, participation is often used before renovation to reach the 70% acceptance rate. According to the literature, tenants are more likely to accept when they are involved in the process, have enough information and their input is used. As a result, it is likely that the expectations of the tenants and the actual outcome are more similar resulting in higher satisfaction. While literature shows that it is likely that the level of participation influences the satisfaction of tenants, there is little literature studying this relationship.

Finally, the literature review studied literature about the energy consumption of households. One of the reasons for energy renovation is to improve energy efficiency and decrease energy consumption. Theoretical methods are used to calculate the energy performance of a dwelling. However, literature shows that the behaviour of the household has a large impact on the actual energy performance, called the rebound- and prebound effect. As a result, the actual energy savings of the renovation are lower than expected. Because the satisfaction of the tenants with the renovation depends on the

Table 2.5: Level of tenant participation

Level	Explanation
Inform	Tenants are informed by the housing corporation about the renovation but have no role in the process and no influence in the decision-making.
Consult	The housing corporation consult tenants when there is a need for input. Tenants have the opportunity to comment on topics provided by the housing corporation but have no influence on the decision-making. The housing corporation does not have to link consequences to this input and retains the influence over the decision-making.
Advise	Tenants have the opportunity to comment and come up with their own ideas and solutions. The housing corporation is open to those ideas and solutions provided by the tenants but has the influence over the decision-making.
Coproduction	The housing corporation sets boundaries and gives the influence over the decision-making to the tenants within those boundaries. Tenants have full influence within those boundaries.
Co-decision	The housing corporation and tenants share the influence on the decision-making. This is done on the basis of equality and they parties must come to a decision together.
Empowerment	The housing corporation empowers the tenants to make the decisions but offers support.
Control	Tenants have full power over the decision-making.

expectations and the actual outcome, the rebound- and prebound effect can influence the level of satisfaction of tenants.

While theories on behaviour differ, it can be concluded that behaviour arises from social aspects (e.g. norms, meaning, culture), external aspects (e.g. technology, economy) and individual aspects (e.g. attitude, intention, habits). These behavioural aspects were also found in relation to energy renovations. Personal aspects, such as restricted knowledge and skills, habits, convenience and the need/desire for thermal comfort, and external aspects, such as quality of installation and function of measure and external circumstances, were found (Gianfrate et al., 2017; Lowery, 2012; Walker et al., 2014). Tenants' participation was suggested to positively influence tenants' behaviour (Gianfrate et al., 2017).

The literature review showed that the topics of participation, satisfaction and energy consumption are often studied. However, there is little research done into these three topics in relation to the renovation process/approach, especially from the point of view of the tenants. Therefore, this study will analyse the effect of the process/approach (including the level of participation) on the satisfaction and energy consumption of tenants.

### 3. Method

As described in literature, there are various ways and levels of participation and these various forms are used by housing corporations. Often this is determined by the experiences of the employees and the social objectives of the housing corporations. In addition to the housing corporation, the tenants are the main stakeholders of a renovation project. The literature review showed that there is little research focussing on the viewpoint of the tenants. Therefore, this study analyses how the renovation process affects the tenants of energy renovation/maintenance projects, focusing on participation, satisfaction and energy consumption. In this chapter, the methods used to study this are explained. First, general explanation of the method is given and then it is explained why the method is used in the study.

#### 3.1. Conceptual model

It can be concluded from the literature that a higher level of tenant participation will likely positively influence tenants' satisfaction with the renovation. In addition, participation is also mentioned to improve the operation of the measures after renovation. While it seems that participation has a positive effect, this is barely studied. Therefore, this study will study the relation between participation, energy consumption and satisfaction.

To study this relationship, a conceptual framework (figure 3.1) is designed using the studied literature. The satisfaction of the tenants depends on the expectations and the actual experience. It can be divided into two part; the satisfaction with the process (e.g. the level of influence in the decision-making, the level and ways of communication and information distribution) and the satisfaction with the outcome of the renovation (e.g. the measures implemented, the financial situation in terms of rent increase and the energy bill). The renovation approach, including the level of participation, may influence both the expectations of the tenants (through more and better information) and the actual situation (influencing the process and the decision-making).

The energy consumption of the household depends on the behaviour, which is determined by the habits, intentions and external circumstances (e.g. life events). The intention arises from behavioural control, social factors, motivation and attitude towards energy saving. The motivation of tenants is triggered by the expected opportunities (performance of the measures) provided by the new measures and the needs of the household (e.g. need for more comfort or decrease of the price the energy bill). The new measures also influence the expected level of effort tenant must make for a certain behaviour. This level of effort, the abilities of the tenants (whether they can perform this effort) and the opportunities provided by the measures determine whether someone has behavioural control. It is expected that the approach (level of participation) influences the knowledge about the performance and effort expectancy. In addition, the abilities and the attitude towards energy saving may be influenced by approach. As a result, the behaviour of the tenants is better adapted to the new situation. Affecting the energy consumption of the dwelling.

In the literature review, the rebound- and prebound effect were discussed. The theoretical calculated energy performance and the savings are the expectations of the tenants. Due to their behaviour, the actual energy savings differ from these calculated savings. For example, due to the improved situation and the need for more comfort, the tenants increase the temperature in their dwelling. The energy consumption increases. This affects satisfaction with the energy bill because the actual energy savings differ from the expected energy savings. On the other hand, behaviour that arises from the need for comfort may result in higher satisfaction of the comfort in the dwelling and therefore increases the overall satisfaction.



Figure 3.1: Conceptual framework

### 3.2. Comparative case study

Case study is a method that is useful for exploratory, descriptive or explanatory studies (Rowley, 2002). It can be used when “a how and why question is being asked about a contemporary set of events over which the investigator has little or no control” (Yin, 2003, pp.9). It investigates “contemporary phenomena within its real life context” (Rowley, 2002, pp.8). According to Swanborn (2003), the case study method is useful to gain detailed knowledge about these contemporary phenomena, getting an idea of the social relationships between those involved and to gain insight into the bottlenecks experienced by participants.

A case can be described as an “instance of a class of events of interest to the investigator” (Bennett, 2004, pp.20-21) and a case study analyses these events in-depth (Zartman, 2005). The advantages of a case study is that it examines data in a real life situation, both quantitative and qualitative approaches can be used and one is able to explain complex real life situations (Zainal, 2007). On the other hand, a lack of strictness must be prevented, and the amount of data should remain manageable. In addition, generalisation of the conclusions is one of the disadvantages of a case study. This can be improved by using a comparative case study. Where a case study focuses only on one case, a comparative case study uses more than one cases to study. The objectives are systematically compared with each other across the cases (Rowley, 2002). It is therefore important that the ‘within case’ analyses process is structured to prevent that the cases cannot be compared (Zartman, 2005).

The method case study is a widely used method in literature. The method is for example used by Glumac et al. (2013) to study different levels of participation and compared these to formulate recommendations for project plans. Romanin (2013) also studied tenants’ participation using a case study. In this study, a renewal project in Sydney was used to study the influence of tenants in decision making. The limitations and possible improvements of co-creative processes in renovation projects were studied by Helgesson (2018). The case study method was used because of the opportunity to gain in-depth knowledge about the different dimensions. In addition, Knudsen & Jensen (2015) used case studies to analyse tenants’ experiences and satisfaction with renovation projects. Because this study compared two cases with each other, a few conclusions were drawn from the differences between the cases. In addition, case studies are also used to study energy renovation projects. Sunikka-Blank et al. (2012) used a case study to study the energy consumption behaviour of households whose homes were renovated and used the outcomes as a prototype for other areas. Hoppe (2012) also used a case study to gain more knowledge into the governance aspect of renovations and used therefore an explorative design. Eight cases were used to provide more data.

Renovation projects of housing corporations are “contemporary phenomena within its real-life context”. Due to the limited amount of research into the topic of this study, there is a need to explore these contemporary phenomena. Because of the limited time available for this study, it is not possible to do a controlled study, such as an experiment. Therefore, a case study fits the goal of this study. This study will use the comparative case study method. The goal of this study is to investigate participation in renovation projects. By comparing different renovation processes, this study is able to explore whether there are differences between these approaches concerning the satisfaction and the energy consumption of tenants.

### 3.3. Interview

Data needs to be collected to be able to perform a comparative case study. Interviews are commonly used as a data collection method in case studies (Yin, 2003). The advantage is the opportunity to collect both quantitative and qualitative data (Woods, 2011). However, this depends on the type of interview. It can be divided into three types, namely; structured, semi-structured and unstructured. In an

unstructured interview, the researcher has a list of topics that need to be discussed and the interviewees have the opportunity to tell their story (Crinson, Leontowitsch, & Morgan, 2016). During a structured interview, interviewees receive pre-determined questions in a specific order that they should answer (Dudovskiy, n.d.). Structured interviews can be face-to-face or by telephone, but also through questionnaires and surveys (Woods, 2011). A semi-structured interview has characteristics of both structured and unstructured interviews. The questions of the interview are partially pre-determined, while there is the opportunity to ask additional questions. It has a certain flexibility and makes it therefore suitable to answer a why question instead of only how many and how much (Miles & Gilbert, 2005).

Like the interview method, a focus group can be used. In a focus group, an informal discussion between participants is created in order to get information (Acocella, 2012). The goal of using a focus group is to promote interaction and to obtain a lot of information in a short period of time. One of the main goals of a focus group is to gather the “collective and public dimensions of opinions” (Acocella, 2012, pp.1128). However, there are also several risks using this method. The free production of information can be slowed down by the speed of the conversation and several coordination problems. In addition, the individual ideas and opinions can be suppressed in a group and therefore the outcomes can be more socially desirable. Therefore, the focus group approach will not be used in this study.

The main disadvantage of unstructured interviews is the difficulty to replicate the interview, making it harder to compare interviews and it is less easy to generalise (Woods, 2011). It is therefore not widely used in literature. Structure interviews, in the form of questionnaires, were used by Chahal, Swan, & Brown (2012) and Knudsen & Jensen (2015). Chahal, Swan, & Brown (2012) used a questionnaire to analyse the tenants’ opinions and knowledge about the use of new measures. Knudsen & Jensen (2015) analysed the satisfaction and experiences of the tenants with the renovation. In addition, the semi-structured form is a commonly used interview approach in literature. Moore et al. (2015) performed an evaluation of low-carbon public housing in Horsham, Australia. They conducted both household and stakeholder interviews. The household interviews were semi-structured to analyse the experience of the households with the dwelling. Each household was interviewed three times over a period of three years. Also, semi-structured interviews were conducted with the key stakeholders to analyse their experiences. These were stakeholders who were involved during the design, construction and operation of the dwellings. Similar, Aapaoja, Haapasalo, & Söderström (2013) studied early stakeholder involvement in renovation projects. They used interviews to gain better insight into the case and the opinions of the stakeholders of the project. Jensen & Maslesa (2015) used interviews for different purposes. They started with semi-structured interviews to gain knowledge about renovation and as a basis for the remainder of the study. Subsequently, more structured interviews were used to evaluate the case study on several parameters. The advantage of the semi-structured form, in contrast to the structured form, is the opportunity to get more detailed information (Woods, 2011). In addition, additional information can be gathered during the interview. On the other hand, semi-structured interviews are more time consuming, difficult to quantify and analyse, not generalisable and possibly biased.

To study the satisfaction levels of tenants, information about their satisfaction levels is needed. On the one hand, quantitative data is needed to compare the cases to analyse whether there are significant differences between them. On the other hand, qualitative data provides insight into the reasons behind certain levels of satisfaction. Because a semi-structured interview provides the opportunity to collect both quantitative and qualitative data, this method is being used. During the interview, a questionnaire with closed questions is completed to collect the quantitative data. To collect the

qualitative data, the interviewer provides additional space for the tenants to comment on the topics discussed.

### 3.4. Structural equation modelling

Structural equation modelling (SEM) can be defined as “a class of methodologies that seeks to represent hypotheses about the means, variances, and covariances of observed data in terms of a small number of structural parameters defined by a hypothesised underlying model” (Kaplan, 2000, pp.1). According to Raykov & Marcoulides (2000) the advantages of SEM is the ability for the quantification and testing of theories, containing latent variables and considering measurement errors.

Within literature, a variety of approaches are considered to be SEM. Path analysis, confirmatory factor analysis and latent growth modelling are commonly used SEM approaches. Latent growth modelling considers growth over a period. This study will investigate the satisfaction of tenants at a certain point in time. Therefore, latent growth modelling cannot be used. The other two approaches will be discussed in more detail.

#### Path analysis

Path analysis is the analysis of the relationships between observed variables, modelled as a system of equations (Kaplan, 2000). Where the other types of SEM use latent variables, path analysis only considers observed variables. It is an extension of multiple regression analysis and measures the parameters of a system (Lleras, 2005). It is assumed that there are no measurement errors for the independent variable and residual terms may be present in the dependent variable (Raykov & Marcoulides, 2000). Therefore, path analysis is seen as a special type of SEM, only being a structural model and not a measurement model (Jiang, 2018). Jiang (2018) uses path analysis to analyse residential satisfaction and the intention to move in China. The difference between the aspirations and the actual living situation result in a gap, affecting the satisfaction and intention to move.

#### Confirmatory factor analysis

Path analysis is limited to only observed variables and the measurement errors are not taken into account, resulting in validity and reliability issues. (Schumacker & Lomax, 2004). Factor analyses determines “which sets of observed variables share common variance-covariance characteristics that define (...) factors (latent variables)” (Schumacker & Lomax, 2004, pp.168).

To simplify SEM, path diagrams are used to graphically present the model being studied (Raykov & Marcoulides, 2000). Figure 3.2 shows the notations that are being used in these diagrams. A difference is made between the observed variables (rectangle), the variables that are measured, and the latent variable (ellipse), unmeasured variables. A circle represents the error variance or disturbance term. Finally, there are two types of arrows. One-way arrows are the regression/directional path, meaning that one variable is explained by the other variable. The two-way arrow represents the covariance between two variables.

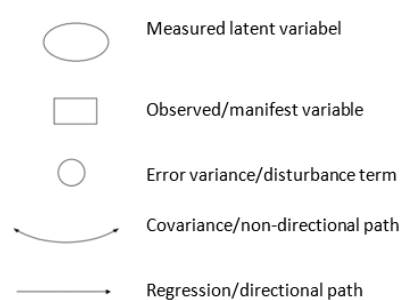


Figure 3.2: Path diagram notation (adapted form Sturgis, 2016)

In addition to the graphical presentation of the model, an equation model can be used. The system of structural equations is as follows (Kaplan, 2000):

$$y = \alpha + B\gamma + \Gamma x + \zeta$$

Where  $y$  =  $p \times 1$  vector of observed endogenous variables  
 $x$  =  $q \times 1$  vector of observed exogenous variables

$\alpha$  = px1 vector of structural intercepts  
 $B$  = pxp coefficient matrix  
 $\Gamma$  = pxq coefficient matrix  
 $\zeta$  = px1 vector of disturbance terms  
 $p$  = the number of endogenous variables  
 $q$  = the number of exogenous variables

By constructing a model, identification should be taken into account. A model should be identifiable to be able to estimate the parameters (Raykov & Marcoulides, 2000). The counting rule can be used to determine the identification of a model. According to the counting rule,  $t \leq p(p+1)/2$  where  $t$  is the number of parameters that should be estimated and  $p$  is the number of non-redundant elements in the covariance matrix (Kaplan, 2000). In literature, there is also often referred to the degrees of freedom (df). This can be calculated as follows:  $df = (p(p+1)/2) - t$  (Raykov & Marcoulides, 2000). When  $df < 0$  the model is under-identified, meaning that there is no unique value for the parameters. A just-identified model ( $df = 0$ ) the parameters can be determined and it will result in a 100% model fit and an over-identified model ( $df > 0$ ) will also provide the opportunity to uniquely identify the values of the parameters but the fit may be below 100% (Arentze, n.d.). While the counting rule is a good model identification approach, it may still be possible that not all parameters can be estimated (Raykov & Marcoulides, 2000). This should be taken into account by the researcher.

To estimate the parameters, correlations are used. Therefore, the structural equations of all endogenous variables must be determined first. The path model shown in figure 3.3 will be used for this example. It is a simplified version of the model presented in this study. The structural equations are as follows:

$$\begin{aligned}
 X_5 &= p_{51}X_1 + e_1 \\
 X_6 &= p_{62}X_2 + e_2 \\
 X_7 &= p_{73}X_3 + e_3 \\
 X_8 &= p_{84}X_4 + e_4 \\
 X_9 &= p_{95}X_5 + p_{96}X_6 + e_5 \\
 X_{10} &= p_{107}X_7 + p_{108}X_8 + e_6 \\
 X_{11} &= p_{119}X_9 + p_{1110}X_{10} + e_7
 \end{aligned}$$

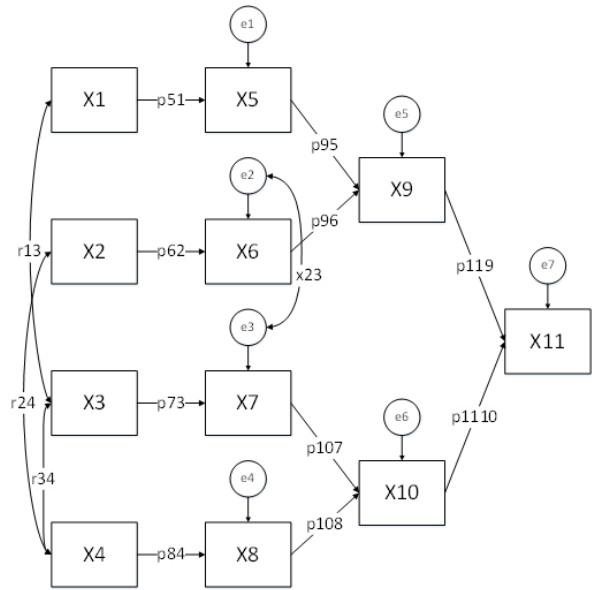


Figure 3.3: Path model

To get the correlations, the structural equation should be multiplied by the predetermined variable. Subsequently, the correlations can be determined. Using the correlation matrix implies that the variables are standardised (Willimams, 2015). Meaning that the variance of a variable is one ( $Cov(X_i^2) = V(X_i) = 1$ ) and that the mean is zero. Furthermore, it is assumed that the residual is uncorrelated with the independent variables ( $Cov(X_i e_j) = 0$ ). The normalised equation can be determined as follows:

$$\begin{aligned}
 X_5 &= p_{51}X_1 + e_1 \\
 X_1 X_5 &= p_{51}X_1^2 + e_1 X_1 \\
 Cov(X_1 X_5) &= p_{51}E(X_1^2) + E(e_1 X_1) = p_{51}
 \end{aligned}$$



Table 3.1: Threshold of fit indices

Fit index	Definition	Threshold
Relative/normed chi-square	$= \chi^2/df$	$<2.0$
Root Mean Square Error or Approximation (RMSEA)	<p>“index of the difference between the observed covariance matrix per degree of freedom and the hypothesized covariance matrix which denotes the model” (Cangur &amp; Ercan, 2015, p. 157)</p> $RMSEA = \sqrt{\max \left\{ \left( \frac{F(S, \Sigma(\hat{\theta}))}{v} - \frac{1}{n-1} \right), 0 \right\}}$ <p> <math>F(S, \Sigma(\hat{\theta}))</math> fit function  <math>v</math> = number of known parameters – number of independent parameters  <math>n</math> = sample size </p>	$<0.07$
Standardised Root Mean Square Residual (SRMR)	<p>“index of the average of standardized residuals between the observed and the hypothesized covariance matrices” (Cangur &amp; Ercan, 2015, p. 156)</p> $SRMR = \sqrt{\frac{\sum_{i=1}^p \sum_{j=1}^i [(s_{ij} - \hat{\sigma}_{ij}) / (s_{ii} s_{jj})]^2}{p(p+1)/2}}$ <p> <math>s_{ij}</math> = component of <math>S</math> sample covariance matrix  <math>\hat{\sigma}_{ij}</math> = component of <math>\Sigma(\hat{\theta})</math> hypothesised model  <math>p</math> = number of observed variables </p>	$<0.08$
Comparative Fit Index (CFI)	<p>“The extent to which the tested model is superior to the alternative model established with manifest covariance matrix” (Cangur &amp; Ercan, 2015, p. 158)</p> $CFI = 1 - \frac{\max [(\chi_t^2 - v_t), 0]}{\max [(\chi_t^2 - v_t), (\chi_i^2 - v_i), 0]}$ <p> <math>\chi_i^2</math> = chi-square of the independence model  <math>\chi_t^2</math> = chi-square of the target model  <math>v_i</math> = degrees of freedom of the independence model  <math>v_t</math> = degrees of freedom of the target model </p>	$\geq 0.95$
Tucker-Lewis Index (TLI) or Non-Normed Fit Index (NNFI)	<p>The difference between the target and independence model as a proportion of the difference between the independence model and the saturated model (where <math>\chi^2/v = 1</math>) (Hallquist, 2017)</p> $TLI = \frac{\left( \frac{\chi_i^2}{v_i} \right) - \left( \frac{\chi_t^2}{v_t} \right)}{\left( \frac{\chi_i^2}{v_i} \right) - 1} = \frac{\left( \frac{F_i}{v_i} \right) - \left( \frac{F_t}{v_t} \right)}{\left( \frac{F_i}{v_i} \right) - \left( \frac{1}{n-1} \right)}$ <p> <math>\chi_i^2</math> = chi-square of the independence model  <math>\chi_t^2</math> = chi-square of the target model  <math>v_i</math> = degrees of freedom of the independence model  <math>v_t</math> = degrees of freedom of the target model </p>	$\geq 0.95$

Doing this for each of the variables, the theoretical/reproduced correlation matrix  $\Sigma$  can be determined. In addition to the theoretical covariance matrix  $\Sigma$ , an observed covariance matrix  $S$  can be

determined using the observed data. The equations of  $\Sigma$  and the values of  $S$  result in  $p(p+1)/2$  equations (where  $p$  is the number of observed variables). By solving these equations, the parameters can be determined. To do this, several estimation methods can be used, such as the 'maximum likelihood' (ML), 'unweighted least squares' (ULS), 'generalised least squares' (GLS) and 'asymptotically distribution free' (ADF) (also known as the 'weighted least squares') (Raykov & Marcoulides, 2000). The maximum likelihood estimation method is the mainly used method (Lancaster & Duncan, 2006). While the method is mainly used with normally distributed data, its advantage over the others is that it can still be used with non-normal data. While ADF is usually used for non-normal data, it requires a very large sample size, while ML is still able to produce good estimates with fewer data.

When the parameters are estimated, the fit of the model should be tested. Hooper, Coughlan, & Mullen (2008) provided guidelines for determining the model fit. There are two types of indices: absolute and incremental (Hooper et al., 2008). An absolute fit index determines how the given model fits the data and shows which model has the best fit. Examples of the absolute fit index are the chi-square, root mean square error of approximation (RMSEA), the (adjusted) goodness-of-fit statistic and the (standardised) root mean square residual (SRMSR and RMSR). On the other hand, an incremental fit index determines how well a model fits compared to no model. Examples of an incremental fit index are normed-fit index (NFI) and the comparative fit index (CFI).

The advantage of structural equation modelling is the opportunity to study both the direct and indirect effect. The conceptual model (chapter 3), which resulted from the literature review, assumes that the satisfaction with a certain determinant of renovation depends on the gap between the expectation and the actual experience of the tenants. The satisfaction with the determinants affects the satisfaction with the process and the results, which subsequently influence the overall satisfaction. Using SEM provides information about the effect of each separate variable (gap and satisfaction) on the overall satisfaction. This makes it possible to identify which aspects are important for the tenants and should be considered during a renovation process.

The type of SEM approach depends, among other things, on the variables used. Latent variables are used when it is difficult to measure a variable, such as attitude or awareness, in one single variable (Wang, Han, Vries, & Zuo, 2016). In this study, the variables that are being studied are: the expected and actual value of several determinants, the satisfaction with these determinants, satisfaction with the process and outcome and the overall satisfaction. Each individual variable is measurable using a single variable. Therefore, this study will use path analysis to study the relation between the actual and expected value (gap) and satisfaction.

### 3.5. Conclusion

This thesis studies the effect of the energy renovation project on tenants' satisfaction and energy consumption. A conceptual model is drawn to structure the study. The renovation approach, including the level of participation, is likely to influence the expectations and experiences of tenants with several factors. The gap between the expectations and experiences will subsequently influence the satisfaction with the factors, the process, the results and the overall satisfaction. The energy consumption is also likely to be affected by the renovation approach. The energy consumption behaviour of tenants is affected through the expectations of tenants about the effort they must put into saving energy and the performance of the measures, the abilities of the tenants and their attitude towards energy saving. The energy consumption behaviour affects energy consumption. It is likely that energy consumption affects the overall satisfaction through the actual results of the renovation. To study these relationships, various methods are used. To study both the satisfaction with the renovation and the energy consumption, the methods comparative case study method is used. By comparing different

cases, this study can analyse whether there are differences between the approaches concerning the satisfaction and energy consumption of tenants. To collect data about satisfaction and energy consumption, semi-structured interviews are used. This provides the opportunity to collect both quantitative and qualitative data. During the semi-structured interviews, a questionnaire with both closed questions (quantitative data) and open questions (qualitative data) is used. The analysis of the data is divided into two parts, tenant's satisfaction and energy consumption. Because there is little known about the relationship between possible determinants and the overall satisfaction, path analysis is used. Path analysis is a form of structural equation modelling (SEM) which analyses the relationships (direct and indirect) of observed variables. As a result, the effect of the gap between expectation and experiences of and the satisfaction with several determinants on the overall satisfaction is determined. The data collected during the semi-structured interviews, including the questionnaire used, and the modification of this data will be discussed in the next chapter.



## 4. Data collection and modification

As described above, the method used in this study is a comparative case study. Therefore, this chapter first describes the cases selected. Subsequently, the data collection process is described.

### 4.1. Case selection

For this comparative case study, cases are selected. To study the similarities, differences and patterns between the cases, the cases should have a common goal (Zartman, 2005). In this study, energy renovation projects in social housing will be used as cases. The common goal is to reduce energy consumption and increase the comfort level of the dwellings. The goal of this study is to analyse the renovation process, taking into account the participation level of tenants, in relation to the satisfaction and energy consumption of the households. Therefore, the cases selected provide a range of different levels and ways of tenant participation.

In total, four cases are selected (figure 4.1), namely;

- renovation project in Eckart, Eindhoven
- renovation project in d'Ekker Veldhoven
- maintenance project in Breeakker, Son
- maintenance project in Tivoli, Eindhoven

The cases used for this study are projects of housing corporation Woonbedrijf. Woonbedrijf was founded in 2005 from a merge of two housing associations, both with a rich history in Eindhoven and its surroundings (Woonbedrijf, n.d.-b). Nowadays, Woonbedrijf is active in Eindhoven, Helmond and surrounding municipalities (figure 4.1). As the largest housing corporation is the area, the home ownership amounted to 32,798 in 2018, including social housing (normal and student) and free sector housing (Woonbedrijf, n.d.-c). Most of the dwellings fall within the affordability categories cheap and affordable. The mission of Woonbedrijf is to provide and maintain a large stock of affordable housing for everyone (Woonbedrijf, n.d.-d). They believe that everyone should be able to live in a house with quality and in a liveable neighbourhood. The wishes of the customers are the guidelines. Woonbedrijf wants to contribute to a better world. Therefore, sustainability is an important aspect. Four themes are used to work more sustainable, namely; renewable energy, closed cycles, natural city and collective awareness (Woonbedrijf, n.d.-a). Renovating the housing stock is part of the goals of Woonbedrijf.

In addition, the Eckart project is one of the projects within the Triangulum project. The Triangulum project is a European project “set to demonstrate, disseminate and replicate solutions and frameworks for Europe’s further smart cities” in the field of sustainable mobility, energy and ICT (Fraunhofer IAO, 2018). The project consortium consists of partners from industry, research and municipalities.

### 4.2. Documentation

One of the data collection approaches for a comparative case study mentioned by Yin (2003) is documentation. He states that “documentary information is likely to be relevant to every case study topic” (pp.85). The data is obtained by various documents such as letters, reports of events, progress reports, newspapers, studies of the same case etc. Possible weaknesses of using documentation is the

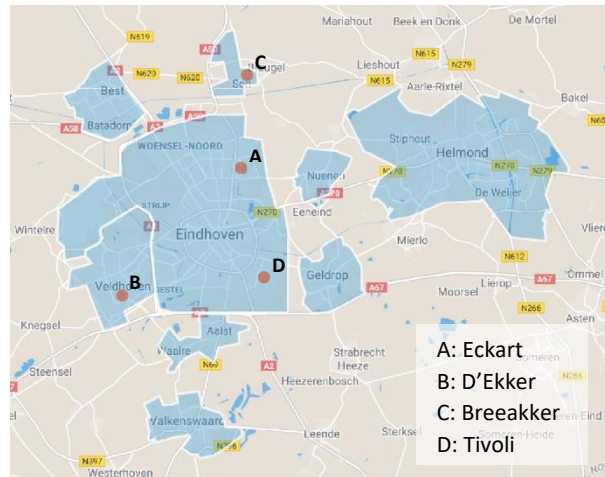


Figure 4.1: Area in which Woonbedrijf is active and the location of the cases (adapted from Woonbedrijf, n.d.-e)

limited accessibility and retrievability of the documents. In addition, the collection of documents may be incomplete, or the documents may be biased. The advantages of documentation are the possibility to verify information from other sources and presumptions can be formed to study further. Because of these (dis)advantages, documentation will be used to obtain a general picture of the cases. To goal is to get an overall view of the different cases that can be used throughout the rest of this study.

All documentation obtained for this study comes from Woonbedrijf, consisting of newsletters, information booklets and letters to tenants. An overview of all documentation being used is given in Appendix 1. The documentation is analysed on the following aspects: the participation process, including aspects such as communication, information sharing, meetings etc., and the measures being applied.

### 4.3. Questionnaire

In this study, a questionnaire is used to gather data about the satisfaction of the tenants with the project. The goal is to analyse the differences between cases concerning these satisfaction levels. Using a questionnaire, it is easier to gather more data and the data is quantitative. Furthermore, the energy consumption data is also collected during the questionnaire.

#### 4.3.1. Questionnaire design

The conceptual model that resulted from the literature review is used for the design of the questionnaire. The interviews are conducted in Dutch, therefore the questionnaire used was Dutch. Both the English and Dutch version of the questionnaire are presented in Appendix 2.

According to the conceptual model, the overall satisfaction is a result of the satisfaction of the process and the results of the renovation. The gap between the expected and actual value of various variables determines the satisfaction with these variables and of the process and the results.

The questionnaire is divided into three sections. First, some general information about the tenants, the living situation before renovation and their attitude towards renovation is asked. Subsequently, the expectations and actual experience of the tenants with the different variables and their satisfaction with the variables, the process, the results and overall satisfaction is asked. Finally, questions about their view on energy consumption and energy saving and their energy consumption data are asked.

Most of the questions are ordinal (e.g. expectation, actual experience and satisfaction). In the literature, 5- and 7-point scales are often used (Lille, Perumean, & McArthur, 2003). To be able to analyse more detailed differences between the cases, the 7-point scale is used in this study. The questions about personal/household characteristics are mainly categorical.

#### 4.3.2. Data collection

The data was collected in the months of April and May 2019. At the beginning of April, the tenants received a letter from Woonbedrijf in which was told that students will come by to complete a questionnaire face-to-face. The questionnaires were completed face-to-face to increase the change of participation of tenants and to ensure the questionnaires were completed correctly. For each case, 30 questionnaires were completed, resulting in a total of 120 respondents. The respondents were selected at random. Another advantage of the face-to-face questionnaire is the opportunity to gain in-depth insight into the given answers of the tenants. As discussed above, the questionnaire provides space to comment on various topics. By conducting the questionnaire face-to-face, it is more likely that the topics will be discussed more extensively compared to having the questionnaire filled and returned by mail or post.

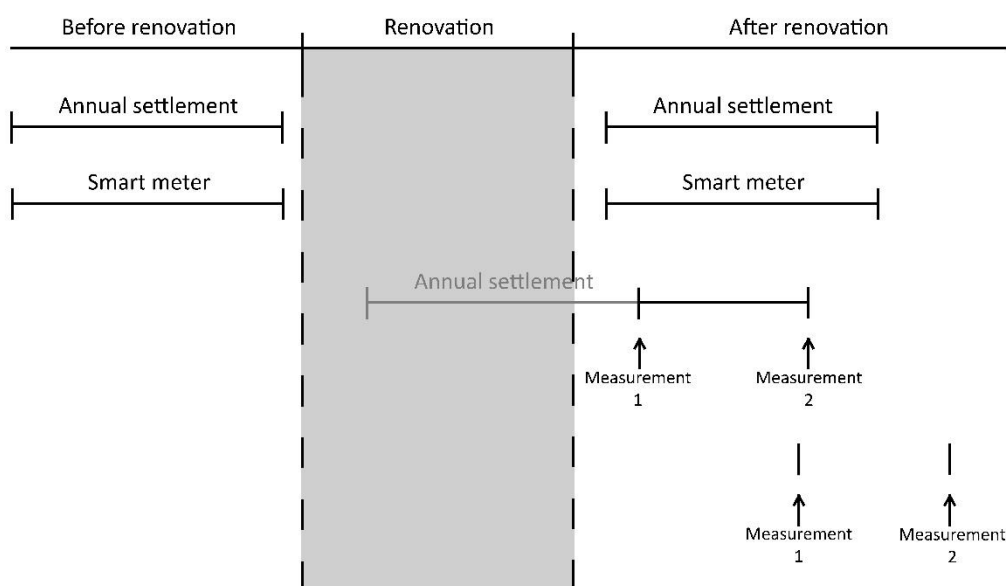


Figure 4.2: Explanation energy data collection

At the same time as the questionnaire, respondents were asked to share their energy consumption data. Energy consumption data, both gas and electricity, of before and after the renovation was collected to compare. Data that falls (partly) within the renovation period were not included. In total, 36 households shared their energy consumption data. Figure 4.2 gives an overview for the various options of data processing. Concerning the energy consumption data before the renovation, data of the annual energy bill and of the smart meter could be collected. Most of the data collected is obtained from the annual energy bill. For the energy consumption data after the renovation, there were four options to obtain the data. As with before the renovation, the annual energy bill and smart meter could be used. In addition, annual energy bills that fall partly within the renovation period and containing the end meter readings were used to collect a first measurement point. The meter reading of the moment of visit is the second measurement point. By subtracting the values of the first measurement point from the second, the energy consumption of a certain period can be calculated. The final option to collect the energy consumption data is to visit twice and collect the meter readings of those two moments.

In addition to the actual energy consumption data, the theoretical energy consumption is also collected. The housing corporation provided the energy label, energy index and theoretical gas and electricity consumption of the dwellings in Eckart, the energy label of the dwellings in d'Ekker and the energy label and energy index of the dwellings in Tivoli.

#### 4.3.3. Data cleaning and processing

As described above, two types of data are collected during the interviews. One part of the collected data is about the expectations, experiences and satisfaction level of tenants. This data is collected in the satisfaction dataset. The other data collected is the energy consumption before and after the renovation and some questions about the opinions of the tenant concerning energy and energy saving. This data is collected in the energy consumption dataset. The cleaning and processing methods used for these datasets are described below.

#### 4.3.3.1. Satisfaction dataset

The conceptual model studied in this research assumes that the gaps between the expectations and actual experiences of the tenants determine the satisfaction with the renovation project. Therefore, the gap between the expectation and the experience should be calculated. The gap is calculated as the value of the actual experience minus the expected value. As a result, a positive gap value means that the actual experience of the aspect is higher compared to the expectation and vice-versa.

In addition, the data should be cleaned before analysing. Respondents with missing values and outliers should be considered. Outliers are detected using boxplots of the various variables. Respondents with outliers in various variables were checked and deleted if the data was invalid. The final dataset consisted of 118 respondents. Concerning missing values, the vast majority of missing values are within the expectation, actual value and satisfaction with the energy consumption. The reason is that most tenants check their energy consumption once a year when they receive their energy bill. Because the renovation took place in the past year for most tenants, they did not yet receive a new energy bill and did therefore not know the impact of the renovation. These missing values will not be considered in the analysis.

Finally, it is important to take into account whether the sample represents the real situation. Table 4.1 shows an overview of the age, gender and household distribution for each case. Data of Statistics Netherlands (in Dutch: Centraal Bureau voor de Statistiek or CBS) is used to gather data about the neighbourhood in general (CBS, 2018). CBS collects statistical data about municipalities, districts and neighbourhoods in the Netherlands. CBS defines a neighbourhood as a part of a municipality that can be demarcated homogeneously from the viewpoint of the type of buildings or socio-economic structure (CBS, 2019). While Eckart, d'Ekker and Tivoli are considered to be neighbourhoods by the CBS, Breeakker lies within the neighbourhood Son. Therefore, the data of Son may differ from the real situation of Breeakker

A one-sample chi-square test is performed to test whether the distribution of the sample is significantly different of the same as the data of the population (CBS data). The outcomes of the tests are also presented in figure 4.1. Considering the age variable, the chi-square test shows that in d'Ekker and Tivoli, the sample significantly differs from the population. In both cases, the higher age categories are overrepresented in the sample. This can partly be explained by the reason that children living with their parents are included in the CBS data. The questionnaires are, on the other hand, completed by the main tenants. There is also a significant difference between the sample and population considering the household composition in Eckart and Tivoli. For both cases, households with children are overrepresented, while single households are underrepresented in the sample. Finally, the analysis shows that women are overrepresented in the sample of Eckart.

#### 4.3.3.2. Energy consumption dataset

Before being able to analyse the gas and electricity consumption data, it should be modified. The data collected has different measurement periods. The data should be normalised to a certain period to be able to compare energy consumption before and after renovation. Furthermore, the gas consumption of the household depends on the outdoor temperature because its mainly used for heating (TRIME, 2017). The collected data is corrected for the temperature. The methods used for the modification is described below.

##### Gas consumption

Gas is used to heat the dwelling during lower outdoor temperature. Therefore, the gas consumption depends on the outdoor temperature. To correct the data and be able to compare it, so called degree days are commonly used. There are two types of degree days, namely; heating and cooling. Because



Table 4.1: Frequencies and one-sample chi-square values of the satisfaction dataset

		Eckart (N=29)			d'Ekker (N=30)			Tivoli (N=30)			Breeakker (N=29)		
Sample	Real	Sample	Real		Sample	Real		Sample	Real		Sample	Real (son)	
		#	%	%	#	%	%	#	%	%	#	%	%
Age													
18-24	15-24	1	3.4	13.8	0	0.0	9.9	1	3.3	11.6	1	3.4	10.9
25-34	25-44	4	13.8	29.0	1	3.3	25.2	5	16.7	36.9	0	0.0	17.3
35-44		5	17.2		2	6.7		3	10.0		1	3.4	
45-54	45-64	4	13.8	28.7	6	20.0	29.4	6	20.0	33.2	3	10.3	30.1
55-64		3	10.3		2	6.7		6	20.0		4	13.8	
65-74	65+	7	24.1	28.6	15	50.0	35.5	8	26.7	18.3	11	37.9	41.8
75+		5	17.2		4	13.3		1	3.3		9	31.0	
Chi-square test		X <sup>2</sup> = 4.164, p = 0.244			X <sup>2</sup> = 8.151, p = 0.017			X <sup>2</sup> = 51.852, p = 0.000			X <sup>2</sup> =5.078, p=0.166		
Gender													
Man		5	17.2	47.9	11	36.7	47.8	12	40.0	48.6	15	51.7	48.3
Woman		24	82.8	52.1	19	63.7	52.2	18	60.0	51.0	14	48.3	51.7
Chi-square test		X <sup>2</sup> = 10.923, p = 0.001			X <sup>2</sup> = 1.490, p = 0.222			X <sup>2</sup> = 0.929 p = 0.335			X <sup>2</sup> = 0.136 p = 0.712		
Household composition													
Single		6	20.7	43.7	10	33.3	36.6	7	23.3	48.4	9	31.0	37.7
Couple		10	34.5	26.4	14	46.7	36.8	9	30.0	21.9	16	55.2	36.2
Couple with child(ren)	With child (ren)	10	34.5	30.0	3	10.0	26.6	9	30.0	29.7	2	6.9	26.2
Single with child(ren)		3	10.3		3	10.0		5	16.7		2	6.9	
Chi-square test		X <sup>2</sup> = 6.363, p = 0.042			X <sup>2</sup> = 1.372, p = 0.503			X <sup>2</sup> = 7.701 p = 0.021			X <sup>2</sup> = 4.934 p = 0.085		
Joined a sounding board													
Yes					2 6.7						4 13.8		
No					28 93.3						25 86.2		

gas is used to increase the indoor temperature, heating degree days are being used. To calculate the number of heating days in a certain period, a reference temperature should be selected. Within the Netherlands, the reference temperature is usually 18 °C (TRIME, 2017). The heating degree days of one day, when the outside temperature was below the reference temperature, is calculated as the reference temperature minus the outside temperature. Data about the degree days per day of recent years is collected (Heuven, n.d.). The sum of all heating degree days of each day in a certain period is the number of heating degree days in that period. Knowing the number of degree days in the measurement period, the gas consumption can be corrected. Dividing the consumption through the

number of degree days of that period, the gas consumption per degree day is calculated. The gas consumption is the consumption per degree day multiplied by the number of degree days of a reference period. The equation of this calculation is as follows (TRIME, 2017):

$$\text{Gas consumption} = \frac{\text{Gas consumption}_{mp}}{\text{Degree days}_{mp}} * \text{Degree days}_{rp} \quad (4.1)$$

Where      mp = measurement period  
                  rp = reference period

The gas consumption of each respondent is calculated using formula 4.1. As described above, there are various options for data processing. Therefore, the measurement period for each respondent differs. The collected data about the degree days is used to calculate the total amount of degree days for each respondent according to the specific measurement period.

#### Electricity consumption

As described above, the electricity consumption is collected through the annual energy bill, smart meter or measurement points (meter readings) at certain moments in time. Subtracting these measurement points, the consumption can be calculated. However, in two cases, solar panels are installed during or after the renovation. The meter provides information about the amount of electricity obtained from the grid and the amount of electricity delivered back. To calculate the electricity consumption of the household, data about the total yield of the PV (Photovoltaic) panels are used. The total electricity consumption can be calculated as follows:

$$\text{Electricity consumption} = \text{Electricity}_{grid} + \text{Electricity}_{PV} - \text{Electricity}_{back} \quad (4.2)$$

Where      Electricity<sub>grid</sub> = amount of electricity obtained from the energy grid  
                  Electricity<sub>PV</sub> = amount of electricity generated by the PV panels  
                  Electricity<sub>back</sub> = amount of electricity delivered back into the energy grid

From the data collected, the values of Electricity<sub>grid</sub> and Electricity<sub>back</sub> are known but the value of Electricity<sub>PV</sub> for each household is unknown. This can be calculated using data of the Photovoltaic Geographical Information System (PVGIS) web application. The PVGIS web application is part of the PVGIS project, a research project into solar radiation and PV performance of the European Commission Joint Research Centre (European Commission, n.d.-e).

The amount of electricity generated by the PV panels depends highly on the degree of solar radiation (European Commission, n.d.-c). The solar radiation that reaches the PV panels (global radiation) depends on the beam/direct-, diffuse and reflected radiation. To estimate the solar radiation intensity on the ground, satellite data (or climate reanalysis data if satellite data is not available) is used. Radiation data using satellites is considered to be very accurate (European Commission, n.d.-c). Algorithms are used to translate satellite data (images), and additional atmospheric data, into radiation data. First, the influence of clouds is calculated. This is done by determining a clear sky day (direct radiation). Using this, the effective cloud albedo can be calculated. The second step is to determine the clear-sky irradiance, which is determined using the atmospheric data. The horizontal radiation can then be determined using both the effective cloud albedo and the clear-sky irradiance. To calculate the inclined radiation, an estimation model of Muneer (1990) is used. This model is considered to be a good performing model (European Commission, n.d.-c). Within PVGIS, one satellite image of the METEOSAT satellites per hour is used. Therefore, the systems had data of the solar radiation for each hour, each day. The nominal power (or peak power) of a PV panel is measured in standardised conditions, irradiance of 1,000 W/m<sup>2</sup>, temperature of 25 °C and the IEC 60904-3 light spectrum (European Commission, n.d.-c). To determine the real power of the panels, the nominal power is

corrected by the real radiation, shallow-angle reflection, real solar spectrum, temperature of the panels, the solar irradiance, system losses.

In the ideal situation, the radiation data of the same period as the collected electricity data is used. However, the data is recently collected and there are no tools that use recent radiation data to calculate the power of the PV panels. Within PVGIS, a selection out of four radiation databases can be made to calculate the power. These databases consist of radiation data from 2005 till 2016. To identify which radiation data (database and year) fits the radiation of the measurement period the best, the radiation data of PVGIS should be compared to the real radiation of the measurement period. Siderea (n.d.) provides data about the yield, global- and inclined radiation per month for the Netherlands. Irradiation data of the KNMI (Royal Dutch Meteorological Institute, in Dutch Koninklijk Nederlands Meteorologisch Instituut) is used to calculate these values, for five locations in the Netherlands, including Eindhoven. The actual amount of radiation in the months in which the data is collected is compared to the amount of radiation of the various databases and years within the same months (appendix 3). The database and year that corresponded the best with the actual radiation (percentage deviation from the real radiation) is used to calculate the generated electricity of the PV panels.

Figure 4.4 provides an overview of the PVGIS web tool. First, the exact location of the PV system should be selected using the map on the left side. To calculate the power of a certain period, daily data about the radiation and power is needed. However, within the daily data section of the tool, it isn't possible to select a certain year and to specify the PV power. Therefore, the hourly radiation data section of the tool is used. Then, the radiation database and the year that corresponds with the real radiation during the measurement period are filled in in the tool.

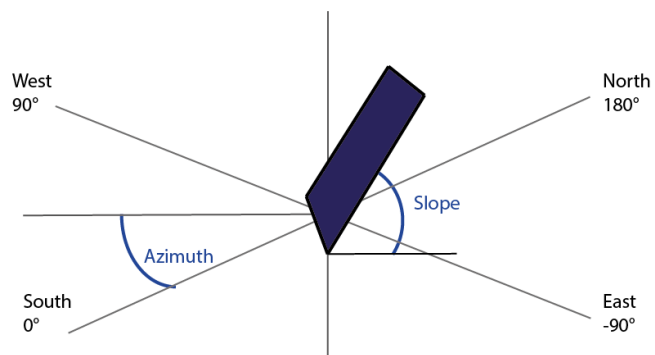


Figure 4.3: Azimuth and slope

Furthermore, mounting information about the PV system is added (mounting type, slope and azimuth). Figure 4.3 gives a representation explaining the azimuth and the slope. To determine the slope of the PV panels, building plans and details are used and for the azimuth, google maps is used. Finally, by selecting PV power, the generated electricity will be calculated by the tool. The PV technology (crystalline silicon), installed peak PV power (kWp) and system loss should be filled in. Information about the peak power is collected from Woonbedrijf. The system loss is presumed to be 14%, which is the default value of the tool. When all the information is filled in, the hourly radiation data and PV power can be downloaded.

The downloaded csv-file contains the following data for each hour per day for the selected year:

- EPV = PV system power (W)
- In-plane irradiance (W/m<sup>2</sup>)
- Sun elevation
- Ambient temperature (deg. C)
- Wind speed (m/s)

To determine the amount of electricity the system produced for a certain day, it is assumed the given power (W) measured each hour lasts one hour. This gives the total amount of electricity produced in one hour. Summing the 24 hours of each day, the amount of electricity produced by the PV system is known (Wh). The yield of the PV system is then calculated by summing the amount of electricity

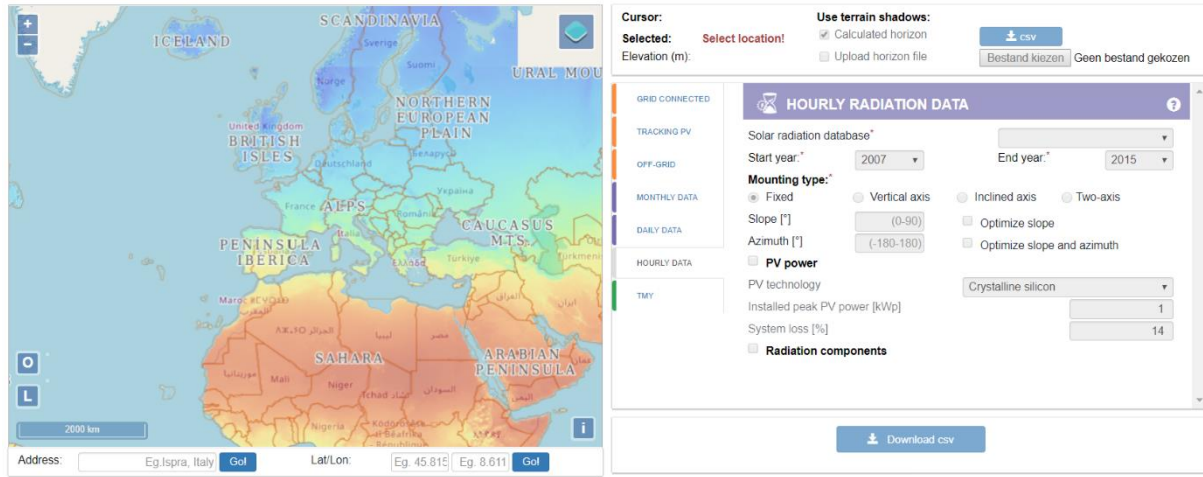


Figure 4.4: Screenshot of PVGIS (adapted from European Commission, n.d.-c)

produced by the PV system in the reference year for the same period. The electricity consumption of the households can be calculated using formula 4.3.

The electricity consumption of households is almost the same throughout the year (TRIME, 2017) if there is no major change in the household composition or dwelling (e.g. renovation). Therefore, only the period should be normalised to be able to compare the energy consumption of the two periods (before and after renovation). This can be done using the following equation (TRIME, 2017):

$$Total\ electricity\ consumption = \frac{Electricity\ consumption_{mp}}{Days_{mp}} * Days_{rp} \quad (4.3)$$

Where  $np$  = reference period (= 365 days)  
 $mp$  = measurement period

In addition to the total electricity consumption, PV panels are installed on some dwellings during the renovation in Eckart and after renovation in d'Ekker. Because electricity generated by PV panels are considered in the calculation of the theoretical energy performance of dwellings, it should also be taken into account in this analysis. Therefore, PVGIS is used to calculate the yearly electricity yield of the PV system. The 'grid connected' section of the tool is used. The solar radiation database used is the PVGIS-SARAH, because this database is also used for the other calculations. Furthermore, the location, PV technology, installed peak PV power (kWp), slope and azimuth are set for each dwelling. Like previous section, the system loss is presumed to be 14%, which is the default value of the tool. The output of the tool is the yearly PV yield per dwelling.

$$Electricity\ consumption_{grid} = Total\ energy\ consumption - Yearly\ yield\ PV \quad (4.4)$$

#### Theoretical energy consumption

As described above, the Energy label before and after renovation is known for all cases. To calculate the theoretical energy consumption of these dwellings, the relationship between the energy label and energy index is used (table 2.4). An energy label contains the energy index values between a certain range. Therefore, the theoretical energy consumption can differ, while the energy label is the same. To take this into account, the maximum, minimum and average change in theoretical energy consumption is calculated as follows (figure 4.5):

$$Maximum\ change = \frac{Minimum\ EI\ after\ renovation - Maximum\ EI\ before\ renovation}{Maximum\ EI\ before\ renovation} * 100\% \quad (4.5)$$

$$Minimum\ change = \frac{Maximum\ EI\ after\ renovation - Minimum\ EI\ before\ renovation}{Minimum\ EI\ before\ renovation} * 100\% \quad (4.6)$$

$$\text{Average change} = \frac{\text{Average EI after renovation} - \text{Average EI before renovation}}{\text{Average EI before renovation}} * 100\% \quad (4.7)$$

In addition, the energy index of three cases is known. The theoretical change in energy consumption is calculated as follows:

$$\text{Chang} = \frac{\text{EI after renovation} - \text{EI before renovation}}{\text{EI before renovation}} * 100\% \quad (4.8)$$

#### Primary energy consumption

As discussed above, the mean theoretical primary energy consumption per energy label is known. To compare the actual and theoretical energy consumption using the Energy label and the Energy Index, the actual total primary energy consumption is calculated. The EPA-method (Energy performance advice ISSO 82.3,2009) (Majcen & Itard, 2014) is used. The primary energy consumption is calculated as follows:

$$\text{Total primary energy [MJ]} = \text{Primary energy gas} + \text{primary energy electricity} \quad (4.9)$$

$$\text{Primary energy gas [MJ]} = \text{Gas consumption [m}^3\text{]} * 35.17 \quad (4.10)$$

$$\text{Primary energy electricity [MJ]} = \text{Electricity consumption [kWh]} * 3.6 \quad (4.11)$$

Where     35.17 = caloric value of gas  
               3.6 = value to convert kWh to MJ

The change in energy consumption (actual and theoretical) is calculated as follows:

$$\text{Chang in energy consumption} = \frac{\text{before renovation} - \text{after renovation}}{\text{after renovation}} * 100\% \quad (4.12)$$

Formula (4.12) shows the percentage difference in energy consumption and formula (4.13) shows the percentage difference of the actual change compared to the theoretical change.

After processing the energy consumption data, the values were analysed. Respondent with unrealistic values were deleted from the data set. These unrealistic values may be caused by mistakes made while taking over the meter readings or values of the annual energy bill. Initially, data from 36 households was collected. After data cleaning and processing, 29 respondents remained and are used in the analysis. In the data collection section (4.3.2), it is described which data collection options were possible. Table 4.2 shows an overview of the number of respondents per option per case. Before renovation, the majority of the data collected came from the annual energy bill. For the data after the renovation, most of the data was collected using two measurement points. Some households already received an annual energy bill after the renovation. Therefore, the end meter readings and the meter readings on the day of visit are used to calculate the energy consumption. In some dwellings, the smart meter was already installed, and the tenants used a management app or received a message of the

Table 4.2: Number of respondents per data collection option

	Before				After	
	Annual energy bill	Smart meter	Annual energy bill	Smart meter	Annual energy bill & measurement point	Measurement points
<b>Eckart</b>	5	1		2	1	3
<b>d'Ekker</b>	6		1		2	3
<b>Breeakker</b>	10		3	1	4	2
<b>Tivoli</b>	7			3	1	3
<b>Total</b>	28	1	4	6	8	11

energy supplier containing the energy consumption of a certain period. Finally, in d'Ekker and Breekker some tenants already received a new annual energy bill containing data only after the renovation. Therefore, the energy consumption of the annual energy bills is used. The different options of data collection, especially after renovation, results in different duration of measurement periods. Figure 4.6 shows an overview of the duration of the measurement periods per case. The duration of the measurement period before the renovation is longer compared to after renovation. In addition, the average measurement period of Breekker after renovation is longer compared to the other cases.

#### 4.4. Conclusion

For this comparative case study, four cases are selected. All cases differ in the various aspects of the renovation process and the results of the renovation. All cases are projects of the housing corporation Woonbedrijf. It is the largest housing corporation in Eindhoven, Helmond and surrounding municipalities. The selected cases are both renovation projects (more intensive) and maintenance projects (less intensive).

In addition to the case selection, the data collection and modification are discussed in this chapter. To gather general information about the projects and gain insight into the differences between the cases, documentation is collected. The results of the analysis of this documentation will be presented in chapter 5.1. In addition, as described in chapter 3, a questionnaire is used to collect data about tenants' expectations, experiences and satisfaction levels and their energy consumption. The data was collected in the months April and May 2019. In total, 120 respondents (30 per cases) completed to satisfaction section of the questionnaire, and 36 shared their energy consumption of before and after the renovation.

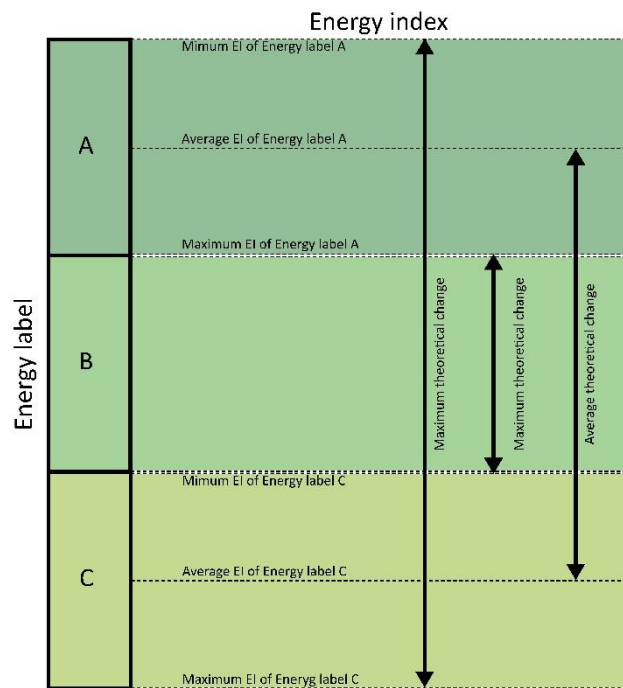
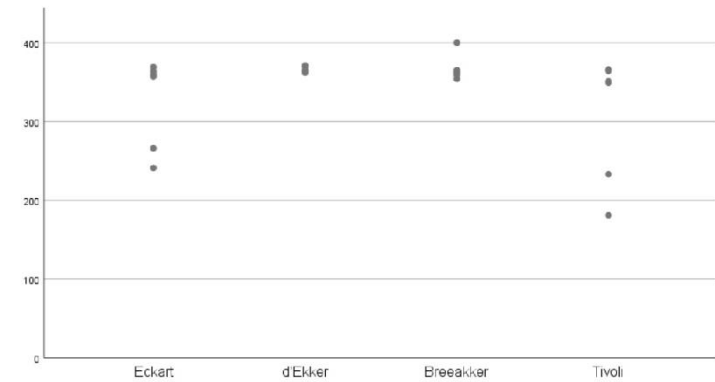


Figure 4.5: Relation energy label and energy index

#### Before renovation



#### After renovation

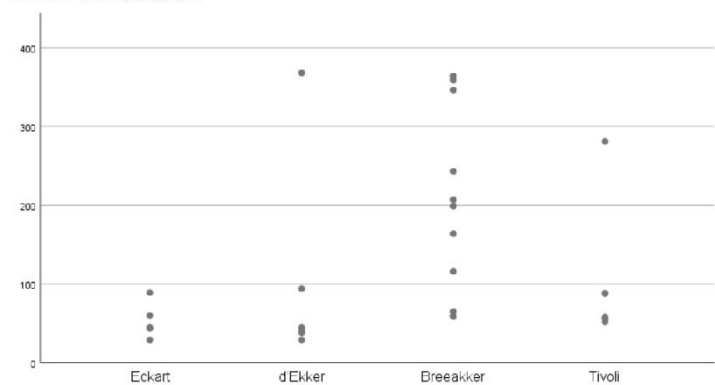


Figure 4.6: Measurement period (in days) of energy consumption data before and after the renovation

After the data is collected, it is cleaned and processed. For the satisfaction data, respondents with missing values and outliers were analysed and deleted if the data was invalid. As a result, the satisfaction dataset consists of 118 respondents. The frequencies of the sample concerning several personal characteristics were compared with the frequencies of the population in the neighbourhood according to CBS (2018). This analysis showed that there are some significant differences between the sample and the population in the neighbourhood. Older age categories are overrepresented in d'Ekker and Tivoli, women are overrepresented in Eckart and Singles are underrepresented in Eckart and Tivoli.

To compare the change in the actual energy consumption with the change in the theoretical energy consumption, the collected data is modified. The gas consumption before and after the renovation is adjusted to the number of degree days of a reference period. For the energy consumption for households with PV panels, the electricity produced by these panels during the measuring period needed to be calculated. This is done using the Photovoltaic Geographical Information System (PVGIS) web application. The total electricity consumption is the sum of the electricity used of the grid and the electricity generated by the PV panels, minus the electricity put back into the grid, adjusted to a reference period. For the dwellings with PV panels, the yearly electricity consumption of the grid is calculated too. The total primary energy consumption is calculated by summing up the primary gas and primary electricity consumption. For the theoretical change, the energy label and energy index of the dwelling before and after the renovation are known. The relationship between the energy label and energy index is used to calculate the minimum, maximum and average theoretical energy consumption change considering the energy label. The results of the analyses are presented in the next chapter.





## 5. Analysis and results

In this chapter, the data are analysed, and the results are presented. This chapter is divided into three sections. First, the four cases will be described and compared to gain insight into the main differences between the cases. Subsequently, the satisfaction dataset is analysed, and results are presented. This results in a path model that describes the relationships between various determinants and overall satisfaction. The cases are compared and the effect of participation on the satisfaction is analysed. In the third section, the energy consumption data is analysed, and the cases are compared. Finally, conclusions from the analyses are drawn.

### 5.1. Case description

#### 5.1.1. *Eckart, Eindhoven*

The Neighbourhood Eckart is an area in the northeast of Eindhoven. The houses within this area are built between 1967 and 1969 and have a low energy label (label D or E). Because there was a need for maintenance, need to improve the average energy label for housing corporations and the opportunity to fit within the Triangulum project, Woonbedrijf decided to perform renovation on the dwellings in Eckart. Woonbedrijf also felt the need to involve the residents more in the process and the “moment of the customer” should be important. Therefore, the tenants have an influence on the moment of renovation and the measures that will be implemented. Woonbedrijf gives the tenants the power to make their own decisions within the guidelines they defined. The principle that is used is called “series of one”, meaning that each dwelling will be renovated separately. Therefore, the tenants have more freedom to fit the renovation to their own wishes. The increase of power over the project resulted also in a higher responsibility for the tenants.

In this project, the 3D-ICT tool WoonConnect is used to create this interactive renovation process (Triangulum, n.d.). WoonConnect is developed by the company De Twee Snoeken, an architectural firm and software developer, with the goal to make the built-up living environment more sustainable and energy-efficient using this tool (WoonConnect, n.d.). It is an online platform with an 3D representation of the built environment containing all sorts of information. Therefore, it can be used throughout the process to for example gain insight, make decisions and involve tenants.

In the project of Eckart, WoonConnect was used as a communication tool between the parties involved. The tenants placed their choices in WoonConnect, and WoonConnect communicated this to Woonbedrijf and the contractor. In addition to using WoonConnect as a communication tool, it was, more importantly, used to help tenants get insight in the renovation and help them understand the impact of their behaviour on the results of the renovation. The conditions of the dwelling and basic settings about the household results in the starting situation. Tenants could select measures and the software would give information about the costs of the investment, influence on the environment and the change in the energy bill. The changes are also visible in the 3D representation of the dwelling. The tenants could compare different sets of measures and choose the most suitable. To create more awareness about the impact on the behaviour, tenants could change the settings of e.g. shower time and heating. The software would again give information about the influence on the environment and the change in the energy bill.

##### 5.1.1.1. Process

The project started at the end of 2013 with the initiative- and performance phase. Subsequently, the definition and design phase took place. During the design phase, the project manager and purchasing managers selected the contractors for the project. Uesaraie (2018) concluded from an interview with the project manager from Woonbedrijf that both contractors selected for the project were involved in the maintenance of the area before the project. Therefore, the contractors had insight into the current

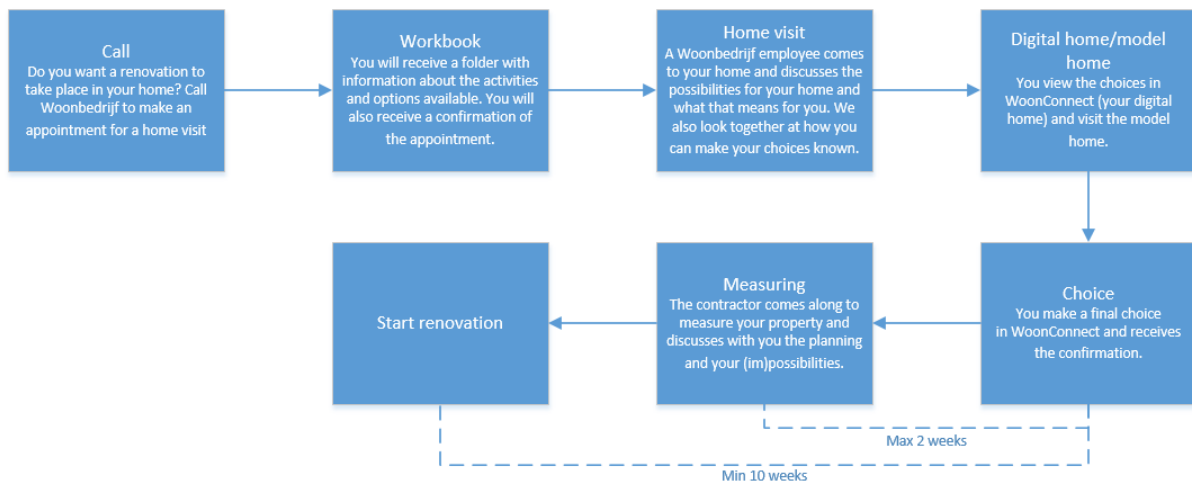


Figure 5.1: Customer journey Eckart (source: Woonbedrijf)

situation. In addition, tenants' opinions on renovation measures were tested during the design phase. A questionnaire was conducted to gain insight into the current living conditions, thoughts about improvement, energy awareness and tenant's opinions of the neighbourhood. In addition, employees of Woonbedrijf conducted interviews to gain some qualitative insights. The questionnaire was not decisive but confirmed the plans of Woonbedrijf. The renovation requirements of Woonbedrijf, the insight and experience of the contractors and, to a lesser extent, the questionnaire with the tenants resulted in the design and the process of the renovation.

Before starting the renovation of all dwellings in the neighbourhood, seven demonstration houses were renovated to test the technical solutions (new technical measures and the use of WoonConnect) and to determine risks during construction. Uesaraie (2018) concluded that the demonstration houses were important for the contractor to make adjustments to the measures and execution. The use of WoonConnect was also tested and the software was adjusted. In addition, it was important for Woonbedrijf to analyse the process to determine points of improvement in the process and test the feasibility.

From April till September 2018, all tenants received the invitation letter containing information about some measures and explaining that the tenants themselves could decide to renovate, how they will make choices and which follow-up steps they had to take (figure 5.1). From this point, the power to (re)start the renovation process lay with the tenants. When tenants decided to start the renovation, they called Woonbedrijf to make an appointment for a home visit. Prior to the home visit, Woonbedrijf sends an information booklet to the tenants with information about the basic package and additional measures and the follow-up steps that will be taken. During the home visit, an employee of Woonbedrijf discussed the measures and questions and wishes of the tenant using WoonConnect. This results in a concept offer in WoonConnect. From this moment, there are two routes that can be followed. One where the tenants themselves had control over the process and one where the tenants were supervised. Depending on the situation of the tenants, Woonbedrijf decided which route was taken.

The situation where the tenant had control over the process is discussed first. Through WoonConnect, by contacting Woonbedrijf for questions and a model house, the tenants had the opportunity to further study the options for the choices they had to make. When the tenants made their decision about their choices, they placed them in WoonConnect. In addition, they had to select a date for the visit of the contractor. Woonbedrijf subsequently checked the choice and checked whether the tenant

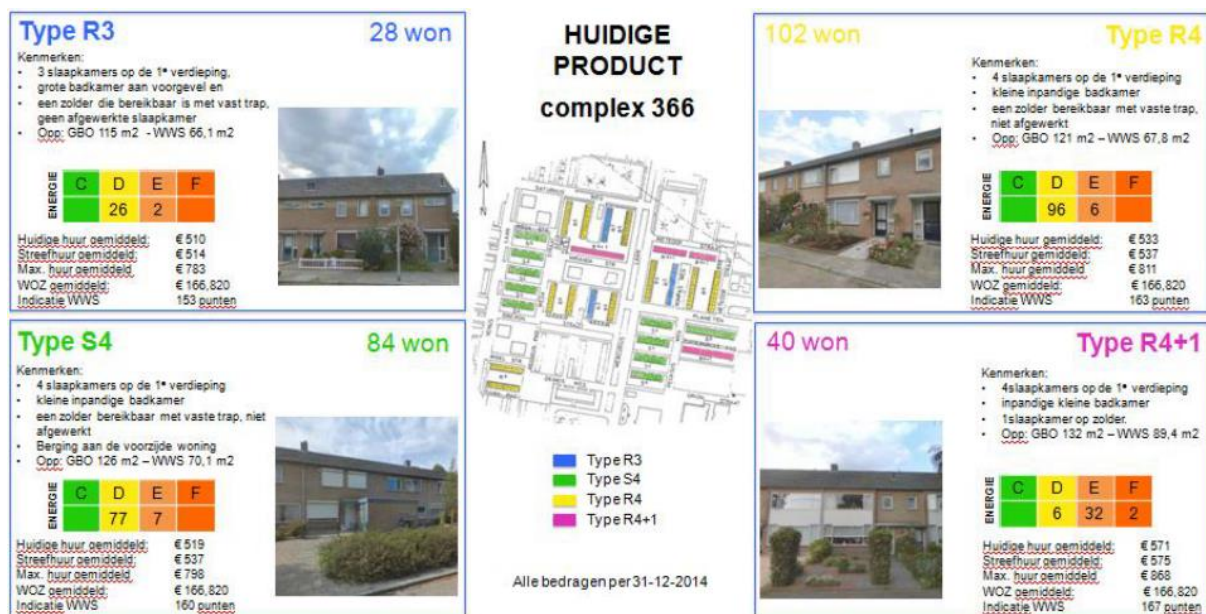


Figure 5.2: Types of dwellings and their location (adapted from Uesaraie, 2018)

had a rent arrears. In case of a rent arrears, Woonbedrijf would contact the tenant and give options; pay rent and continue the process, put in on hold or continue with only basic package. In case there was no rent arrears, the choice of the tenant was directly approved. The tenant received the confirmation of the offer and the contractor received the offer and the planned appointment with the tenant. When the contractor approved the offer, Woonbedrijf made the offer final and the tenant would receive the final offer in WoonConnect. From this moment, the power over the project was moved again to the tenants. They had to determine the weekly planning for the renovation. Within two weeks of making the choices, the contractor would visit the tenants to do a measurement of the dwelling. From this moment, it was no longer possible to make changes to the offer by the tenant. After the appointment, the detailed planning would be finalised by the contractor and send to the tenants. Finally, two weeks before the start of the renovation, the tenant received information from the contractor with contact information, last instructions and the day planning. Two days before the renovation, the contractor called the tenant to check whether everything was prepared for the renovation.

In the guided route, after the home visit, the tenant would receive the concept offer. The tenants also have the opportunity to ask questions by phone and visit the showroom and/or model home, but they couldn't use WoonConnect to further study the measures. In case the tenants wanted to make any changes to the first offer, this was done together with an employee of Woonbedrijf. Thereafter, the tenant signed the offer. Equal to the other route, Woonbedrijf checked whether the tenant had a rent arrears and gave the tenants the choice about the continuation of the process. When the concept offer is signed and there are no rent arrears, the tenants receive the final offer. The tenant has, in this case, not the opportunity to determine the planning. They would receive the planning made by the contractor and could discuss this through telephone contact. The contractor also makes the appointment to measure the dwelling. From this moment on, the route is equal to the other route. The tenant receives the detailed planning, contact information, last instructions and the day planning and is called by the contractor.

#### 5.1.1.2. Measures

In this project, tenants had the opportunity to select the measures for the renovation. They could choose the basic package, these are measures that are carried out together to improve the dwelling,

Table 5.1: Measures Eckart

		Energy saving measures	Types	Other	Types
Basic package	Roof	New insulated roof	All	New chimney for better ventilation	All
		PV panels and inverter* (choice)	All	New skylight/dormer windows	All
				Larger or additional skylight*	All
	Façade	HR++ glass	All	Painting old wood window frames	All
		Supplement insulation***	All	Replace valve windows	All
				Install a living room window that can be opened	All
				Replace front (& back***) door	All
				Replace rain pipe	All
		Installing air ventilation***	All	Repair masonry and clean joints	All
				Install a not to open living room window (choice)	All
				Model and colour of the door (choice)	All
				Install air vents	All
	Ground and first floor	Install CO <sub>2</sub> sensors connected to ventilation system	All	Install switch and extraction point mechanical ventilation kitchen, toilet and bathroom	All
				Shorten doors for ventilation	All
				Mechanical ventilation	All
	Attic			Throughput of central heating boiler through roof	All
				Hinges and locks	All
	Safety	Check and repair/change installations for electricity, gas and water	All		
Additional		Insulation above windows	All	Replace kitchen, bathroom or toilet**, ***	All
		Insulated wall in the storage room*	S4	Separate attic room*	R3 R4
				Move bathroom*	R4 R4-1 & S4

\* rent or service costs increase, \*\*rent increase possible \*\*\*if necessary

and/or choose some or all the additional measures. It was therefore possible to only carry out some additional measures and not the more extensive basic measures. Within the neighbourhood of Eckart, there are four types of dwellings (figure 5.2). An overview of the measures is given in table 5.1. Based on the types of dwelling, some specific additional measures can be taken.

The information booklet that was sent at the beginning of the process contains the renovation measures (basic and additional). In addition, it informed the tenants about the measures that contained an increase of rent or service costs. As seen in the literature review, there is a maximum

rental price of social housing. Therefore, Woonbedrijf informed the tenants the maximum rent increase possible for their dwelling. The rent increase of all chosen measures must be within this limit. The additional costs due to the installation of solar panels are paid through service costs and are therefore always possible. In addition to the information about the measures, the information booklet also contained information about the consequences of the different measures during and after renovation. This was done textually and by using symbols (figure 5.3). The description informed about the duration of the work, possible inconvenience, temporarily unavailability of rooms and whether the tenant had to clean or finish afterwards.



Figure 5.3: Explanation symbols (source: Woonbedrijf)

### 5.1.2. D'Ekker, Veldhoven

Veldhoven is a city southwest of Eindhoven and is part of the metropolitan region of Eindhoven. The Neighbourhood d'Ekker in the southeast of Veldhoven. The dwellings needed to be maintained and adapted to the current standards in energy efficiency and comfort. Therefore, it was decided in September 2012 to start with the preparation. The neighbourhood consists of 493 dwellings. Therefore, the project is divided into three phases (figure 5.4).

#### 5.1.2.1. Process

In October 2013, the tenants were invited to join a sounding board. The purpose of the sounding board was to discuss wishes, complaints and experiences from the tenants before and during the renovation. The housing corporation considered these matters and, when possible, responded. After this process, tenants were invited in September 2014 to join the sounding board to determine together how the renovation plan could be executed.



Figure 5.4: Renovation phases of d'Ekker (source: Woonbedrijf)

In December 2014, the tenants received the first newsletter. This contained a general planning, maintenance measures inside and outside the dwelling and the existence of two test dwellings that were transformed into model homes afterwards. Tenants had the opportunity to visit the two model homes in March and April 2015. Prior to the visit, tenants received an information booklet. This contained information about the general planning, the steps of the process that were of interest to the tenant (figure 5.5), and the mandatory and additional measures were explained. During the visit, tenants were informed about the plans, possible inconveniences during renovation and had the opportunity to ask questions. In the newsletter of July 2015, the most frequently asked questions including the answers were shared. During the renovation, the tenants were able to visit the model home.

At the end of 2015, tenants were informed about the planning of the first phase. Before the start of the renovation of each phase, tenants of this phase were asked to join the sounding board, meeting every 1.5/2 months. The members of the board were introduced in one of the newsletters. In March of 2016, the renovation of the first phase started. The tenants of the second phase were informed about the planning in October 2016 and the renovation started in January 2017. Finally, tenants of the



third phase were informed about the planning in September 2017 and the renovation started in January 2018.

Prior, tenants also received an execution booklet containing information about the measures, choice options and about the execution of the renovation. Two months before the renovation, a kick-off meeting was organised to once more discuss all the measures and work. Furthermore, the contractor visited the tenants to measure the dwelling, discuss the planning and to make the choices final. Agreements were made about the preparation the contractor would do and what the tenant had to do themselves (e.g. cover furniture with foil). During the renovation, the tenants had the opportunity to visit a rest house (the model home). The purpose of this house was to get away from the renovation, to do the laundry and make use of sanitary facilities. Furthermore, Woonbedrijf provided a shower trailer, chemical toilet and an emergency kitchen. At the renovation of the first dwellings, it became clear that the renovation resulted in dust nuisance. Therefore, Woonbedrijf gave some suggestions to reduce the nuisances and offered two free work hours to the tenants that could be used for some chores (e.g. hang a lamp or pain window frames). Finally, Woonbedrijf also has a guest house for residents who (for medical reasons) cannot stay home during the indoor work.

After the renovation, tenants received a user manual containing information about the measures, how they work and how to use or clean them. The experiences and satisfaction of the tenants with the renovation were examined by an external party. Tenants were called during renovation, after completion outside and after completion inside. Information gathered was used to improve the still remaining part of the process.

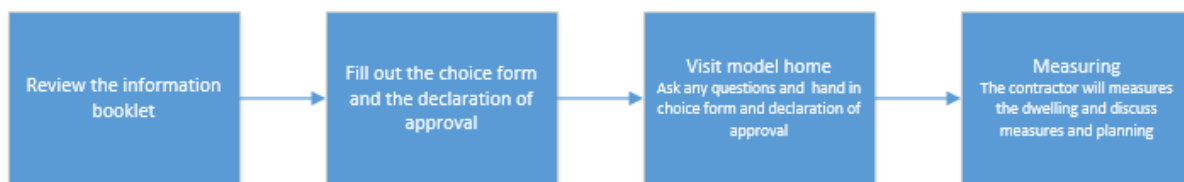


Figure 5.5: Process for tenants of d'Ekker

To involve tenants in the renovation project, Woonbedrijf had launched a competition called 'Duurzaam d'Ekker' (in English 'sustainable d'Ekker'). Woonbedrijf asked the tenant 'who would be the most creative re-user of d'Ekker'. Tenants had to come up with ideas to re-use leftover materials of the renovation. The winners of the competition were announced in the newsletter of April 2016. The winning idea was to use the leftover materials to create art. During the development of the art piece, a different material was chosen because of practical reasons.

#### 5.1.2.2. Measures

There are three types of measures; mandatory measures, additional measures without rent increase and additional measures with rent increase (table 5.2). The mandatory measures are maintenance work, asbestos removal and insulation measures. Tenants with a kitchen, toilet and/or bathroom from 1991 or older could renew these without any rent increase. Any additional measures to these rooms result in a rent increase. As discussed above, a sounding board was created to discuss the content of the renovation. The sounding board did not have any influence on the selection of the measures. However, they could make suggestions about the execution of the measures and Woonbedrijf adopted these suggestions whenever possible.

Tenants of dwellings in the first and second phase had a second chance to apply for additional measures. Woonbedrijf contacted them in April 2018 because for a large proportion of these tenants

Table 5.2: Measures d'Ekker

		Energy saving measures	Types	Other	Types
Mandatory	Outside	applying or supplementing cavity insulation ***	All	Cleaning and repairing masonry and replace joint work	All
		Apply ventilation grille and HR ++ glass to bedrooms without a ventilation grille	All	Paint wooden, metal and concrete parts and concrete panels	All
		Place double glazing in roof window	All	Replace rain pipe and gutters***	All
		installing double glazed toilet and front door frame	A, B	Replacement of house number plate	All
		installing roof insulation***	B	Clean and repair aluminium frames and windowsills	All
				Replace front door and install draft profiles at the front door	All
				Repair the chimney	All
				Repair brick property boundaries	All
				Replace asbestos sewage	All
				Replace roof tiles	B
	Inside	isolate the parapets under the windows	A	remove of asbestos channels in bathroom, toilet, attic and kitchen and asbestos in ceiling bathroom	All
				applying demand-controlled mechanical ventilation and install suspended ceiling in toilet	All
				Apply exhaust duct hood	All
				Apply cove in kitchen for exhaust duct hood and mechanical ventilation	All
				Shorten interior doors***	All
				Replace older combi-boilers with HR combi boiler	All
				replace groups cabinet	All
				install and/or replace smoke detectors	All
Options	Outside			front door (colour and model)	All
	Inside	isolate the wooden floor*	All	change kitchen, toilet and/or bathroom**	All
				Free-hanging toilet instead of standard*	All
				Fixed stairs to the attic	A, B
				Install washing machine and/or condenser dryer connection in the attic*	A, B

\* rent or service costs increase, \*\*rent increase possible \*\*\*if necessary

the renovation was a long time ago and choices may have changed. They had the opportunity to change the kitchen, toilet and/or bathroom (from 1991 or older), insulation of the living room floor, insulation of the bedroom and living room windows, central heating system if possible and/or place a HE-boiler. Also, mandatory measures that were not yet executed could still be executed.

### 5.1.3. Breeakker, Son

Breeakker is a neighbourhood build in 1960 for the working class of Philips. It is located north of the centre of the village Son, north of Eindhoven. Together with the village Breugel, they form the municipality of Son and Breugel. The municipality is also part of the metropolitan region of Eindhoven. Breeakker is a spacious and green neighbourhood. In total, 142 dwellings needed to be renovated. The neighbourhood consists of semidetached and terrace houses.

#### 5.1.3.1. Process

At the end of 2016, it became clear that urgent maintenance work was needed. Therefore, Woonbedrijf started with the preparation of the renovation. In May 2017, the tenants received the first newsletter called 'woonbericht', by post. In this newsletter, Woonbedrijf communicated to the tenants that they were preparing the maintenance of the dwellings. It was also told what the plans were in general terms. Furthermore, Woonbedrijf wanted to involve tenants during the preparation phase to help by communicating information from the neighbourhood and to provide additional input to the project. Therefore, tenants were asked in the first newsletter to sign up of a sounding board. As concluded in the literature review, there is a need for a good differentiation in for example age and background. Therefore, the resident supervisor (in Dutch, bewonersbegeleider) analysed the tenants that signed up. In addition, he went into the neighbourhood to ask tenants personally to participate in the sounding board. Eventually, the sounding board consisted of eight tenants. The sounding board came together once a month. Representatives of Woonbedrijf informed the tenants about matters related to e.g. progress and planning. Furthermore, the tenants had the opportunity to discuss issues from the neighbourhood.

Because the sounding board is the representation of the tenants in the neighbourhood, the members were introduced in the second newsletter distributed in October 2017. In this newsletter, Woonbedrijf also informed the tenants about other aspects of the project that were important at that moment. The contractor of the project was selected. Tenants were informed who the contractor was, and that the contractor would contact them about the first inventories of their dwelling. Furthermore, they were informed about the start of the renovation of the test dwellings, the possibility to visit the model home and the distribution of an information booklet in the upcoming month. The information booklet contained information about the measures, choices tenants could make, the impact of the work, the outline of the planning, content of the visit of the contractor and the ways of information distribution and the contacts of Woonbedrijf and the contractor.

In preparation for the renovation, two dwellings were renovated in November 2017. One of the dwellings was occupied during renovation. Therefore, the impact of the renovation on the tenants was also tested. The tenants of these dwellings, sounding board, contractor and Woonbedrijf evaluated together the process and outcome of this test renovation to conclude with points for attention and



Figure 5.6: Overview of block division and planning (source: Woonbedrijf)



Table 5.3: Measures Breeakker

		Energy saving measures	Other
Mandatory	Roof	Insulating roof plate on existing roof boarding	Replace battens and roof tiles
		Replace dormer of Woonbedrijf for an isolated dormer	Make the chimney water repellent, restore joints and replace lead
			Replace roof gutter
			Apply permanent nesting for birds under 1 <sup>st</sup> / 2 <sup>nd</sup> roof tile
			Replacing wooden planks of roof overhang
			Replace roof windows
	Front and back façade	Replacing single glazing by insulating glass	Check ventilation grids crawl space
		Insulate concrete façade parts above bedroom and shower frames	Replace rain pipe
			Draft-free front doors
		Check insulation behind façade cladding and replace	Paint façade cladding
			Paint front door incl. frame and awning
		Check cavity insulation and replenish***	Clean all aluminium window frames and panels
			Replace lamp
	Side façade	Insulate behind façade cladding	Local repair joint work
		Check cavity insulation and replenish***	Paint façade cladding
	Storage		Local repair joint work
			Painting concrete facade
	Inside	Replace cover of measuring pit by an insulated lid	Painting storage door incl. frame
			Applying mechanical ventilation in the attic for the shower room and new ventilation duct bathroom/roof
			Replace visible asbestos materials in the attic
			Shorten doors 1 <sup>st</sup> floor for mechanical ventilation***
			Replace boiler***
			Replace the meter cupboard***
			Checking hinges and locks
Options			Checking natural air vents
			Colour front doors
			Layout glazing in front door frame
			Replace own central heating boiler for boiler of Woonbedrijf*
			Larger skylight*
			Replace dormer of Woonbedrijf by insulated dormer

\* rent or service costs increase, \*\*rent increase possible, \*\*\*if necessary

improvement for further renovation. The unoccupied dwelling was transformed into a model home. In late November and early December there were three opportunities of the tenants to visit. This was done in small groups to provide enough attention to each tenant.

Before the start of the renovation, the contractor documented all important details of the dwelling and the specific choices of the tenants made for the measures. During the first inventories it appeared that, in some cases, options were not possible. This was discussed with the tenants. In addition, the planning for the specific dwelling was discussed with the tenants. During the renovation, the contractor informed the tenants about the progress and any deviations from the planning and this was monitored by Woonbedrijf.

In February 2018, the contractor started with the renovation of the first dwellings. The renovation was divided into two building flows, starting with the blue building flow (figure 5.6). Subsequently, the red building flow. During the renovation, tenants had the opportunity to visit a rest home (the model house). Approximately two months before the renovation, the dwelling was furnished by a member of the sounding board. The goal of the rest home was to give the opportunity to escape any discomfort (e.g. noise) and the opportunity to meet each other at this location and discuss issues over a cup of tea or coffee. The rest dwelling was also used as a location for the consultation hour of the residents' supervisor of Woonbedrijf and the foreman of the contractor.

During and several weeks after the renovation, the tenants received a service call. This was done by an external company and was meant to measure the satisfaction of the tenants. The results of these calls were shared with the project team of Woonbedrijf and the contractor. Any points for attention and improvement were discussed and follow-up actions were addressed.

#### 5.1.3.2. Measures

During the renovation of the dwellings, mainly only urgent maintenance work was carried out (table 5.4). In addition, work has mainly been done on the outside of the dwelling. The main reason for this is the large impact of work inside and outside and the average high age of the residents. The mandatory and additional measures were explained in an information booklet. For the choices, choice forms were included that had to be filled in by the tenants. During the home measuring visit, the definitive choice of the tenants was discussed with them. The sounding board had contributed to the options provided to the tenants. The tenants in the sounding board have given advice about for example which options were presented to the other tenants.

#### 5.1.4. *Tivoli, Eindhoven*

Tivoli is an area in the southeast of Eindhoven. The dwellings were built from 1929 because Philips needed affordable housing for the working class. In the spring of 2018, Woonbedrijf started with a major maintenance of 110 of the dwellings in the southern part of the area. This project, called 'Tivoli Rood', is the fourth phase of a larger project within the neighbourhood. These dwellings were built in 1948. The aim is to carry out maintenance in order to increase the lifespan of the dwellings by thirty years. It will increase the level of comfort and decrease the energy consumption of the households.

##### 5.1.4.1. Process

In 2011, Woonbedrijf started with the preparation of the main Tivoli project. They invited tenants of Tivoli to attend an information meeting about the future of the neighbourhood. The purpose of this meeting was to clarify the ideas about the neighbourhood. Subsequently, plans were made for each subarea together with tenants. The preparation of 'Tivoli Rood' started in 2016. Due to circumstances, this was later than planned and communicated to the tenants in 2011. To inform the tenants of the progress, newsletters (called 'Woonbericht Tivoli Rood') were shared with them. The first newsletter was shared in February 2017, informing tenants about the start of the maintenance, the measures, costs and some other aspects.

Figure 5.7: Overview of the main Tivoli project

In February 2018, preparations for the maintenance project were almost finished and therefore information about the planning was shared with the tenants through a newsletter. Prior to the start, several steps were taken (figure 5.8). First, the contractor visited the dwellings for measurement and placed measures preventing nesting in the roof. Subsequently, the tenants received an information booklet. Through the information booklet, tenants were informed about the distribution of information, planning, mandatory and additional measures, tips and agreements during renovation, roadmap for damage or disagreement cases. Next, Woonbedrijf and the contractor visited for an advice conversation to discuss these measures and to visit the model house to see the measures in real life. Minimal 6 weeks before the start of the renovation, a final conversation took place in which the choices became definitive.

The renovation of the dwellings is divided into three phases which took place from April 2018 till February 2019. For all dwellings, the renovation started with the exterior of the dwelling. Shortly

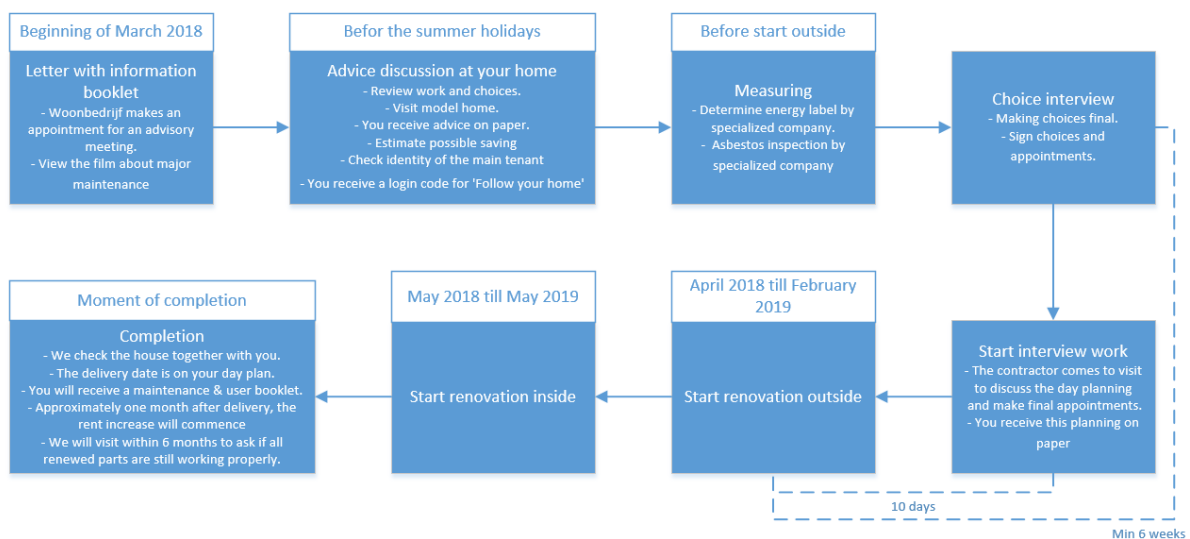


Figure 5.8: Customer journey Tivoli (source: Woonbedrijf)

afterwards the interior side was renovated, depending on the tenants' choices. The renovation of the interior depends on the choices of the tenants. During the renovation, the tenants were kept up to date via, as during the preparation through the newsletter and sometimes through a separate letter. In addition, every Monday and Wednesday a walk-in hour was held in the model home with the contacts of Woonbedrijf and the contractor. Tenants were able to follow the renovation of their dwelling through the website 'volgjewoning', which contains information about the planning. During and after renovation, the tenants were called by an external party about their satisfaction with the renovation.

At completion, employees of Woonbedrijf and the contractor would visit the tenants to check the house and the new measures. In addition, they would receive a maintenance and user booklet containing information about the maintenance and use of the new equipment. Six months after completion, Woonbedrijf would visit again to check everything.

#### 5.1.4.2. Measures

In the main information booklet and additional information booklets, tenants could read which measures were taken and which additional options they could choose from. Table 5.4 gives an

Table 5.4: Measures Tivoli

		Energy saving measures	Other
Mandatory	Roof	Insulate roof	New larger attic window
			Replace chimney
			New roof tiles
			New drain
	Front and back facades	New plastic frames with HR ++ glass	Painting the front door and making it draft-free
			Clean and repair stones/joints
	Extension kitchen	Insulate roof	Replace roof coverings
			New eaves
			Apply steel strip for roof reinforcement
			New back door and wooden window frames
			Repeating and cleaning stones / joints
			New draining
	Ventilation		Extraction valve for kitchen, shower and toilet
	Boilers	Replace central heating boiler through high-efficiency boiler	
	Meter cupboard		Check the group cabinet
			Replace old fuse box
			Check electricity
Additional		Ventilation heat pump*	Renew shower, kitchen and or toilet**,***
		Floor insulation*	Attic with fixed staircase*
		Reinsulate cavity wall*	Terrace cover*
			Washing machine connection*
			Sound-proof wall*
			Extra socket*

\* rent or service costs increase, \*\*rent increase possible \*\*\*if necessary

overview of the measures. Furthermore, the booklets contained information about the outcome of the measures, activities that the tenants had to do in advance of the renovation and possible discomforts during renovation using the symbols (figure 5.3). To further explain this, a short information movie was made. In addition to the measures, the tenants received four job vouchers (in Dutch *klusbonnen*). These job tickets could be used for chores inside and outside the home, such as cover and move furniture, remove self-fitted facility and remove plants. During the conversation about the definitive choices, the tenant had to decide on how many job tickets they hand in and for what purpose.

#### *5.1.5 Comparison of cases*

In previous sections, the four cases are described. Comparing them, several similarities and differences can be distinguished. For all four cases, the need for maintenance was the main reason for the start of the project. The projects of Eckart and d'Ekker are renovation projects and Tivoli and Breeakker are major maintenance projects. As described in the literature review, in case of a renovation project, a 70% approval threshold for a housing complex or otherwise a 100% approval threshold applies. In the case of d'Ekker, tenants had to fill in an agreement statement. This statement was included in the information booklet and tenants were asked to fill it in and to hand it in during the model home visit. In case of the renovation of Eckart, tenants had to decide themselves whether they wanted to start with the renovation. Renovating using the concept of 'series of one' results automatically in a 100% approval rate when the tenants decide to renovate. Because Tivoli and Breeakker are major maintenance projects, tenants didn't have the opportunity to approve.

##### *5.1.5.1. Process*

Literature review showed different ways and levels of participation. A higher level of participation means that the participating party is more involved and has more power in decision-making. Considering participation in the different cases, in particular the Eckart case stands out. Woonbedrijf felt the need to involve tenants in the process and 'the moment of the customer' and 'own responsibility' were important aspects. First, the tenants had the power to start the renovation. They were invited to renovate but the decision was up to them. When they decided to start the process, the tenants made a choice to have the basic package carried out (or not) and/or to carry out (some) additional measures. Tenants did not have the full power over the measures because they had to choose out of a set designed by Woonbedrijf. In addition, tenants had the power to decide when the renovation was carried out (if the date was still available). From the literature review, seven levels of participation were concluded (table 2.5). The approach used in the Eckart case can be described as coproduction. The housing corporation placed boundaries (decision to start, choice in measures and renovation period) and the tenants had the opportunity themselves to make decisions within these boundaries.

Compared to the other cases, Eckart had the highest level of participation. However, the other cases also had some form of participation. Both the d'Ekker and Breeakker projects had sounding boards. The d'Ekker project was divided into three phases. For each phase, a sounding board was created. Tenants within the sounding board were asked to indicate their wishes, complaints and experience before and during the renovation. The housing corporation considered these matters and, if possible, respond to it. Participants of the sounding board had an advisory role in the process. The decision to make any changes in the process still lies with the housing corporation. Tenants that didn't participate, were only informed about the progress of the process and other important issues. In Breeakker, the main goal of the sounding board was to inform tenants and to gain insight into their opinions. For the tenants within the sounding board, the participation form can mainly be considered to be the 'advice' form. The role of the tenants is to advise and Woonbedrijf determines the decisions but is open to

ideas and solutions. The other tenants were informed through the newsletters, the model home, the information booklet and through the sounding board participants. For those tenants, the form of participation was 'inform', the tenants receive information but do not provide input.

The use of a sounding board gives some level of power to some of the tenants. Literature review shows that aspects such as skills, confidence, time and benefits are important for tenants to decide to participate. As a result, the sounding board may result in a lack of representativeness of certain groups because they do not have e.g. the confidence or time to participate. In Breeakker, the resident supervisor paid attention to this. However, it may still be the case that the tenants of the sounding board do not represent the neighbourhood. This was the main reason not to put together a sounding board in the Tivoli case. In this project, Woonbedrijf tried to get feedback from all tenants. For example, during the visit of the test house, several comments about the colour of the window- and door frames were made. As a result, Woonbedrijf decided to give the tenants the opportunity to vote for a colour from a set of options. In addition, compared to the d'Ekker and Breeakker cases, more one-on-one appointments with tenants were made. The form of participation can therefore be considered to be the 'consult' form. Woonbedrijf gives the tenants the opportunity to comment on the decision-making but decides whether to give consequences to these comments.

The way of information sharing does not differ much between the cases, except for Eckart. In the other three cases, tenants were mainly informed about the process through the newsletters. In addition, additional information was provided about the measures, choice options, activities that the tenants had to do in advance of the renovation and possible discomforts during renovation. Breeakker and d'Ekker communicated the consequences for the tenants textually for the whole, where Eckart and Tivoli used bullet points and symbols per set of measures. In the projects of d'Ekker and Tivoli a renovation movie was made to further explain this. Information about the measures and choice options was also demonstrated in the model houses. In all four cases, test houses were used to test the renovation process. One or more of these test houses were used as model houses.

The difference between the cases in communication and information sharing is the number of personal meetings. In Tivoli, the number of personal meetings is higher compared to the other three cases. In this project, tenants were more supervised in the decision-making of the additional measures. During the advice meeting, the measures were discussed, and the model home was visited. Subsequently, a choice interview was held to make the choice final and the contractor would visit to discuss the planning. Afterwards, Woonbedrijf and the contractor would visit to check the new measures. In the other cases, the contractor would visit once to measure the dwelling and finalise the chosen measures. However, Woonbedrijf visited the tenants in Eckart once to discuss the options and to explain WoonConnect and in d'Ekker a kick-off meeting was held before the start of each phase. In case of questions, tenants could contact Woonbedrijf and the contractor by calling and/or during consultation hours.

#### 5.1.5.2. Measures

All four cases provided the opportunity to choose (additional) measures. In Eckart tenants could choose to carry out the basic package (or not) and/or (some) additional measures. In the other cases, tenants could choose between additional measures in addition to the mandatory measures. In all four cases, tenants had the opportunity to select measures out of a set compiled by Woonbedrijf. Therefore, the participation form for the measures is coproduction with a delegating management style. Tenants were co-decision maker within the boundary conditions of Woonbedrijf.

In all cases, the renovation/maintenance could result in a rent increase, but only within the choice possibilities of tenants. The amount of rent increase was shared through WoonConnect (Eckart),

information booklets and execution booklets (d'Ekker). In case of any additional choices, tenants had to officially decide upon the choices. In case of Eckart, this was done through WoonConnect if tenants filled in their choices independently or by signing the offer of the housing corporation (guided route). In d'Ekker and Breeakker during the home measuring of the contractor and in case of Tivoli during a separate choice interview.

In the projects of Eckart and Tivoli, Woonbedrijf tried to communicate the impact of the measures on energy consumption. Tenants in Eckart that independently filled in WoonConnect were able to analyse the effect of the measures and could change some behaviour settings to analyse the impact on their energy consumption. In Tivoli, possible savings were calculated using the annual energy bill if tenants were interested in it. In all four cases, tenants were informed that the renovation/maintenance resulted in a higher living comfort and lower energy bills.

## 5.2. Satisfaction

In this section, the data about the expectation, experience and satisfaction of tenants is used. With this data, a path model is identified which shows the relationships between each determinant and the overall satisfaction. Subsequently, the cases will be compared using the path model but also the outcome of various ANOVA analyses, which analyse whether there are differences between the four cases, boxplots and the comments made by the tenants during the interviews (appendix 4).

### 5.2.1. Path analyses

#### 5.2.1.1. Model identification

In chapter 2, a conceptual model is created using literature about renovations and theories about satisfaction. According to this model, the gap between expectation and actual experienced determines satisfaction. The conceptual model is used as a guideline for the identification of the path model. Within the questionnaire, tenants were asked to give values to their expectations and actual experience. The gap is calculated as the actual value minus the expected value. A gap of zero means that there is no gap between expectation and actual experienced, a positive value means that tenants experienced more than expected and vice versa.

To identify and analyse the path model, the software RStudio with the Lavaan package is used. To start the model identification, a full model was used. This means that all gap variables determine all satisfaction variables of each topic. The satisfaction variables of each topic have a relation with the satisfaction variables of the process and the result and finally, these variables determine the overall satisfaction. The Lavaan package adds the error terms for endogenous variables by default. Finally, it is assumed that all exogenous variables are correlated. According to the fit statistics, there is not a good fit between this full model and the data. Furthermore, the model consists of a lot of nonsignificant paths and correlations. In the second step of the model identification, the nonsignificant paths and correlations were deleted from the model. As a result, the fit of the model improved, but did not reach the desired result. Therefore, the correlation matrices (theoretical and observed) were used to determine possible paths in the model. Paths were changed, added and/or deleted to analyse the fit of the various possible models. Finally, the path identification resulted in the model of figure 5.9 and table 5.6. Table 5.5 shows an overview of the estimates (Hooper et al., 2008) of various goodness of fit indices. The table shows that most fit indices are within the limits of a well-fitted model. Only the estimate of the standardised root mean square residual (SRMR) falls outside the limit. The SRMR is “an index of the average of standardised residuals between the observed and the hypothesised covariance matrices” (Cangur & Ercan, 2015, p. 156). The fit index is known to be lower in case of a higher sample size (Hooper et al., 2008). The sample size (N=118), used in this model is considered within literature to be a small sample size (Wang & Wang, 2012). Therefore, the higher estimate of the SRMR may be

Table 5.5: Goodness of fit indices of the model

Fit index	Estimate	Limit well-fitting model (Hooper et al., 2008)
Chi-square ( $\chi^2$ )	190.499	
Degrees of freedom (df)	178	
Relative/normed chi-square ( $\chi^2/df$ )	1.070	<2.0
Root Mean Square Error or Approximation (RMSEA)	0.024	<0.07
Standardised Root Mean Square Residual (SRMR)	0.093	<0.08
Comparative Fit Index (CFI)	0.989	$\geq 0.95$
Tucker-Lewis Index (TLI)	0.986	$\geq 0.95$

caused by the sample size. Literature also indicates that the fit indices are useful guidelines, but adhering strictly to the recommended limit values may lead to a rejection of an acceptable model (Hooper et al., 2008). Therefore, the identified model is considered to be useful for exploring the effect of certain determinants on the overall satisfaction with the renovation project and comparing the four cases with each other.

#### 5.2.1.2. Model analysis

According to the model, both satisfaction with the process and the results have a relationship with the overall satisfaction. Table 5.7 gives an overview of the effect of each variable on the overall satisfaction and the satisfaction with the process and results. The satisfaction with the results (0.624) determines the overall satisfaction more than the satisfaction with the process (0.427), indicating that the results are more important for the overall satisfaction. The effect of the satisfaction with the results on the overall satisfaction is both direct and indirect through the satisfaction with the process. The other satisfaction variables affect the overall satisfaction through the satisfaction with the process and/or the results. Each of these satisfaction variables is subsequently affected by the corresponding gap variables and by any other gap and/or satisfaction variables. These relationships will be discussed below.

It should be noted that the variables (gap and satisfaction) of the information, rental- and energy costs do not have a relationship with the overall satisfaction of tenants. A likely reason for the absence of the information in the model is that most tenants were slightly to very satisfied with the information (22.9% slightly satisfied, 33.9% reasonably satisfied and 28.0% very satisfied). Tenants stated during the interviews that the information was good, but the communication about changes in the received information was lacking. Furthermore, there was no mandatory rent increase for all tenants. Only tenants that choose for additional measures received a rent increase, and the amount was clearly mentioned in the received information. It is likely that, because tenants had the opportunity themselves to select additional measures, the rent increase did not affect their satisfaction. Finally, concerning the energy costs, most tenants stated that they did not know if their energy consumption, and therefore their energy bill, did change after the renovation. Therefore, it does not influence their satisfaction.

The satisfaction with the influence, discomfort and nuisance and communication with the housing corporation directly affect the satisfaction with the process, but also the satisfaction with the results. All effects are positive, meaning that a higher satisfaction with each aspect results in a higher satisfaction with the process and the overall satisfaction. It is remarkable that the satisfaction with the



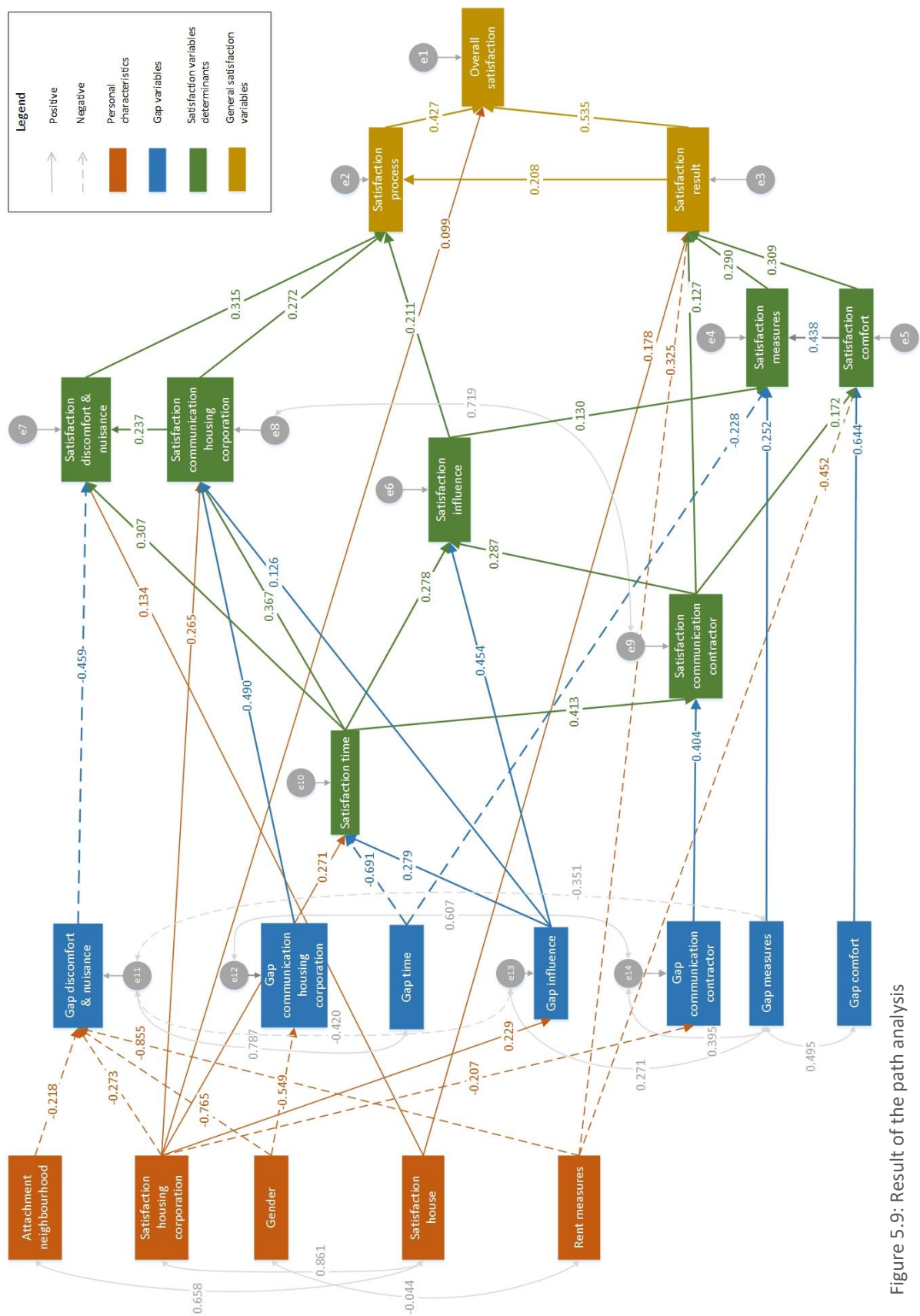
results influence the satisfaction with the process. Tenants that are unsatisfied with the result due to problems that still exist after the renovation, are less satisfied with the renovation process. Probably because these problems should have been solved during the process. The satisfaction with the communication with the housing corporation has the largest impact (0.347) on the satisfaction with the process. This is because it has a direct effect but also an indirect effect through the satisfaction with the nuisance and discomfort. During the interviews, several tenants mentioned that issues due to the nuisance and discomfort were solved with the help of the housing corporation. Additional facilities or changes within the renovation process were made to help the tenants. The gap between expectation and the actual amount of communication with the housing corporation and gap regarding the perceived amount of influence and the satisfaction with the self-invested time affect the satisfaction with the communication with the housing corporation, but also the satisfaction with the housing corporation before the renovation started. The satisfaction with the communication with the contractor has a smaller effect on the satisfaction with the process (0.105), because it affects the satisfaction indirectly through the satisfaction with the results. During the interviews, tenants in all cases mentioned that they first contacted the contractor to solve issues. When this didn't have the desired result, the housing corporation was contacted. It is likely that the communication with the contractor was mainly about the measures taken. Therefore, the communication results in a change in satisfaction with the results. While the communication with the housing corporation were mainly process-based. The satisfaction with the self-invested time has also quite a large effect (0.328) on the degree satisfaction with the process. The satisfaction affects the satisfaction with the process through the satisfaction with the nuisance and discomfort, the communication with the housing corporation and the contractor and the influence. The gap between expected and actual amount of invested time has a large negative impact (-0.691) on the degree of satisfaction. Meaning that the more time tenants had to invest compared to their expectations, the less satisfied they were. But the gap between the expected and actual amount of influence and the satisfaction with the housing corporation before the renovation also affect the satisfaction with the time. The time tenants had to put themselves into the renovation, consisted out of activities for the preparation of the execution of the renovation (e.g. covering, packing, moving things), work that needed to be done afterwards (e.g. cleaning up, painting) and being present at certain moments. In all cases, tenants mentioned that these activities took more time than expected. Especially the activities cleaning after the renovation and being present, while due to change in the planning the appointment was moved, resulted in more discomfort and nuisance for tenants, resulting in a lower satisfaction level. The satisfaction with the discomfort and nuisance has also quite a large effect (0.315) on the satisfaction with the process. As stated before, the satisfaction with the discomfort and nuisance is affected by the satisfaction with the time, but also by the gap between tenants expected and experienced amount of discomfort and nuisance and the satisfaction with the housing corporation before the start of the renovation.

The satisfaction with the measures and comfort change have a small effect on the satisfaction with the process through the satisfaction with the result. Therefore, it slightly affects the overall satisfaction through the process. However, it mainly affects the overall satisfaction indirectly only through the satisfaction with the results. Especially the satisfaction with the comfort is important for the results (0.436), and for the overall satisfaction (0.311). Tenants that experienced a higher improvement of the level of comfort are also more satisfied with it. As discussed above, the communication with the contractor affects the satisfaction with the comfort. It became clear during the interviews that good communication with the contractor resulted in issues of the tenants being considered by the contractor (sometimes resulting in additional work). It is likely that this improved the satisfaction with the comfort of tenants. Furthermore, measures that were not properly implemented, were fixed if the tenant communicated this with the contractor. This also explains why the satisfaction with the

Table 5.6: Results of the estimated path model

<b>Overall satisfaction</b>			
Satisfaction with the process	0.427*** (0.042)		
Satisfaction with the results	0.535*** (0.054)		
Satisfaction with the housing corporation	0.099** (0.041)		
<b>Satisfaction with the process</b>		<b>Satisfaction with the results</b>	
Satisfaction with the results	0.208** (0.085)	Satisfaction measures	0.290*** (0.059)
Satisfaction with the communication with the housing corporation	0.272*** (0.065)	Satisfaction with the communication with the contractor	0.127*** (0.039)
Satisfaction with the influence	0.211*** (0.063)	Satisfaction with the comfort	0.309*** (0.062)
Satisfaction with the discomfort and nuisance	0.315*** (0.055)	Satisfaction with the dwelling before renovation	0.178*** (0.037)
		Rent measure	-0.325*** (0.128)
<b>Satisfaction with the communication with the housing corporation</b>		<b>Satisfaction with the communication with the contractor</b>	
Gap of communication housing corporation	0.490*** (0.073)	Gap of the communication with the contractor	0.404*** (0.068)
Satisfaction with the self-invested time	0.367*** (0.074)	Satisfaction with the self-invested time	0.413*** (0.085)
Satisfaction with the housing corporation	0.265*** (0.070)		
Gap of the influence	0.126* (0.066)		
<b>Satisfaction with the self-invested time</b>		<b>Satisfaction with the comfort</b>	
Gap of the self-invested time	-0.619*** (0.060)	Gap of the comfort	0.644*** (0.100)
Gap of the influence	0.279*** (0.066)	Rent measures	-0.452** (0.194)
Satisfaction with the housing corporation	0.271*** (0.069)	Satisfaction with the communication with the contractor	0.172*** (0.057)
<b>Satisfaction with the discomfort &amp; nuisance</b>		<b>Satisfaction with the measures</b>	
Gap of the nuisance and discomfort	-0.456*** (0.067)	Gap of the time	-0.228*** (0.053)
Satisfaction with the communication with the housing corporation	0.237*** (0.080)	Gap of the measures	0.252*** (0.069)
Satisfaction with the time	0.307*** (0.085)	Satisfaction with the comfort	0.438*** (0.072)
Satisfaction with the house	0.134** (0.069)	Satisfaction with the influence	0.130** (0.055)
<b>Satisfaction with the influence</b>			
Gap of the influence	0.454*** (0.073)		
Satisfaction with the communication with the contractor	0.287*** (0.067)		
Satisfaction with the self-invested time	0.278*** (0.072)		
<b>Gap of the communication with the contractor</b>		<b>Gap of the influence</b>	
Satisfaction with the housing corporation	-0.207** (0.103)	Satisfaction with the housing corporation	0.229*** (0.092)
<b>Gap of the nuisance</b>		<b>Gap of the communication with the housing corporation</b>	
Gender	-0.765*** (0.262)	Gender	-0.549*** (0.214)
Attached to neighbourhood	-0.218*** (0.076)		
Satisfaction with the housing corporation	-0.273*** (0.096)		
Rent measures	-0.855*** (0.275)		

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1, the numbers in the parentheses are the standard errors



communication with the contractor affects the satisfaction with the influence. When the contractor takes the issues of the tenants into account, tenants get the feeling that they can influence the renovation. Tenants that are satisfied with the comfort improvement, are also more satisfied with the measures. The satisfaction with the comfort has the largest impact on the satisfaction with the measures. But also, the gap between the expected and actual amount of improvement due to the measures, the gap between expected and actual self-invested time and the satisfaction with the influence affects the satisfaction with the measures.

Finally, there are also some additional variables about the tenants (personal variables) that affect the gap and/or satisfaction variables. The variables about whether tenants chose some additional measures with rent increase have the largest effect (-0.313) of these variables on the overall satisfaction. Tenants that choose additional measures are more satisfied compared to tenant that

Table 5.7: Effect of variables on satisfaction level

		Overall	Process	Result
Satisfaction	Satisfaction with the process	0.427		
	Satisfaction with the result	0.624	0.208	
	Satisfaction with the influence	0.117	0.219	0.038
	Satisfaction with the discomfort & nuisance	0.135	0.315	
	Satisfaction with the communication housing corporation	0.148	0.347	
	Satisfaction with the communication contractor	0.178	0.105	0.213
	Satisfaction with the time	0.201	0.328	0.098
	Satisfaction with the measures	0.207	0.060	0.290
	Satisfaction with the comfort	0.311	0.091	0.436
Gap between expectation and actual experience	Gap of the influence	0.128	0.235	0.045
	Gap of the discomfort & nuisance	-0.061	-0.144	
	Gap of the communication housing corporation	0.073	0.170	
	Gap of the communication contractor	0.072	0.042	0.056
	Gap of the time	-0.166	-0.203	-0.127
	Gap of the measures	0.052	0.015	0.073
	Gap of the comfort	0.200	0.058	0.281
Personal variables	Satisfaction with the housing corporation	0.224	0.265	0.019
	Attachment to the neighbourhood	0.013	0.031	
	Gender	0.007	0.017	
	Rent measures	-0.313	0.029	-0.522
	Satisfaction house	0.145	0.079	0.178

Table 5.8: Mean and ANOVA – Satisfaction aspects per case

	Mean					ANOVA	
	<i>Eckart</i>	<i>d'Ekker</i>	<i>Breeakker</i>	<i>Tivoli</i>	<i>Total</i>	<i>F</i>	<i>p</i>
<b>Time</b>							
Expected	4.41	4.03	3.48	3.83	3.94	1.872	0.138
Actual	4.55	5.27	3.41	4.33	4.40	5.922	0.001
Gap	0.14	1.23	-0.07	0.50	0.46	4.848	0.003
Satisfaction	5.45	4.23	5.41	5.23	5.08	4.918	0.003
<b>Influence</b>							
Expected	4.14	4.07	4.03	4.20	4.11	0.058	0.982
Actual	4.28	3.60	3.55	4.50	3.98	1.902	0.133
Gap	0.14	-0.47	-0.48	0.30	-0.13	2.594	0.056
Satisfaction	5.55	4.40	4.86	5.40	5.05	3.735	0.013
<b>Communication</b>							
Expected <i>Housing corporation</i>	4.38	4.53	4.59	4.97	4.62	0.907	0.440
<i>Contractor</i>	5.43	4.87	4.48	5.30	5.02	3.367	0.023
Actual <i>Housing corporation</i>	4.17	4.10	4.55	5.00	4.46	1.640	0.184
<i>Contractor</i>	5.71	4.50	4.86	5.70	5.19	4.642	0.004
Gap <i>Housing corporation</i>	-0.21	-0.43	-0.03	0.03	-0.16	0.868	0.460
<i>Contractor</i>	0.29	-0.37	0.38	0.40	0.17	1.628	0.187
Satisfaction <i>Housing corporation</i>	5.31	4.67	5.41	5.73	5.28	2.554	0.059
<i>Contractor</i>	5.82	4.60	5.59	5.97	5.49	4.816	0.003
<b>Discomfort and nuisance</b>							
Expected	4.21	4.33	4.14	4.37	4.26	0.120	0.948
Actual	4.45	5.07	3.90	4.43	4.47	1.812	0.149
Gap	0.24	0.73	-0.24	0.07	0.20	1.796	0.152
Satisfaction	4.52	3.90	5.24	5.20	4.71	4.518	0.005
<b>Measures</b>							
Expected	5.55	5.00	5.17	5.47	5.30	1.140	0.336
Actual	6.24	4.70	5.07	5.63	5.41	7.369	0.000
Gap	0.69	-0.30	-0.10	0.17	0.11	3.913	0.011
Satisfaction	6.24	5.20	5.62	5.97	5.75	4.116	0.008
<b>Comfort</b>							
Expected	5.55	5.43	5.14	5.57	5.42	1.202	0.312
Actual	5.97	5.30	5.14	5.33	5.43	2.906	0.038
Gap	0.41	-0.13	0.00	-0.23	0.01	3.012	0.033
Satisfaction	6.00	5.43	5.24	5.77	5.61	2.294	0.082
<b>Satisfaction</b>							
Process	5.52	4.67	5.76	5.73	5.42	4.008	0.008
Result	6.14	5.63	5.48	5.93	5.80	2.263	0.085
Overall	5.83	4.93	5.72	5.87	5.58	4.256	0.007
<b>Personal/household variables</b>							
Satisfaction with the housing corporation	5.31	5.50	5.69	5.70	5.55	0.544	0.653
Satisfaction with the house before the renovation	4.48	5.20	5.34	5.00	5.01	1.667	0.178

didn't choose these measures. It mainly affects the overall satisfaction through the satisfaction with the results, indicating that the additional measures resulted in a larger comfort improvement and

Table 5.9: Correlation between gap and satisfaction variable

	Eckart		d'Ekker		Breeakker		Tivoli		Total	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
Time	-0.663	0.000	-0.740	0.000	-0.198	ns	-0.654	0.000	-0.643	0.000
Influence	0.636	0.000	0.628	0.000	0.478	0.009	0.509	0.004	0.592	0.000
Communication										
Housing corporation	0.532	0.003	0.221	ns	0.688	0.000	0.557	0.001	0.495	0.000
Contractor	0.179	ns	0.239	ns	0.502	0.006	0.588	0.001	0.394	0.000
Discomfort and nuisance	-0.719	0.000	-0.636	0.000	-0.428	0.021	-0.595	0.001	-0.612	0.000
Measures	0.089	ns	0.449	0.013	0.418	0.024	0.701	0.000	0.477	0.000
Comfort	0.256	ns	0.421	0.020	0.354	0.060	0.828	0.000	0.523	0.000

Note: ns = not significant

improvement of the dwelling. In addition, tenants that were more satisfied with their dwelling before the renovation, will be more satisfied with the renovation. While both these variables mainly affect the overall satisfaction through the satisfaction with the result, the satisfaction with the housing corporation before the renovation is important for the satisfaction with the process.

### 5.2.3. Case comparison satisfaction

#### 5.2.3.1. Time

According to the path model, the satisfaction with the time indirectly affects the overall satisfaction through the satisfaction with the discomfort and nuisance, communication with the housing corporation, communication with the contractor and the amount of influence. Therefore, the total effect of the satisfaction with the self-invested time on the overall satisfaction is reasonably large (table 5.7). There is a significant difference between the cases concerning the actual self-invested time ( $F=5.922$ ,  $p=0.001$ ), the gap between expectation and actual experience ( $F=4.848$ ,  $p=0.003$ ) and the satisfaction about the self-invested time ( $F=4.918$ ,  $p=0.003$ ). While the expectations of all tenants are comparable, tenants in d'Ekker actually had to invest a lot of time into the renovation, resulting in a large gap between expectation and experience (table 5.8 and figure 5.10). Tenants in d'Ekker stated that they did put a lot of time into the renovation. A couple of respondents mentioned that they had to spend a lot of time solving any problems with the contractor and the housing corporation and did a lot themselves after the renovation. According to the path model, the gap between the expectation and actual experience of the time has a negative effect on the satisfaction of the self-invested time and the overall satisfaction. This is also reflected in this analysis, tenants in d'Ekker are least satisfied with the self-invested time compared to the other cases.

Some tenants in the Eckart and Tivoli also commented that they had to do a lot themselves, while others stated that it was clear what they had to do themselves. This is mainly reflected in the spread of the actual time for the Eckart and Tivoli case (figure 5.10). Even though the spread of the given values in these cases is large, the spread of the satisfaction variables is smaller compared to d'Ekker and Breeakker. The mean satisfaction level of Eckart, Breeakker and Tivoli are quite comparable. The mean of the gap variable is slightly larger in Tivoli, resulting in a slightly lower satisfaction level.

While the gap between expectation and actual experience has the largest effect on the satisfaction with the self-invested time, the path model also showed that the gap between the expected and experienced amount of influence and the satisfaction with the housing corporation before the renovation also affects satisfaction. Both variables have a positive effect on the satisfaction level. The gap between the expected and experienced amount of influence is significant at 0.1 level ( $F=2.594$ ,  $p=0.056$ ). Mainly in Tivoli, but also in Eckart, tenants experienced more influence than expected, while

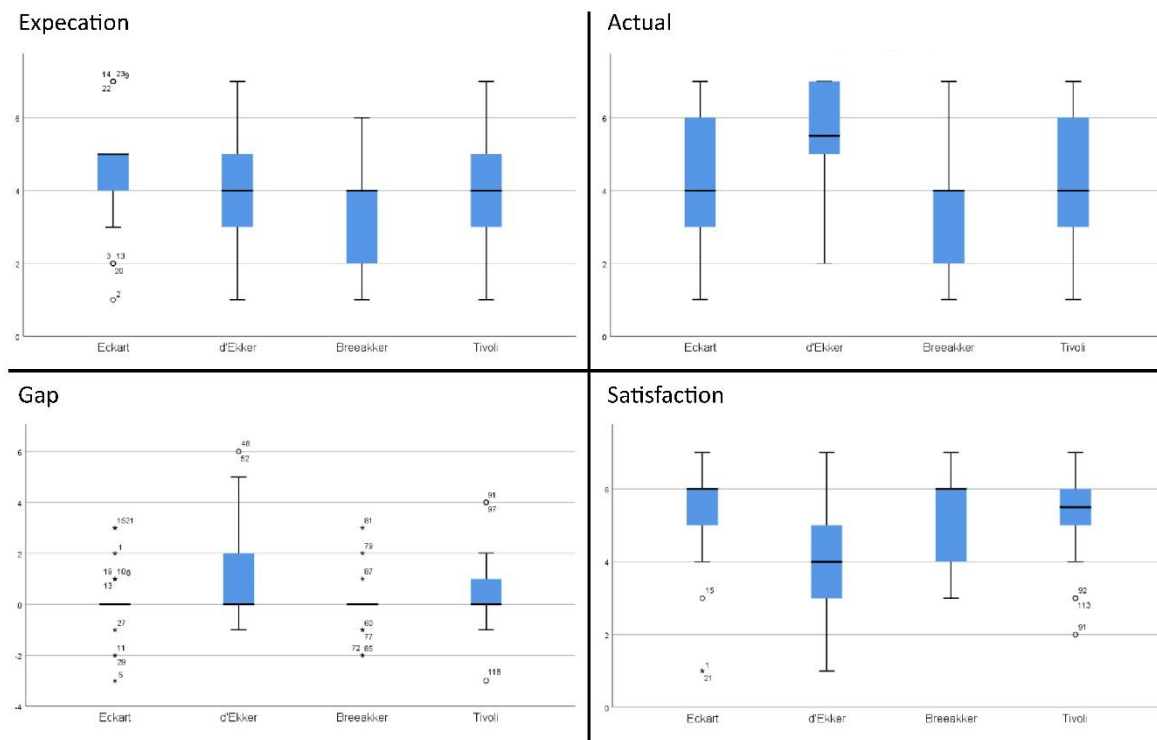


Figure 5.10: Boxplot of the time variables per case

tenants in d'Ekker and Breeakker experienced less. Therefore, the gap has a positive effect on the satisfaction level in Tivoli and Eckart but has a negative effect in d'Ekker and Breeakker. The determinant influence will be further explained later in this analysis. There is no significant difference between the cases concerning the satisfaction with the housing corporation before the renovation (table 5.8).

#### 5.2.3.2. Communication

According to the path model, the satisfaction with the communication (both with the housing corporation and the contractor) is affected by the gap between expectation and the actual amount of communication. Even though there is no significant difference between the cases concerning the gap variables (table 5.8), figures 5.11 and 5.12 show that the spread of the gap between expectation and actual experience for both the communication with the housing corporation and the contractor is larger in the d'Ekker case with more negative values. This negative gap results in a lower satisfaction level with the communication with the housing corporation (4.67) and contractor (4.60) compared to the other cases. Respondents stated during the interviews that the communication between them and the housing corporation and contractor was lacking, but also the communication between the contractor, freelancers (hired by the contractor) and housing corporation was bad. One respondent told that when mistakes were made, the contractor and housing corporation would blame each other. Furthermore, one of the respondents stated that there was only a one-way communication from the housing corporation to them and another told that sometimes there was no response. The lower satisfaction level of these tenants is also because of the lower satisfaction level with the self-invested time. Tenants stated that they had to put a lot of effort (time) into the communication. This negatively affected their satisfaction level.

In all four cases, tenants stated that they would first contact the contractor to discuss the renovation before contacting the housing corporation. According to the path model, the communication with the housing corporation affects the satisfaction with the process, while the communication with the

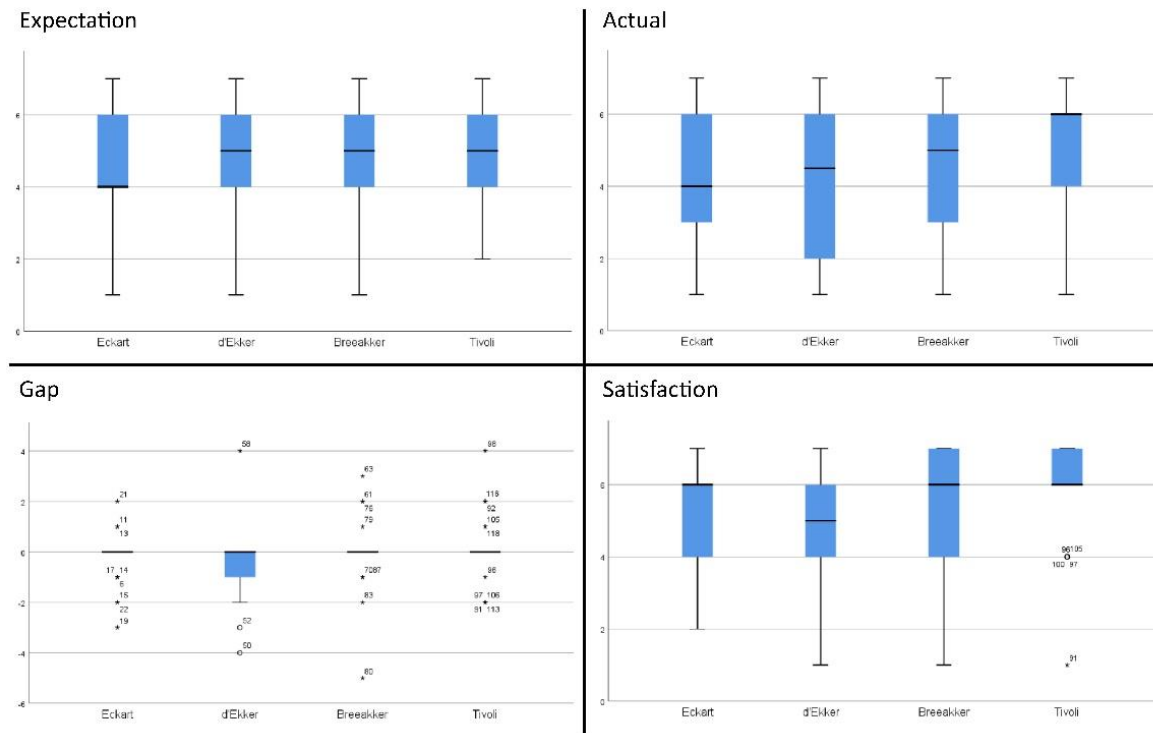


Figure 5.11: Boxplot communication with housing corporation variables per case

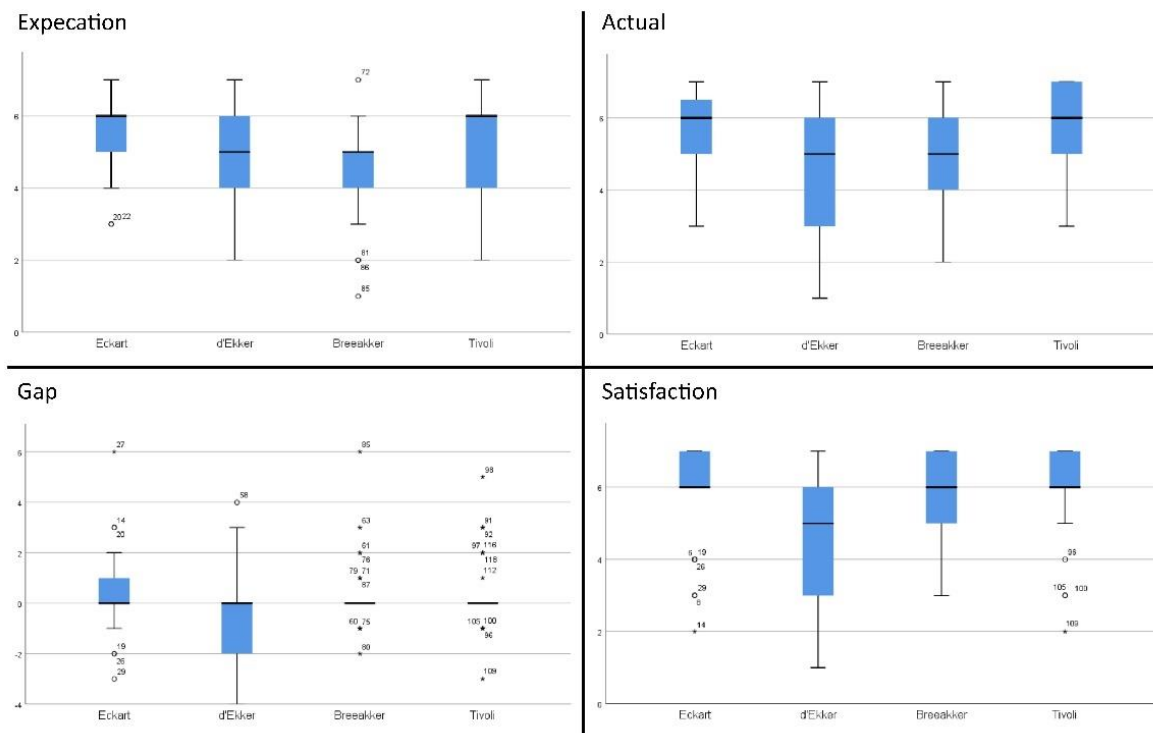


Figure 5.12: Boxplot communication with contractor variables per case

contractor mainly affects the satisfaction with the results (thus also affects the satisfaction with the process indirectly). Furthermore, the path model shows a correlation between the two satisfaction with communication variables and the satisfaction with the communication with the contractor is slightly more important for the overall satisfaction than the satisfaction with the communication with



the housing corporation. Tenants in Tivoli are the most satisfied with the communication with the contractor ( $F=4.816$ ,  $p=0.003$ ) and with the communication with the housing corporation ( $F=2.554$ ,  $p=0.059$ ) and the spread is much smaller. One of the respondents stated that the housing corporation and contractor were easily accessible by phone and/or the model house, and they dealt with their comments/problems. Respondents in Eckart are also satisfied with the communication with the contractor. One of the tenants mentioned that the contractor visited often. It is likely that the presence of the contractor resulted in higher satisfaction. Tenants in d'Ekker are on average the least satisfied.

#### 5.2.3.3. Influence

In section 5.1, the descriptions of the cases are given. From these descriptions and the comparison of it, it became clear that different levels and ways of influence were given to the tenants by the housing corporation. First, there were differences in the level of influence before the start of the renovation process. Tenants in Eckart had to start the renovation process themselves and tenants in d'Ekker had to accept or reject the proposal of the housing corporation because it was a renovation project (70% approval rate). Tenants in Breeakker and Tivoli didn't have any influence into the decision to renovation. Because the tenants in Eckart and d'Ekker had the opportunity to accept the renovation prior to the start, it is expected that they experienced some influence at the beginning. However, this wasn't mentioned by any tenant during the interviews. Second, tenants in all cases had the opportunity to select measures. In Eckart, tenants had the opportunity to select which measures were taken, the basic (more intensive) package and/or additional measures. While for the other cases, there were some mandatory measures and they had the opportunity to select any additional measures. Tenants could join a sounding board in d'Ekker and Breeakker. The purpose of the sounding board in Breeakker was mainly to inform tenants. While in d'Ekker, the purpose was to hear the wishes, complaints and experiences of the tenants. The housing corporation reviewed these matters and possibly took it into account.

According to the path model, the satisfaction with the level of influence is mainly affected by the gap between expected and actual level of influence. According to table 5.8, there is no significant difference concerning the expected and actual amount of influence and a significant difference at a 0.1 level concerning the gap variable between the four cases. However, the mean values indicate a dichotomy between the Eckart and Tivoli case on one side, and the d'Ekker and Breeakker case on the other side. An additional independent samples t-test is performed to analyse whether there is a significant difference between these two groups. This shows that there is indeed a significant difference between the actual amount of influence between Eckart and Tivoli on one side, and d'Ekker and Breeakker on the other side ( $t=2.361$ ,  $p=0.020$ ) and the gap between expectation and reality ( $t=2.773$ ,  $p=0.006$ ) and the satisfaction ( $t=3.107$ ,  $p=0.002$ ). While tenants in Eckart and Tivoli experienced on average more influence than expected, tenants in d'Ekker and Breeakker experienced less. As a result, tenants in d'Ekker and Breeakker are less satisfied. It is notable that in both these cases a sounding boards is used during the process. One of the respondents in d'Ekker commented that she expected a lot of influence because she joined the sounding board, but actually she had less influence. Other tenants stated that nothing was done with their wishes, there was no communication about these wishes and the housing corporation did what they wanted to do. One of the respondents in Breeakker stated that he missed being able to join the sounding board and wanted to be more involved. Furthermore, he mentioned that, according to him, the sounding board did not represent the whole neighbourhood. On the other hand, one of the respondents that joined the sounding board expressed the feeling that the sounding board had some influence in the decision-making.

The reason for the dichotomy in the cases may be that in Eckart and Tivoli a more personal approach is used during the renovation process. In Eckart, tenants had influence over the moment of renovation,

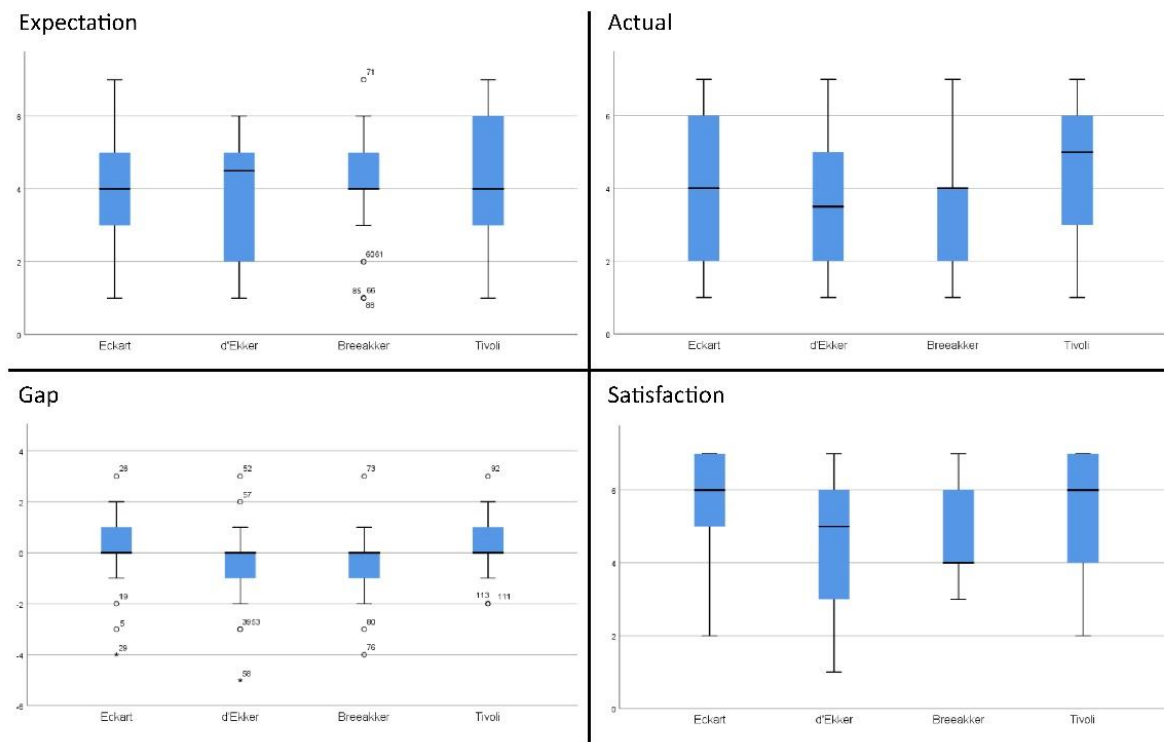


Figure 5.13: Boxplots of the influence variables per case

resulting in the “series of one” approach and had more freedom of choice concerning the measures. In Tivoli, there were more personal meetings between the tenants and the housing corporation/contractor. It is likely that tenants had more opportunity to discuss their feelings and wishes. Furthermore, free working vouchers were used for some additional work in Tivoli. It is likely that tenants in Eckart and Tivoli got the chance to adjust the outcome of the renovation more to their wishes. However, during the interviews it also became clear that tenants that stand their grounds or had a good relationship with the contractor could get more done compared to others, resulting in inequality between tenants. For example, one tenant stated that she was told that the dwelling would stay the same. She made sure more additional measures were taken by contacting the housing corporation and the contractors. The path model shows that the communication with the contractor affects the satisfaction with the influence.

#### 5.2.3.4. Discomfort and nuisance

The gap between expected and actual experienced amount of discomfort and nuisance during the renovation has a negative effect on the satisfaction with the discomfort and nuisance and the overall satisfaction. This means that when the actual experienced discomfort and nuisance is higher compared to the expectations, the satisfaction will be lower. Figure 5.14 shows that the spread of the given values is quite large for each case for all variables. A respondent in Breeakker stated that during a previous renovation, they experienced a lot of discomfort and nuisance. Therefore, they also expected it to be a lot during this renovation. Afterwards, it was not as bad as expected. Another respondent (in Tivoli), who has also undergone a previous renovation, stated that, even though she knew what to expect, the amount of discomfort and nuisance was still higher than expected. On the other hand, a respondent in d'Ekker stated that she did choose for the minimum amount of measures and therefore did not expect a lot of discomfort and nuisance. However, she did experience a lot of discomfort and nuisance during the process. Aspects such as previous experiences and knowledge about the measures influence the expectation of the tenants. On average, tenants' expectations are lower compared to their actual

experiences, which means that residents often underestimate the impact of a renovation process, resulting in a lower overall satisfaction.

There are no significant differences between the cases concerning the expectation, actual experience and gap variables. There is a significant difference between the cases in the satisfaction level with the discomfort and nuisance ( $F=4.518$ ,  $p=0.005$ ). This shows that tenants in d'Ekker are the least satisfied with the amount of discomfort and nuisance. Aspects such as many activities at the same time, inconvenience due to temporary facilities outside or in the model home and uncertainty during the process and an unstructured process were mentioned during the interviews and increased the amount of discomfort and nuisance during the renovation. Some respondents stated that they did not understand why people had to stay at home during the execution, because this was not doable.

While tenants in d'Ekker are on average slightly unsatisfied with the amount of discomfort and nuisance, tenants in Eckart are slightly satisfied but less satisfied than tenants in Breeakker and Tivoli. An important aspect of the Eckart case is the opportunity to select the moment of renovation. However, the so called "series of one", is the main complaint of the tenants. One of the respondents stated being glad to be able to select the moment of the renovation, but the amount of nuisance is therefore high and takes longer because neighbouring dwellings are renovated in different periods. This was also concluded by Uesaraie (2018). In addition, the housing corporation provided services and facilities (e.g. chemical toilet and emergency kitchen) for tenants in d'Ekker, Breeakker and Tivoli. In Eckart, obtaining temporary facilities or other measures such as a rest house was the own responsibility of the tenants. The absence of these facilities wasn't mentioned by the tenants during the interviews in Eckart. On the other hand, tenants in d'Ekker mentioned the inconvenience due to these temporary facilities. Tenants in Tivoli often made arrangements with neighbours and/or family to use their dwellings (e.g. to shower or cook). It may be that, because the renovation was voluntary in Eckart, tenants expect less assistance of the housing corporation or that by not offering facilities, tenants will look into other options. Nevertheless, the absence of these facilities doesn't necessarily negatively affect the experienced amount of discomfort and nuisance and the satisfaction with it.

The satisfaction with the communication with the housing corporation and the self-invested time also affects the satisfaction with the nuisance and discomfort. In Eckart, d'Ekker and Tivoli, tenants mentioned that they have spent a lot of time covering and moving their furniture and cleaning their dwelling during/after the renovation. This may have increased their experienced amount of discomfort and nuisance. In the information booklets provided by the housing corporation before the renovation, it was explained what activities tenants had to do themselves. This was also mentioned during the meetings with the contractor. Nevertheless, it is likely that tenants still underestimate the work they have to do themselves. As a result, they experience more discomfort and nuisance.

Aspects such as covering and moving furniture and cleaning the dwelling during/after the renovation, were barely mentioned during the interviews with tenants in Breeakker. A likely reason is that in this case, most measures took place outside of the dwelling, and therefore the tenants had to do less themselves compared to the other cases. Tenants only mentioned that they had to empty the attic because of the measures at the roof.

#### 5.2.3.5. Comfort

According to the literature, the improvement of the comfort is often one of the motivators for homeowners to renovate their dwelling (Mortensen, Heiselberg, & Knudstrup, 2014, 2016; Wilson, Crane, & Chryssochoidis, 2015). While tenants (mostly) don't have the choice to renovate, the comfort improvement is one of the most important determinants of the overall satisfaction. According to table 5.7, the gap between expected and actual comfort improvement has an effect of 0.200 on the overall

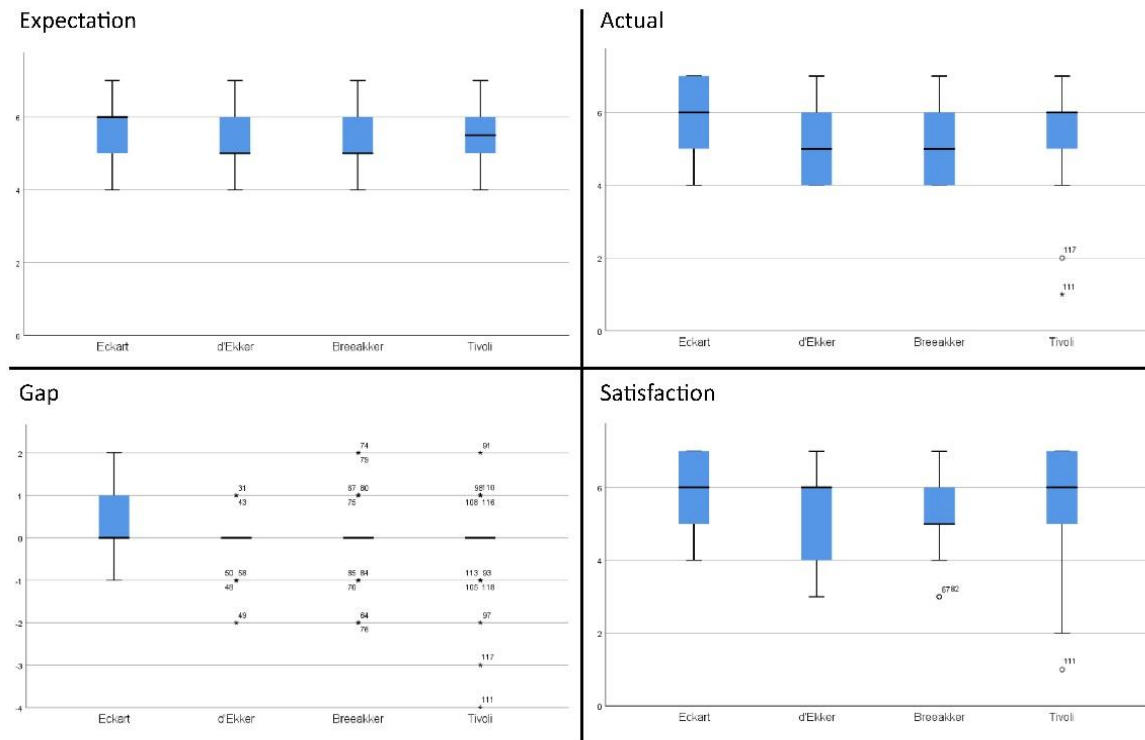


Figure 5.15: Boxplot Comfort per case

satisfaction, the highest effect of all gap variables. The satisfaction with the comfort has an effect of 0.311 on the overall satisfaction, the highest effect of the satisfaction variables besides the more general satisfaction variables of the process and results.

Comparing the four cases with each other, table 5.8 shows that there is a significant differences between the cases concerning the actual experienced improvement of the comfort level ( $F=2.906$ ,  $p=0.038$ ), the gap between expectation and reality ( $F=3.012$ ,  $p=0.033$ ) and the satisfaction with it ( $F=2.294$ ,  $p=0.082$ ). Tenants in Eckart experienced more improvement than expected. Resulting in the highest satisfaction level of the four cases. The case description (section 5.1.1.) shows that during the design phase, questionnaires and interviews were conducted with tenants about the dwelling and possible improvements. Furthermore, tenants had more freedom of choice concerning the measures that would be applied. It is likely that because of this, the wishes and needs, which probably influence their expectations, of the tenants were better met compared to the other cases. As a result, the gap value is higher resulting in a better satisfaction level. The mean of the gap variable of both d'Ekker and Tivoli are negative, indicating that tenants experience less improvement than expected. During the interviews, tenants of both d'Ekker and Tivoli mentioned that the measures didn't improve the level of comfort or stated that it is even colder after the renovation in some rooms. Nevertheless, tenants are reasonably satisfied with the comfort. It is likely that other determinants such as the satisfaction with the communication with the contractor and whether they choose additional measures explain the difference between the negative gap variable and higher satisfaction level. Tenants in Breeakker are the least satisfied with the comfort improvement. While this can partly be explained by the less intensive measures, tenants also mentioned that the level of comfort improved at the attic, but the comfort in the living room stayed the same because no measures were taken there. However, the level of comfort in the living room is more important for most tenants, because they spend more time in it. If the comfort in the living room would have been improved (e.g. floor insulation), it is likely that their satisfaction level with the comfort and overall satisfaction would have been higher.

Finally, the path model shows that tenants that choose additional measures with rent increase are more satisfied with the renovation compared to tenants that didn't. In section 5.1, the measures taken in each case are discussed. Most of the additional measures result in a rent increase. Only 31% of the tenants in Breeakker chose an additional measure with rent increase, compared to 90% in Eckart, 77% in d'Ekker and 73% in Tivoli. Comparing the additional measures, it becomes clear that the additional measures in Eckart, d'Ekker and Tivoli will have more impact on the use and appearance of the dwelling and therefore the comfort. Therefore, these measures will improve the level of comfort more in these cases.

#### 5.2.3.6. Measures

During the interview, respondents were asked what their expectation was, and actual experience is about the improvement of the dwelling due to the new measures. Therefore, the gap between expectation and actual experience indicates whether respondents experience a performance gap of the measures. There is no significant difference between cases concerning the expectations about the performance of the measures and improvement of the dwelling due to the measures ( $F=1.140$ ,  $p=0.336$ ). Most of the respondents expected that the quality of the dwelling would improve reasonably to very much. Considering the actual experience of the measures and the dwelling after renovation, there is a significant difference between the cases ( $F=7.369$ ,  $p=0.000$ ).

On the other hand, tenants in d'Ekker and Breeakker experienced less improvement compared to their expectations. This effect is the largest in d'Ekker. Tenants in d'Ekker are therefore also the least satisfied with the measures (table 5.8). One of the reasons for the lower satisfaction in d'Ekker may be that, according to the tenants, only minor measures were taken while there was a major overdue maintenance. In Breeakker, the measures are less intensive compared to the other cases. Therefore, it is likely that the tenants experience a smaller change compared to the situation before the renovation and are therefore less satisfied with the improvement. However, tenants also mentioned that some, in their opinion, important measures were not done during the renovation such as floor insulation and solar panels and some measures didn't work as expected.

It is remarkable that both Eckart and Tivoli are more satisfied with the measures. Tenants in Eckart experienced a large improvement of the dwelling, and often more than expected, and tenants in Tivoli experienced a slightly higher improvement due to the measure than expected. Resulting in a higher level of satisfaction with the measures. In both processes, no sounding board is used to inform and involve tenants. As discussed before, a more personal method is used in both cases. In Eckart, tenants could start the renovation themselves and had more freedom of choice in the measures and moment of renovation. Tenants in Tivoli had more meetings with the housing corporation and the contractor to discuss the renovation and the measures. Previous section showed that tenants in these two cases are more satisfied with the level of influence they had during the process. The path model shows that this variable also affects the satisfaction with the measures. It is likely that due to the more personal method, tenants' expectations about the measures are altered. Table 5.8 shows that tenants in both cases experience a larger improvement than expected.

While the gap between the expectation and actual experienced improvement influences the satisfaction with the measures, the satisfaction with the comfort is the main determinant of the satisfaction with the measures. Previous section showed that in d'Ekker, Breeakker and Tivoli tenants stated that they didn't experience the difference in comfort as expected and that the measures didn't fit their needs. Nevertheless, tenants in Tivoli are reasonably satisfied with the comfort improvement, resulting in a higher satisfaction level of the measures.

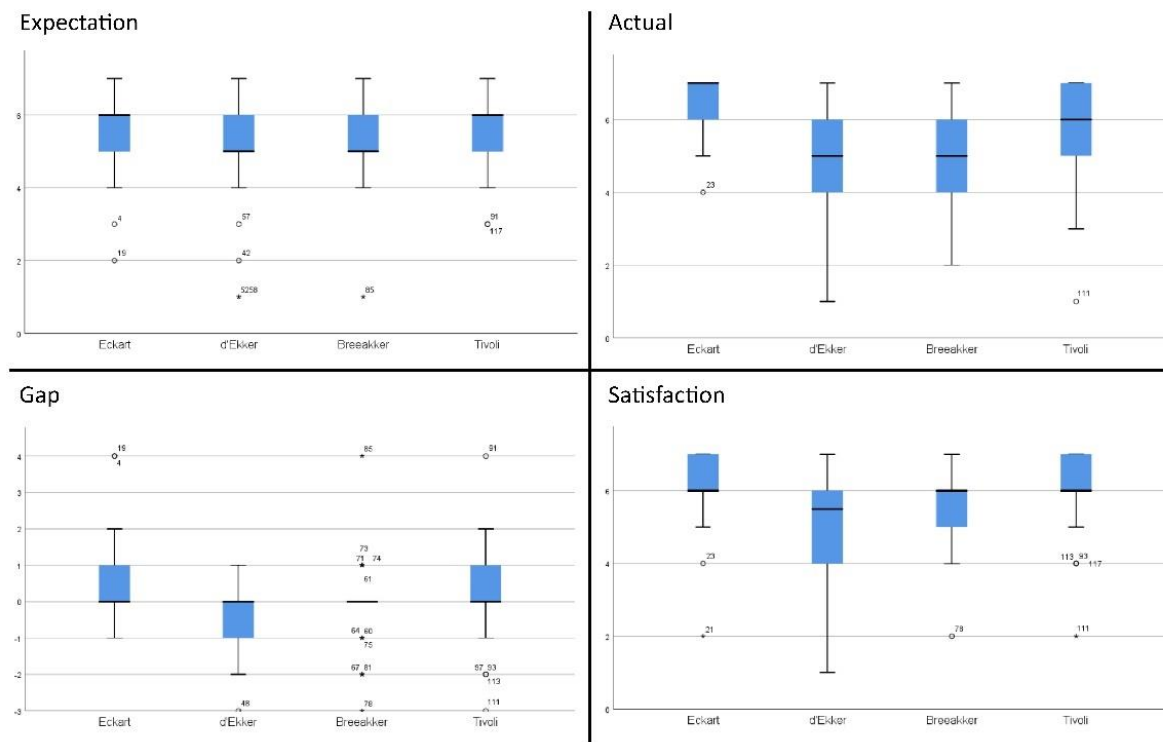


Figure 5.16: Boxplot measures per case

#### 5.2.3.7. Satisfaction

The path analyses showed that the satisfaction with the results of the renovation are more important for the overall satisfaction than the satisfaction with the process. Partially because the satisfaction with the process is affected by the satisfaction with the results. Even though the result isn't always as expected, most tenants experienced an increase in the level of comfort and the measures did improve the dwelling. Table 5.7 shows an overview of the effect of the various variables on the satisfaction with the results. This shows that mainly the satisfaction with the comfort (0.436) and in a lesser extend the satisfaction with the measures (0.290) and the satisfaction with the communication with the contractor (0.213) mainly affect the satisfaction level. Tenants in Eckart are the most satisfied with the results (average of 6.14). On average, they are the most satisfied with both the comfort and measures and the satisfaction with the communication with the contractor is quite high, resulting in a higher satisfaction with the results. On the other hand, tenants in Breekker are the least satisfied with the results (average of 5.48). This can be explained by the relatively low satisfaction with the comfort. As discussed before, the absence of some, for them, important measures may have influenced this. It should furthermore be noted that, while tenants in Tivoli and d'Ekker are on average more satisfied with the results than tenants in Breekker, the spread of the given values is larger in these cases (figure 5.17). Showing that there are also some tenants that are unsatisfied with the results.

Considering the satisfaction with the process, table 5.8 shows that both tenants in Breekker (average of 5.76) and Tivoli (average of 5.73) are reasonably satisfied, but also tenants in Eckart are quite satisfied (average of 5.52). Mainly the satisfaction with the time (0.328), communication with the housing corporation (0.347), discomfort and nuisance (0.315) affect this. Tenants in d'Ekker are the least satisfied considering all these variables. This explains the reasonably lower average satisfaction level (4.67) of these tenants with the process. The poor communication with the housing corporation, but probably also the lacking communication between the contractor and housing corporation are the

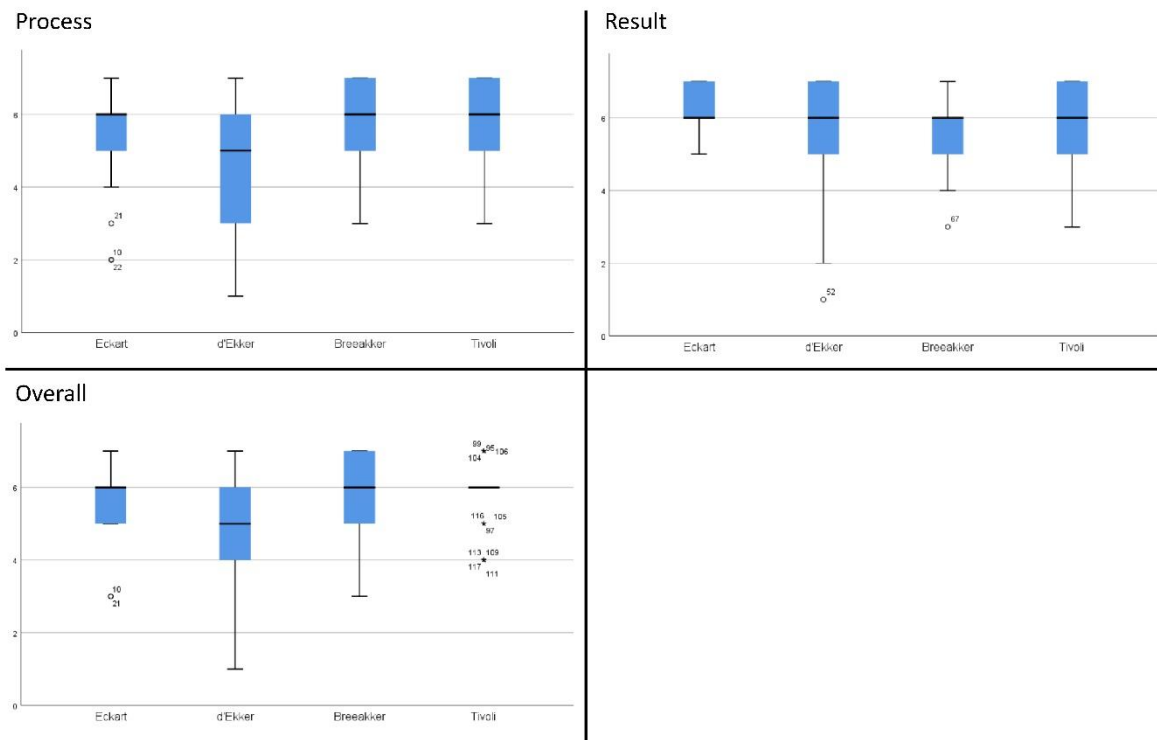


Figure 5.17: Boxplot Satisfaction per case

main causes for this. Due to the poor communication, the tenants had to put a lot of time into the communication and additional work.

Overall, tenants are quite to reasonably satisfied with the renovation. The average satisfaction level of Eckart, Breeakker and Tivoli is comparable, while the value is much lower for the d'Ekker case (average of 4.93). Of most of the satisfaction variables, d'Ekker scored the lowest average values. The analyses showed that tenants are especially less satisfied with the satisfaction with the process and the variables that affect this satisfaction level. Improvements in these aspects should result in a higher overall satisfaction.

#### 5.2.4. Participation

As discussed before, there are various participation approaches used in the four cases. Within d'Ekker and Breeakker, a sounding board was created to involve tenants in the process. Participants of the sounding board may experience the renovation process different compared to nonparticipants. The same applies for the two WoonConnect routes used in Eckart. It is expected that there are differences in expectation, experience and satisfaction. Therefore, this section will compare the participants and nonparticipants concerning the various variables. The path model shows no effect of the sounding board and WoonConnect route on the overall satisfaction. This is likely caused by the small number of respondents within a sounding board and the small number of respondents within the Eckart case (WoonConnect). Therefore, the differences between the participants and non-participants will be compared using only an independent samples t-test.

##### 5.2.4.1. Sounding board

Through the sounding board, the housing corporation provided the opportunity for the tenants in d'Ekker and Breeakker to provide input during the process. Therefore, the tenants expected that they would have more influence in the process. According to table 5.10, tenants that participated indeed expected more influence in the process compared to nonparticipants ( $t=1.850$ ,  $p=0.070$ ). However,

there is no significant difference between the participants and non-participants concerning the actual experienced level of influence. One of the respondents in d'Ekker stated that she expected a lot of influence because she joined the sounding board. However, the actual level of influence was lower. On the other hand, a participant in Breeakker experienced some level of influence. For example, due to the sounding board, the cladding remained the same due to the aesthetic value of it. This didn't result in a difference in actual experienced influence between participants and non-participants. There is also no significant difference between the groups concerning the satisfaction with the level of influence.

According to Simmons & Birchall (2007), tenants with more spare time are more likely to start participating in tenants' associations and tenant's management organisations, but once someone started, time became less important. This study shows that there is a significant difference between participants and non-participants considering the expectation ( $t=2.527$ ,  $p=0.014$ ) and actual amount of time ( $t=1.917$ ,  $p=0.060$ ) they put into the renovation. However, this does not result in a significant difference between the two groups concerning the satisfaction level. It is likely that the amount of time spent on the renovation because of joining a sounding board doesn't affect the satisfaction with the time.

Finally, table 5.10 shows that there is no significant difference between participants and non-participants concerning the level of satisfaction with the results and process and the overall satisfaction. In Breeakker the goal of the sounding board was mainly to inform tenants and to gain insight into their opinions. In d'Ekker, participants were asked to indicate their wishes, complaints and experience before and during the renovation to advise the housing corporation. Literature review showed that one of the reasons for participation is a higher satisfaction level (Debusschere et al., 2009; Schoenmakers, 2015). It was therefore expected that the involvement of the participants resulted in a higher level of satisfaction. Especially in d'Ekker, where the level of influence was expected to be higher compared to Breeakker. However, this cannot be concluded from this study.

#### 5.2.4.2. WoonConnect

In Eckart, WoonConnect was used as communication tool and to increase the insight of the tenants into the project. The tool expects some level of expertise of the tenants, which may not count for all tenants. Therefore, two types of routes were designed. In the first route (independent), tenants independently used the tool to analyse the various measures, communicate their choice and the intended renovation period. For tenants that couldn't fill in WoonConnect by themselves, the second route was developed. Within this route, the housing corporation filled in the choices with the tenants together.

Tenants that independently used WoonConnect, probably spend more time analysing the various options. However, according to the analysis, there is no significant difference between the self-invested time variables. Furthermore, because they analysed the measures more, it is expected that there are differences in the expectations, actual experience and satisfaction with the measures and the comfort after renovation. However, table 5.10 shows no significant differences between the two groups. During the interviews, tenants that independently used WoonConnect didn't mention the tool. It is therefore unclear whether these tenants actually analysed the measures more compared to the other tenants. There is a significant difference between the expectation of the level of influence between the two groups. Tenants that independently filled in WoonConnect, expected more influence compared to the other tenants. However, this did not result in any differences between the groups concerning the satisfaction level.



Table 5.10: Mean and t-test: satisfaction variables per sounding board participation and WoonConnect route

	Sounding board participation				WoonConnect route			
	Mean		T-test		Mean		T-test	
	Yes	No	t	p	Independent	Woonbedrijf	t	p
N	6	53			11	18		
<b>Time</b>								
Expected	5.17	3.60	2.527	0.014	4.64	4.28	0.608	0.548
Actual	5.67	4.21	1.917	0.060	4.64	4.50	0.192	0.849
Gap	0.50	0.60	-0.146	0.885	0.00	0.22	-0.460	0.650
Satisfaction	5.67	4.72	1.448	0.153	5.36	5.50	-0.226	0.823
<b>Influence</b>								
Expected	5.17	3.92	1.850	0.070	5.00	3.61	2.415	0.023
Actual	4.33	3.49	1.081	0.284	5.00	3.83	1.596	0.122
Gap	-0.83	-0.43	-0.639	0.525	0.00	0.22	-0.399	0.693
Satisfaction	5.33	4.55	1.171	0.246	5.55	5.56	-0.020	0.985
<b>Communication</b>								
Expected <i>Housing corporation</i>	6.00	4.40	4.941	0.000	4.36	4.39	-0.045	0.965
<i>Contractor</i>	5.68	4.57	1.965	0.054	5.55	5.35	0.459	0.650
Actual <i>Housing corporation</i>	6.17	4.11	5.165	0.000	3.82	4.39	-0.987	0.332
<i>Contractor</i>	5.83	4.55	1.699	0.095	5.64	5.76	-0.283	0.779
Gap <i>Housing corporation</i>	0.17	-0.28	0.774	0.442	-0.55	0.00	-1.553	0.132
<i>Contractor</i>	0.17	-0.02	0.250	0.804	0.09	0.41	-0.604	0.551
Satisfaction <i>Housing corporation</i>	5.50	4.98	0.727	0.470	4.82	5.61	-1.415	0.169
<i>Contractor</i>	5.83	5.00	1.124	0.266	4.45	6.06	-1.087	0.287
<b>Discomfort and nuisance</b>								
Expected	4.00	4.26	-0.394	0.695	4.18	4.22	-0.060	0.953
Actual	4.50	4.49	0.012	0.990	4.45	4.44	0.012	0.991
Gap	0.50	0.23	0.337	0.738	0.27	0.22	0.086	0.932
Satisfaction	4.67	4.55	0.171	0.865	4.27	4.67	-0.563	0.578
<b>Measures</b>								
Expected	5.00	5.09	-0.159	0.874	5.55	5.56	-0.020	0.984
Actual	4.67	4.91	-0.373	0.710	6.09	6.33	-0.688	0.498
Gap	-0.33	-0.19	-0.309	0.759	0.55	0.78	-0.422	0.680
Satisfaction	5.17	5.43	-0.489	0.627	6.36	6.17	0.465	0.646
<b>Comfort</b>								
Expected	4.83	5.34	-2.402	0.033	5.65	5.50	0.313	0.757
Actual	5.17	5.23	-0.133	0.895	5.82	6.06	-0.603	0.552
Gap	0.33	-0.11	1.370	0.176	0.18	0.56	-1.265	0.217
Satisfaction	5.50	5.32	0.353	0.725	6.09	5.94	0.364	0.719
<b>Satisfaction</b>								
Process	5.50	5.17	0.495	0.623	5.64	5.44	0.345	0.733
Results	5.50	5.57	-0.122	0.904	5.91	6.28	-1.543	0.134
Overall	5.17	5.34	-0.219	0.772	5.91	5.78	0.387	0.702

It was expected that the tenants who filled in WoonConnect independently would be more satisfied

with the renovation and especially with the results of the renovation. However, there is no significant difference between the two groups concerning the satisfaction with the process and results and the overall satisfaction. No arguments to support this was found during the interviews.

### 5.3. Energy consumption

It can be concluded from section 5.1 that one of the reasons for the renovation/maintenance is to improve the energy label and to improve the energy efficiency of the dwellings. However, the literature review showed that the rebound- and prebound effect can influence the efficiency of this improvement. Therefore, the data consumption of the tenants from before and after the renovation and the theoretical energy data is collected. In addition, questions about energy and energy saving were asked during the questionnaire. This will be discussed in this section. Appendix 5 shows an overview of the energy consumption and the change.

#### 5.3.1. Case comparison energy consumption

The available theoretical energy consumption data differs per case. As described in the literature review, there are various energy performance measures in the Netherlands. The energy label is known for all cases and the energy index is known for the dwellings in Eckart, Breeakker and Tivoli.

Because for all cases the energy label is known, the cases will first be compared using these values. Figure 5.18 gives an overview with the change in energy label per respondent per case, the minimum, maximum and average theoretical change given the measures, the actual energy consumption change and the change in energy obtained from the grid. Chapter 4.3.3.2 describes how these values are calculated. Considering the theoretical change, it is expected that tenants in Eckart save the most energy due to the renovation. Because PV panels are installed by four of the six respondents in Eckart, there is a difference between the energy consumption and the energy obtained from the grid. However, both change in the energy consumption and the energy obtained from the grid are higher than the theoretical change, except for one case. Meaning that the tenants don't save as much energy as expected.

This may be explained by the overestimation of the theoretical energy consumption. According to literature (Majcen & Itard, 2014; Majcen, Itard, & Visscher, 2013), the theoretical energy consumption significantly reduces per energy label, while in reality, the decrease in energy consumption is less compared to this theoretical calculated decrease. This means that dwellings with a larger difference between the energy labels before and after renovation, the potential energy saving is overestimated compared to dwellings with a smaller change. For all respondents in Tivoli the actual change is between the minimum and maximum theoretical change or higher. The theoretical change in Tivoli is much smaller compared to Eckart. Therefore, the change in Eckart is more overestimated.

Furthermore, another possible explanation is that tenants in Tivoli stated to be more interested in energy saving and that the renovation did stimulate them to save more energy (figure 5.19). From literature, it was expected that the renovation approach affects the energy consumption behaviour through the attitude towards energy saving, knowledge about the performance of the dwelling and the effort expectancy. During the interview tenants in Tivoli mentioned that it was explained how they could better operate the thermostat to save more energy. As a result, these tenants changed their energy consumption behaviour. It is therefore likely that the renovation approach in Tivoli changed the attitude of (some) tenants and their knowledge about the performance of their dwelling. In addition, tenants in Tivoli stated that the dwelling is still cold, while tenants in Eckart stated that it is warmer compared with before the renovation. This may be caused by the rebound effect, tenants in Eckart use more energy to increase their level of comfort.

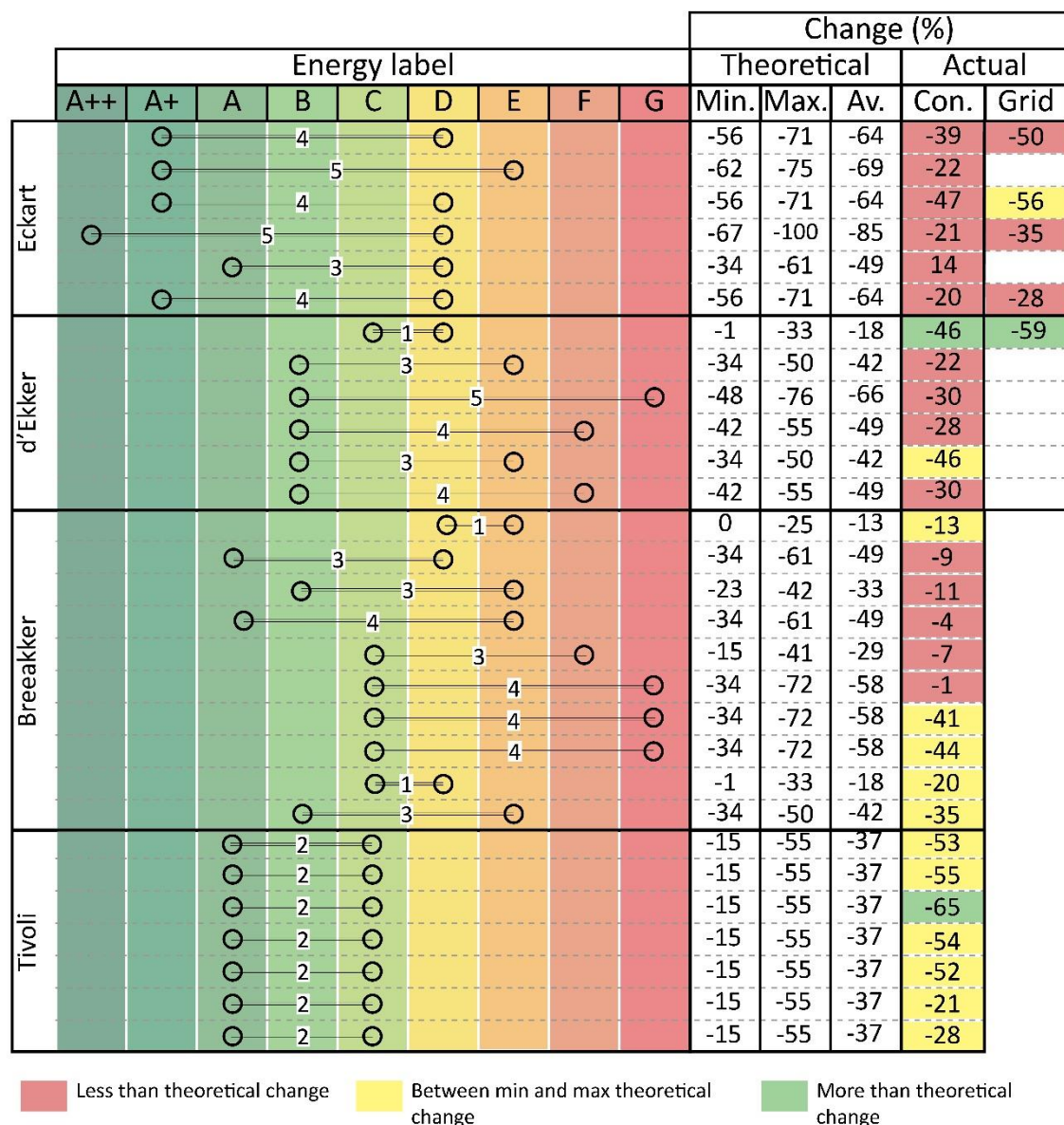


Figure 5.18: minimum-, maximum- and average theoretical change, actual change in total energy consumption and the change in energy consumption of the grid per case per respondent

Some tenants in Breeakker and d'Ekker also saved energy as expected or even more. After renovation, tenants in d'Ekker got the change to install PV panels. Compared to the other tenants in d'Ekker, the first tenant saved more energy than expected. This is the only respondent in this project with PV panels. This may have influenced the energy consumption behaviour of the tenant. However, no clear explanation can be given from the data that explains the difference between this tenant and the others. In Breeakker, most tenants are interested in energy saving. However, there is a large spread in the given values about their knowledge and skills to actually change their consumption. This spread is also large in Eckart and d'Ekker. A lot of tenants mentioned that they knew measures such as LED-lighting and electronic devices with a higher energy label but are unsure about small changes in daily live. Educating tenants during the renovation about changes they can make in their behaviour, as is done in Tivoli, may help tenants to decrease their energy consumption.

In addition to the energy label, the actual energy index before and after the renovation is known for the Eckart, Breeakker and Tivoli case (figure 5.20). While this provide a more precise overview of the

differences between the theoretical and actual energy saving, it doesn't provide completely new insights. However, it shows that, where the analyses with the energy label in Tivoli stated that most respondents saved energy within the expected limits, the analyses with the energy index shows that they actually saved more than expected. In this case, the energy index instead of the energy label provides more accurate information.

## 5.4. Conclusion

In this chapter, the four cases are first described. Path analysis is used to identify a model about the relationships between the gap between the expectations and experiences of several determinants, the satisfaction with these determinants, the satisfaction with the process and result and the overall satisfaction. Subsequently the cases are compared for each of the determinants of the overall satisfaction using ANOVA tests. Finally, the energy consumption of households is considered. An overview of the comparison is given in table 5.11. By comparing the four case, differences and similarities can be distinguished. According to the conceptual model (figure 3.1) compiled using literature about participation, satisfaction and energy consumption, it was assumed that the gap between tenants' expectations and experiences determine the satisfaction with certain aspects and the overall satisfaction with the renovation. Therefore, data was collected about the expectations, experiences and satisfaction of several aspects and the satisfaction with the process, results and overall. A path model is estimated describing the effect of the gaps (difference between expectation and experience) and the satisfaction levels. The path model (figure 5.9) showed that the gap between the expectation and the actual experience indeed influences the satisfaction of the tenants. The overall satisfaction of tenants can be improved by the housing corporation if they balance the expectations and experience or even exceed the expectations of tenants. It is therefore important to measure the expectations of tenants before the process and actual experience throughout and after the process. In all four cases, service calls were conducted before, during and after the renovation to analyse the experiences of tenants. During these service calls, expectations can be gathered too. Aspects such as

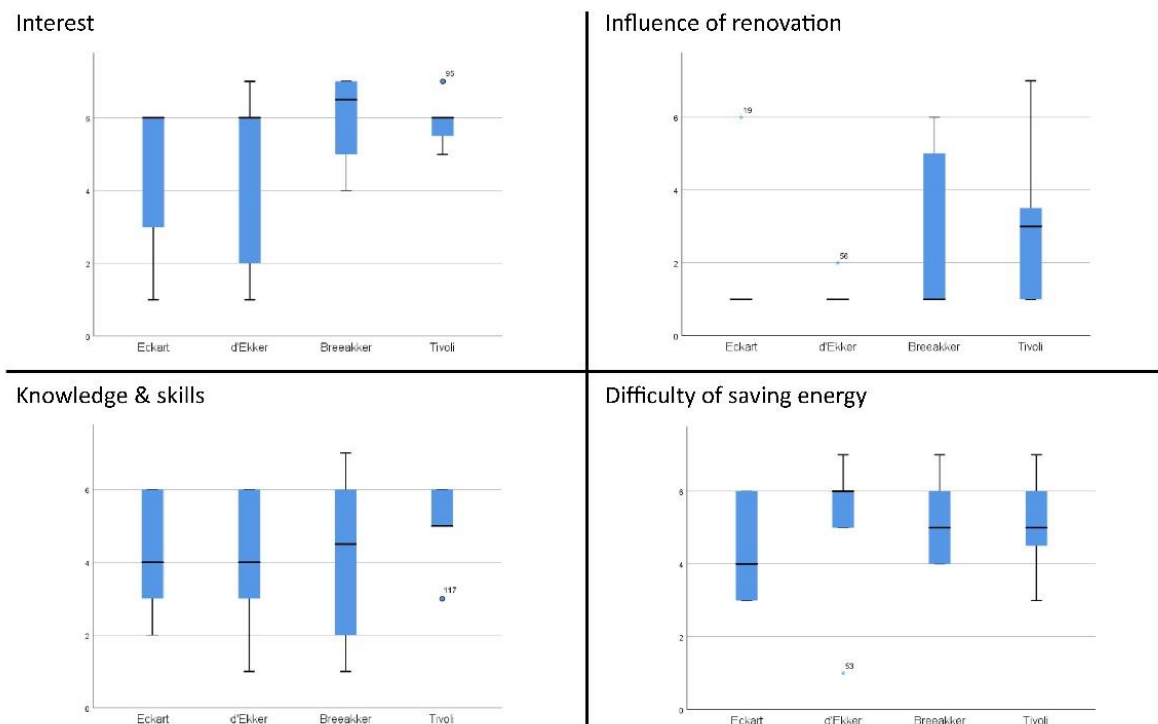


Figure 5.19: Questionnaire energy questions (respondents with energy consumption data)

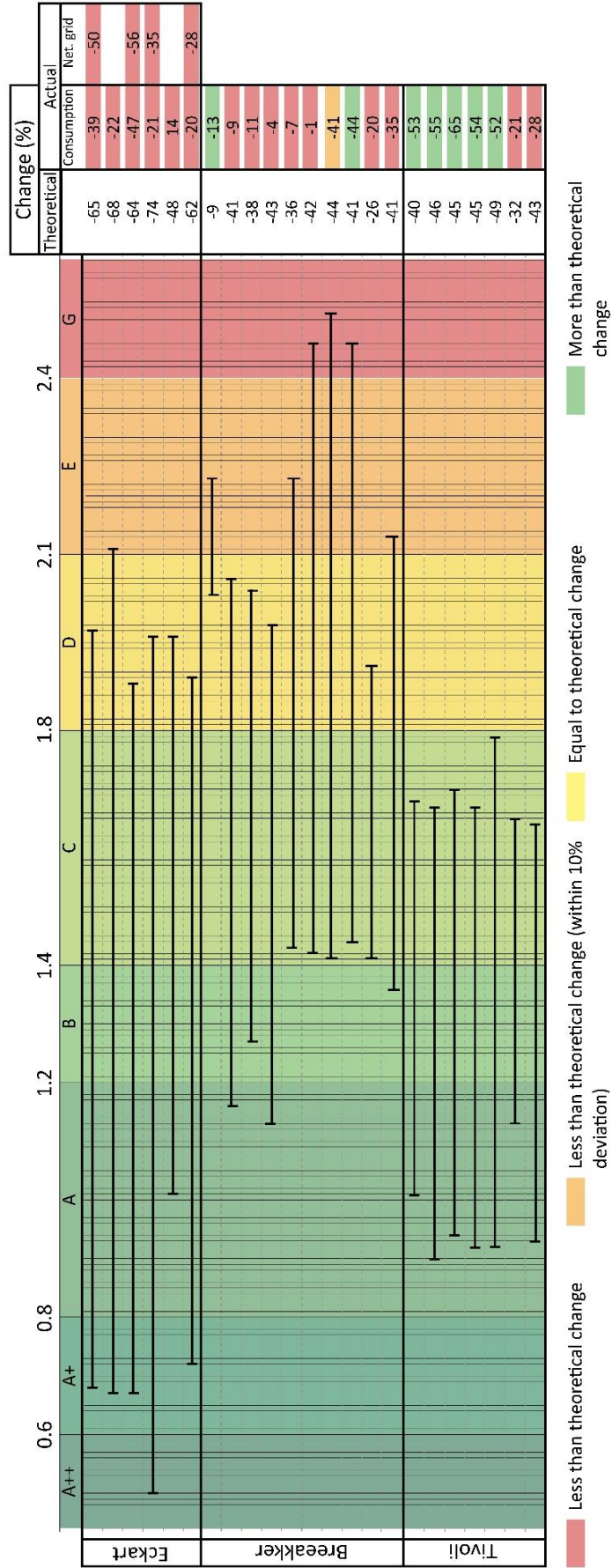


Figure 5.20: Change in energy index and actual energy consumption per respondent per case

discomfort and nuisance or the communication with the housing corporation can be adjusted throughout the process according to the perceived gaps. The gaps between the expectations and experience, e.g. of the measures and comfort, should be considered after the process and could possibly be improved afterwards.

The analyses show that the gap between the expected and experienced comfort affects the overall satisfaction the most of all gap variables and the satisfaction with the comfort, besides the satisfaction with the process and results, of the satisfaction variables. Tenants in d'Ekker and Breeakker were the least satisfied because the measures didn't live up to their expectations and/or some measures weren't taken. On the other hand, tenants in Eckart are most satisfied. The case description (section 5.1.1.) showed that a questionnaire and additional interviews were conducted during the design phase to analyse tenant's needs and wishes and the freedom of choice of the measures was larger. It is therefore important to align the measures to the needs and wishes of the tenants, and clearly communicate when measures are not possible. This will adjust the expectations of the tenants and improve their satisfaction level.

The gap variables of the difference between the expected and actual amount of self-invested time has also a large effect on the overall satisfaction compared to the other gap variables. The more time tenants must invest into the renovation, compared to their expectation, the less satisfied they are with the time and the overall satisfaction. The satisfaction with the self-invested time is one of the main determinants of the overall satisfaction. The comparison between the cases showed that especially d'Ekker differed from the other cases. These tenants actually had to invest much more time than expected due to poor communication with the housing corporation and the contractor and the amount of work they had to do after the renovation themselves. Resulting in a lower satisfaction level. This affected the satisfaction with the communication (both with the housing corporation and the contractor), the discomfort and nuisance and the level of influence.

In all four cases, the need for maintenance was the main reason for the start of the project. Furthermore, the need to improve the energy label was also an important reason. While the reasons to renovate are similar for the projects, the approach used differs. First, the Eckart and d'Ekker cases are renovation projects, while the Breeakker and Tivoli cases are major maintenance projects. This has the consequence that tenants in Eckart and d'Ekker had to approve or reject the proposal of the housing corporation. In case of d'Ekker, at least 70% of the tenants have accepted the proposal. In Eckart, a "series of one" approach is used. This means that the renovation of each dwelling is considered to be one project. When the tenants choose to start the renovation process, the 100% approval rate was automatically obtained. Tenants in Breeakker and Tivoli didn't have the opportunity to approve. While it was expected that this would affect the overall satisfaction through the attitude towards the renovation before the start of the renovation, the path analysis shows that the attitude doesn't affect the overall satisfaction.

Considering the process approach used in the four cases, the main difference between the cases is the participation level used. From the literature review, it was concluded that there are seven levels of tenant participation in renovation projects, namely; inform, consult, advise, coproduction, co-decision, empowerment and control (table 2.5). In d'Ekker and Breeakker, sounding boards were used. The purpose of the sounding board in Breeakker was mainly to inform the tenants, while in d'Ekker the housing corporation wanted to gain additional insight into the wishes and experiences of the tenants. Therefore, the level of participation for these tenants is consult (Breeakker) and advise (d'Ekker) and inform for the nonparticipants. In Eckart, tenants could decide themselves to start the renovation process, choose the renovation period and could choose from a more comprehensive set of measures. Therefore, the participation form can be considered as being coproduction, because the tenants can



make decision within the boundaries set by the housing corporation. Finally, in Tivoli no specific level of influence was given to the tenants, therefore the participation level is considered to be inform. It should be noted that the participation level of nonparticipants of the sounding board and tenants in Tivoli is mainly inform, all tenants had some influence in the decision-making about the (additional) measures. It was expected that, the higher the participation level (more influence), the more satisfied tenants would be with the level of influence and the overall results. While the analyses showed that tenants in Eckart are the most satisfied and tenants in Tivoli aren't the least. Remarkably, there is a dichotomy between Eckart and Tivoli on the one side, and d'Ekker and Breeakker on the other side. This implies that a more personal approach results in a higher experience of influence and satisfaction level. Aspects such as a planning that is more adjusted to the planning of the tenants and having influence on some additional measures or work increases the amount of influence tenants perceived to have.

Another consequence of the approach used in Eckart is the absence of services and facilities provided by the housing corporation during the renovation. Analyses show that the absence of these services and facilities doesn't necessarily mean that tenants experience more discomfort and nuisance and are therefore less satisfied with it. On the other hand, providing these services and facilities also doesn't necessarily improve the satisfaction of tenants. For all cases, the satisfaction with the discomfort and nuisance is affected by the amount of self-invested time (e.g. covering, cleaning and moving), previous experiences and the knowledge about the measures/work.

The path analyses also showed that the satisfaction with the communication with the contractor is slightly more important than the communication with the housing corporation. This is mainly because the communication with the contractor affects the satisfaction with the results (direct and indirect), which is more important for the overall satisfaction than the satisfaction with the process. For both the communication with the contractor and housing corporation applies that a better accessibility and willingness to help results in a higher satisfaction level. Lacking communication towards the tenants, but also between the housing corporation and contractor results in a lower satisfaction level.

The results of the renovation are more important for the overall satisfaction than the process. Overall, tenants in Tivoli (average of 5.87) and Eckart (5.83) are most satisfied. This can be explained by their higher satisfaction with the comfort and the improvement due to the measures. In d'Ekker, tenants are overall the least satisfied. Mainly the poor communication with both the housing corporation and the contractor influenced the other variables and eventually the overall satisfaction.

Concerning the energy consumption data, it was expected that the difference in theoretical and actual energy consumption change was smaller in the Eckart case compared to the other cases because the WoonConnect tool provided more insight into the energy consumption change of tenants due to the renovation and behaviour. However, the actual energy consumption of tenants in Tivoli was most comparable with the theoretical energy consumption. Tenants stated that they changed their thermostat settings due to information received during the renovation process. Furthermore, these tenants stated to be influenced by the renovation to save more energy. This may imply that the method used in Tivoli to inform tenants about the effect of their behaviour on the energy consumption is more effective compared to WoonConnect, causing the rebound- and/or prebound effect to be larger in Eckart compared to Tivoli. This indicates that it is likely that the renovation process can affect the energy consumption behaviour of tenants.

Table 5.11: Overview case comparison

	<b>Eckart</b>	<b>d'Ekker</b>	<b>Breackker</b>	<b>Tivoli</b>
	<b>General</b>			
<b>Type of project</b>	renovation	renovation	major maintenance	major maintenance
<b>Year construction</b>	ongoing, started June 2018	March 2016 – December 2018 3 <sup>rd</sup> phase: January 2018 – December 2018	February 2018 – June 2018	April 2018 – February 2019
<b># dwellings</b>	102 finished at the moment of data collection	493 in the total project 147 in the 3 <sup>rd</sup> phase	142	110
<b>Reason</b>	- need of maintenance - improve average energy label - need to involve tenants	- need to renovate - adapt to current level of energy efficiency and comfort	- need of maintenance	- need of maintenance - increase the lifespan - improve energy label
	<b>Process</b>			
<b>Participation measures</b>	- questionnaire - decision to start - selection of measures - planning	- sounding board - selection of measures - sustainable d'Ekker	- sounding board - selection of measures	- selection of measures
<b>Participation form and information communication</b>	- coproduction - invitation letter - information booklet - home visit - WoonConnect - model home - contractor visit/measuring - consultation hour	- inform & advise - newsletters - additional letters - information booklet - execution booklet - model home - contractor visit/measuring - kick-off meeting - consultation hour - renovation movie - user manual	- inform & consult - newsletters - information booklet - model home - contractor visit/measuring - consultation hour	- inform - newsletters - test house/model home - additional letters - information booklet - advice meeting - choice interview - volgewoning.nl - renovation movie - consultation hour
<b>Services</b>	- own responsibility - chemical toilet - emergency kitchen	- rest house - shower trailer - chemical toilet - emergency kitchen	- rest house	- rest home (incl. shower) - chemical toilet - emergency kitchen - work vouchers



		- work vouchers		
		<b>Satisfaction</b>		
<b>Time</b>		High average value of actual self-invested time → high gap between expectation and actual experience → lower satisfaction level		
<b>Communication</b>		Lacking communication with tenants and between housing corporation and contractor → low satisfaction level (housing corporation & contractor)		Easily accessible and willing to help → most satisfied with communication (housing corporation & contractor)
<b>Influence</b>	Personal approach → high satisfaction level	Less influence than expected → less satisfied	Less influence than expected → less satisfied	Personal approach → high satisfaction level
	WoonConnect not mentioned during interviews	No difference due to sounding board participation	No difference due to sounding board participation	
<b>Discomfort and nuisance</b>	Coproduction?? "Series of one" → more discomfort and nuisance over longer time period Own responsibility of services/facilities not mentioned	Many activities at the same time, inconvenience due to temporary facilities & uncertainty → Unsatisfied		
<b>Comfort</b>	Actual experience higher than expectation → most satisfied		No measures applied that influenced their daily comfort	
<b>Measures</b>	Actual experience higher than expectation → most satisfied	Actual improvement lower than expected → less satisfied		Satisfied with measures but some measures weren't taken

<b>Satisfaction</b>	Satisfaction with results high, measures improved the dwelling and comfort improved	Low satisfaction with process → low overall satisfaction Lacking communication influenced most determinants	Most satisfied with process, but least with results Minor measures applied → missing important measures	Satisfaction process & results quite high → overall most satisfied
<b>Energy consumption</b>				
<b>Measures</b>	choice: - basic package - additional measures	mandatory and additional	mandatory and additional	mandatory and additional
<b>Rent increase</b>	not mandatory, rent increase for some measures in basic package and additional measures	not mandatory, only for some additional measures	not mandatory, only for some additional measures	not mandatory, only for some additional measures
<b>Energy saving measures</b>	basic package and choice options	mandatory measures and choice option (floor insulation)	mandatory measures and choice option (dormer and boiler)	mandatory measures and choice option (savings pump, floor insulation, reinsulate cavity wall)
<b>Energy label before renovation</b>	D or E	C or lower	D or lower	D, E
<b>Energy label after renovation</b>	A or higher (depending on choices of residents)	C or higher	A, B, C, D	A
<b>Energy consumption after renovation</b>	Actual change lower than theoretical change (most respondents)	Actual change lower than theoretical change (most respondents)	Actual change lower than theoretical change (most respondents)	Influence of renovation → larger actual change then theoretical change

## 6. Conclusion, discussion and further research

The improvement of the housing stock of housing corporations is considered to play an important role in the decrease of the CO<sub>2</sub> emission and total energy consumption and to counteract climate change. Therefore, housing corporations will carry out a lot of energy renovation projects in the coming years. It is important for the housing corporation, but also for the tenants, that the renovation is carried out successfully. To judge whether these projects were successful, Uesaraie (2018) analysed which criteria determine the successfulness of a renovation project. Both the tenant's satisfaction and the energy reduction are important factors. Therefore, this study analysed these factors using four case studies. The cases are selected because of their different approaches to tenant involvement. Tenant participation is a commonly used approach by housing corporations to include tenants during the renovation process. Literature review showed that participation is about the level of control/power of certain participants. The definition of tenant participation in this study is adopted from Rus et al. (2010, pp. 5): "involvement in and the influence on the planning and policymaking of housing corporations". There are different degrees of participation, starting with no power for the participants to full power. According to literature, a higher level of tenant participation should result in a higher satisfaction level (Debusschere et al., 2009; Schoenmakers, 2015). However, most literature focuses on tenant participation in a broader sense. Formal tenant participation (set down in legislation) through tenant organizations and residents' committees mainly has to do with planning and policymaking on a larger scale. During renovation projects, more informal forms of participation are used, e.g. sounding boards. There is little literature about the effect of these informal forms of tenant participation on a renovation process. Therefore, the aim of this study is to analyse the satisfaction of tenants and the energy reduction in relation to renovation processes, including the participation forms used. The main research question of this thesis is as follows:

*How does the renovation process, including the level of participation, affect the satisfaction level of tenants and the energy reduction?*

Additional sub-questions are formulated to be able to answer the main question. The scientific importance of this thesis is the contribution to the existing literature by addressing the research gap described above. It has furthermore practical/social importance because the results can be used by housing corporations to improve the renovation process, making it more in line with the wishes of tenants. The main and sub questions will be answered in the coming paragraphs and the conclusions and limitations will be discussed, resulting in recommendations for practices and further research.

According to theories, the satisfaction level is the result of a comparison between the expectations and the perceived performances or experiences (Oliver et al., 1994; Patterson, 1993). The gap approach, which considers the difference between the expectations and experience, is derived from this and used in literature to determine satisfaction levels in various study areas (Galster, 1987; Jiang, 2018; Patterson, 1993). Within this study, the gap approach is also used to study the effect of the gap between expectation and experience of several determinants on the satisfaction with the renovation projects. Little is known about the determinants that affect the satisfaction level. Studies about tenant participation, tenants' satisfaction and the acceptance of tenants to participate in renovation projects are used to determine possible determinants. These determinants are 'influence', 'time', 'discomfort and nuisance', 'communication', 'information', 'measures', 'financial consequences' and 'comfort'. During interviews, tenants were asked to score their expectation, actual experience and satisfaction level with the above-mentioned determinants and their satisfaction with the process, results and entire project. This data is used to estimate a path model, which describes the relationships between all variables. While it was expected that the information and the financial consequences (costs due to energy consumption and rent) affect the overall satisfaction, the analyses showed no relationship

between these variables. However, for all respondents, there was no mandatory rent increase. Furthermore, the renovation took place less than a year ago for most respondents. Therefore, they didn't know the effect of the renovation on their energy consumption and energy bill. Therefore, this study didn't show a relation between the energy consumption and the satisfaction with the renovation. In renovation projects with mandatory rent increase and/or that took place more than a year before the study period, the financial change may influence the overall satisfaction.

Satisfaction with the comfort improvement affects the overall satisfaction the most apart from the satisfaction with the process and the results. According to the literature, the comfort improvement is one of the main reasons for homeowners to renovate their dwelling (Mortensen et al., 2014, 2016; Wilson et al., 2015). While tenants cannot decide to renovate, comfort improvement is still important. Satisfaction with the measures has also a larger impact on the overall satisfaction compared to the other determinants. The case comparison showed that, to increase satisfaction with comfort, the measures and the wishes of tenants must be aligned. Tenants in Breeakker stated that the measures improved the attic, but the comfort in frequently used spaces such as the living room didn't change. In addition, tenants that choose additional measures with rent increase (majority of the additional measures) are also more satisfied. Implying that tenants select measures that fit their needs. It is therefore recommended to evaluate the wishes and needs of the tenants at the start of the renovation process and include these measures if possible. When certain measures cannot be taken, this should be communicated to the tenants to alter their expectations of the renovation. Because the expectations influence satisfaction, it is important to clearly communicate the effect of the measures on the use and comfort of the dwelling. This prevents a large difference between expectation and actual experience. Within all four cases, information booklets stated that the comfort will improve, and model houses showed measures that could be different in the tenant's dwelling (different type or additional measures). Vague and/or too general descriptions and incorrect representations may affect the expectations of tenants. In Eckart, the 3D tool WoonConnect is used to provide more insight into the measures. Tenants didn't mention during the interviews that the tool affected their expectations of the renovation and the expectations weren't significantly different from the other cases.

Another important factor is time. Satisfaction with the self-invested time affects the satisfaction with the discomfort and nuisance, the influence and the communication with the housing corporation and the contractor. Because of this, satisfaction with time has a large effect on the overall satisfaction. During the interviews, aspects that influenced their gap variable and satisfaction with the self-invested time are incorrect information about the planning, lacking communication and poor finish. Tenants that invested a lot of time into communication and/or invested more time into the process due to missing communication will be less satisfied with the self-invested time and are therefore less satisfied with the communication. The analyses showed that the communication with the contractor is slightly more important compared to the communication with the housing corporation. It is important for housing corporations to monitor the communication between the tenants and the contractor and intervene when needed.

As described above, one of the expectations of this thesis is that the participation level affects the satisfaction level. According to the literature review, the higher the participation level, the more influence tenants have in the renovation process. According to the path model, satisfaction with the level of influence has the smallest effect on the overall satisfaction of all determinants. Nevertheless, the comparison between the four case studies provided insight into the differences between the cases, which affect the overall satisfaction. Analyses showed that there is a significant difference between Eckart and Tivoli on one side, and d'Ekker and Breeakker on the other. The approach in d'Ekker and Breeakker used a sounding board to inform tenants about the renovation and discuss it with them.

While in Eckart and Tivoli a more personal approach is used. According to Rus et al. (2010), formal participation, but also participation through sounding boards, often results in a lack of representativeness. The ideas and wishes of a sounding board are never a true representation of all tenants. It is likely that, because a renovation directly affects each tenant, all tenants want to have a certain influence in the process. It is therefore recommended to use a more personal approach to communicate with each tenant about the wishes, complaints and ideas. Additional work that benefits the tenants is also likely to increase the satisfaction level of the influence. To manage this, it is recommended to use free work hours or vouchers. Budget should be reserved for each household, to be used for additional work that is important for the tenants. Influence on the renovation period is also experienced as a positive aspect by residents. It is therefore recommended to involve tenants in the decision about the planning of the renovation. However, full choice as with the “series of one” mainly results in a higher experience of discomfort and nuisance. An approach that balances between the traditional way (housing corporation and contractor decides about the planning) and the “series of one” is likely to fit best. Further research into the wishes of both the housing corporation, contractor and tenants is needed to determine the best approach.

The path model shows that the gap between the expectation and experience affect the satisfaction levels of all determinants. The theory of Oliver, Balkrishan, & Barry (1994) and Patterson (1993) is useful in the explanation of the satisfaction levels of tenants in (energy) renovation projects. Within all four cases, service calls before, during and after renovation were conducted to analyse the satisfaction of tenants. These service calls focus on the experiences of the tenants with events that were experienced. Adding questions about the expectations of tenants (at the start of the process), the housing corporation can adjust their approach during the process when major differences between expectations and actual experience arise and/or is able to use this information for other projects. The expectations of the tenants in this study are asked after the renovation. During the interviews, it became clear that recalling the expectations after the renovation is hard for many tenants. This may have resulted in the small gap values for most of the tenants. It is therefore expected that the gap between expectations and actual experience becomes larger when the expectations are asked before the renovation process. Resulting in a better understanding of the gap variables on the satisfaction level of the tenants. It is therefore recommended for further studies to investigate the effect of the gap between expectation and experience on the satisfaction level, considering the limitation of this study. Furthermore, it is likely that the scores of the experiences change over time because tenants experience the change due to the measures. It is therefore recommended to further research the effect of time on the satisfaction level of tenants.

Another limitation of this study is the sample size used for the path analyses. There is no unanimity about the required sample size in the literature. Wang & Wang (2012) analysed the sample size for structural equation modelling and concluded that a sample size between 100 and 150 is usually considered to be enough. However, they also found studies that recommend a sample size of over 200 and relevant studies with less than 100 samples. It should be noted that most of these studies consider structural equation models with latent variables, while this study only uses measured variables. Therefore, the sample size of this study (118) is considered to be small but sufficient for exploring the effect of determinants on the satisfaction with the renovation. The sample size is too small for a multi-group path analysis. Therefore, the cases are compared using the main path analyses and the ANOVA test to determine differences between the cases. Further research into differences between renovation approaches using multi-group path analysis may provide more insight into the effect of the approach on the satisfaction of tenants.

The comparison of the change in the theoretical and actual energy consumption indicates that it's likely that the renovation process can affect the energy consumption behaviour of tenants. The literature review showed that the rebound- and prebound effect often cause differences between the change in theoretical and actual energy savings (Majcen et al., 2013; Sunikka-Blank et al., 2012). The rebound- and prebound effect are caused by changes in behaviour. It is likely that tenants in the four cases also changed their behaviour. For most of the respondents, the actual energy change is lower compared to their theoretical energy change. This can be the result of both the rebound- and prebound effect. In Tivoli, it is likely that the influence of the renovation approach (informing tenants) affected the energy consumption behaviour, resulting in a higher actual energy saving than theoretical. The tool WoonConnect, used in Eckart, contains additional information for the tenants about the influence of their behaviour (e.g. shower time) on energy consumption. Because of the small sample size with energy consumption data, it is not possible to determine whether the information provided actually affected the energy consumption behaviour. In addition, the choice for additional energy saving measures (e.g. PV panels and ventilation heat pumps) may also affect the energy consumption behaviour. Tenants that choose these additional measures probably save more energy compared to others.

While the energy consumption data indicates that the renovation process affects the energy consumption behaviour of tenants, it should be noted that the sample size is very small (N=29). The main reason is the difficulty to collect the data. In addition, the measurement period, especially of the energy consumption after the renovation, is quite short and the yield of the PV panels is unknown. Therefore, the yearly energy consumption needed to be modelled using various methods. As a result, the calculated energy consumption used may deviate from the real energy consumption. Furthermore, changes in e.g. household composition are not taken into account. The conclusions drawn from the energy consumption data only indicate that the process influences the energy consumption data. This cannot be stated with certainty. Therefore, further research into the relationship between the renovation process, including aspects such as provided information and additional measures, and the energy consumption behaviour is needed.

To conclude, this study showed that the approach used during the renovation influences the satisfaction of tenants and is likely the influence the energy consumption behaviour of tenants as well. The path analyses and case comparison resulted in the following recommendation for housing corporations to improve the renovation process and increase the satisfaction of tenants:

- Evaluate the wishes and needs of tenants during the design phase.
- Communicate the differences between the wishes/needs and the actual measures and the reason for these differences.
- Clearly communicate the effect of the measures, prevent too general and/or vague descriptions.
- Measure the expectations of tenants before and measure their experiences during and after the renovation process. Adjust the approach during the process according to the gap between the expectation and experience to increase satisfaction with the process.
- Use a personal approach so that each tenant is able to express his/her feelings, wishes, complaints etc.
- Use work hours/vouchers to adjust the renovation to the wishes and needs of the tenants, while regulating the amount of additional work per dwelling.
- Monitor the communication between the contractor and tenants and intervene when needed.



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# Appendix

## 1. Documentation

Eckart	d'Ekker
<ul style="list-style-type: none"> <li>- Workbook home type R3</li> <li>- Workbook home type R4</li> <li>- Workbook home type R4-1</li> <li>- Workbook home S4</li> <li>- Blueprint Journey</li> <li>- Invitation letter start renovation</li> <li>- Customer journey</li> </ul>	<ul style="list-style-type: none"> <li>- Newsletter December 2014</li> <li>- Newsletter July 2015</li> <li>- Newsletter December 2015</li> <li>- Newsletter April 2016</li> <li>- Newsletter September 2016</li> <li>- Newsletter October 2016</li> <li>- Newsletter February 2017</li> <li>- Newsletter April 2017</li> <li>- Newsletter July 2017</li> <li>- Newsletter September 2017</li> <li>- Newsletter December 2017</li> <li>- Newsletter March 2018</li> <li>- Newsletter April 2018</li> <li>- Newsletter November 2018</li> <li>- Information booklet type A</li> <li>- Information booklet type B</li> <li>- Information booklet type C</li> <li>- Execution booklet Type A</li> <li>- Execution booklet Type B</li> <li>- Execution booklet Type C</li> </ul>
Breeakker	Tivoli
<ul style="list-style-type: none"> <li>- Newsletter October 2017</li> <li>- Newsletter May 2017</li> <li>- Newsletter March 2018</li> <li>- Information booklet home type A</li> </ul>	<ul style="list-style-type: none"> <li>- Newsletter October 2011</li> <li>- Newsletter February 2017</li> <li>- Newsletter June 2017</li> <li>- Newsletter July 2017</li> <li>- Newsletter September 2017 (incl. option form)</li> <li>- Newsletter January 2018</li> <li>- Newsletter May 2018</li> <li>- Information booklet</li> </ul>



## 2. Questionnaire

### 2.1. English version

#### Questionnaire satisfaction and energy behaviour

*As part of my graduation thesis, I am curious about your expectations and findings with regard to the renovation/major maintenance of your home.*

*This questionnaire contains a number of general questions about you and your living situation. Subsequently, questions are asked about the process and the result of the renovation/major maintenance. The questions about the process concern the period prior to and during the execution. The questions about the result concern the home after renovation. The questionnaire concludes with a few questions about energy consumption*

*For different topics you will be asked what your expectations were, your actual experience and satisfaction. The questionnaire contains also questions about your satisfaction with the entire process, the results of the work and the entire renovation/entire maintenance in total. You will be asked to answer by choosing a value on a scale from 1 to 7. The value from 1 and 7 is given with the question. Choose the value on the scale that best fits your expectation, finding or satisfaction.*

General						
What is your age?						
<input type="checkbox"/> 18-24	<input type="checkbox"/> 25-34	<input type="checkbox"/> 35-44	<input type="checkbox"/> 45-54	<input type="checkbox"/> 55-64	<input type="checkbox"/> 64-74	<input type="checkbox"/> 75+
What is your gender?						
<input type="checkbox"/> Man	<input type="checkbox"/> Woman					
What is your household composition?						
<input type="checkbox"/> Single	<input type="checkbox"/> Couple without child(ren)	<input type="checkbox"/> Couple with child(ren)	<input type="checkbox"/> Single with child(ren)	<input type="checkbox"/> Other		
<u>Your dwelling:</u>						
How long did you live in your dwelling before the renovation/maintenance process?						
..... years						
How satisfied were you with your dwelling before the renovation/maintenance?						
1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
How attached were you to your dwelling before the renovation/maintenance?						
1 – Not at all attached	2	3	4	5	6	7 – Very attached
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
How satisfied were you with Woonbedrijf before renovation/maintenance?						
1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
How was your attitude towards renovation before the start of the renovation/maintenance?						
1 – Very negative	2	3	4	5	6	7 – Very positive
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<u>Your neighbourhood:</u>						
How attached are you to your neighbourhood?						

1 – Not at all attached	2	3	4	5	6	7 – Very attached
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Did you participate in the sounding board group(s) set up for the project? D'Ekker & Breeakker

☐ Yes ☐ No

Have you fill in WoonConnect independently (or with family / friends) or with the help of Woonbedrijf?? Eckart

☐ independently ☐ Woonbedrijf

Selected measures:

Have you selected any measures with an increase in rental or service costs?

☐ Yes ☐ No

Did you select any energy saving measure?

☐ Yes ☐ No

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**Process**

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*Eckart: Woonbedrijf invited you to start the renovation of your home. After you decided to renovate, you (together with Woonbedrijf) were able to make choices about the measures and the planning via WoonConnect. Via the workbook and WoonConnect you have received information about the renovation. Before and during the work there have been various contact moments with Woonbedrijf and the contractor. The following questions are about both the period before and during the execution.*

*D'Ekker /Breeakker: The renovation/major maintenance of your home started before the actual execution. Woonbedrijf approached you to share the renovation / major maintenance plans with you, you were invited to be part of a soundboard group and you were able to choose additional measures for your home. Woonbedrijf and the contractor have informed you before and during the execution by means of, for example, the housing report, an information booklet. In addition, there have been opportunities to ask questions or get more information. The following questions are about both the period before and during the execution.*

*Tivoli: The major maintenance of your home started before the actual execution. Woonbedrijf has approached you, among other things, to share the plans for major maintenance with you, visited you and you were able to choose additional measures for your home. Woonbedrijf and the contractor have informed you before and during the work by means of, for example, the housing report, an information booklet. In addition, there have been opportunities to ask questions or get more information. The following questions are about both the period before and during the execution.*

Influence

*You have had influence during the preparation of the work. This means that something has changed due to your choices or questions/comments. For example, it may be that the additional measures carried out or the way that measures were performed has changed.*

*Eckart: You were able to choose when the renovation started, which measures were implemented (basic package and/or additional measures) and you had influence on the planning.*

*d'Ekker: During the preparation you were able to participate in a soundboard group. You were also allowed to choose additional measures.*

*Breeakker: During the preparation you were able to participate in a soundboard group. You were also allowed to choose additional measures.*

*Tivoli: During the preparation you were able to choose additional measures.*

How much influence did you expected to have during the renovation/maintenance process prior to the execution of the work?

1 – None	2	3	4	5	6	7 – Very much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much influence did you actually have during the renovation/maintenance process prior to the execution of the work?

1 – None	2	3	4	5	6	7 – Very much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the level of influence during the process?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

### Time

*Before and during the execution of the work, you had to invest time into the process. For example, the delving into the choice options or planning and being present for appointments with Woonbedrijf or the contractor.*

How much time did you expected to put into the renovation/maintenance?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much time did you actually put into the renovation/maintenance?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the total amount of time you put into the renovation/maintenance?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

### Inconvenience and nuisance

*A renovation/maintenance process (preparation and execution work) entails inconveniences and nuisances.*

How much discomfort and nuisance did you expect to experience?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much discomfort and nuisance did you actually experience?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the amount of inconvenience and nuisance?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

### Information

*During the entire process, different ways have been used to inform you about the process and the content of the renovation/maintenance. For example, through newsletters (Woonbericht) and the information booklet.*

How much information did you expected to receive during the renovation/maintenance process?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much information did you actually receive during the renovation/maintenance process?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the amount of information you received?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

#### Communication

*In addition to informing, Woonbedrijf and the contractor have created various moments to communicate with you about the renovation/maintenance. This means that you had the opportunity to ask questions and/or to comment on various parts of the preparation, the execution and the result. Examples are home visits, meetings and planned office hours.*

How much communication did you expected to have with Woonbedrijf and the contractor during the process?

	1 – Very little	2	3	4	5	6	7 – A lot
Woonbedrijf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
:							
Contractor:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much communication did you actually have with Woonbedrijf and the contractor during the process?

	1 – Very little	2	3	4	5	6	7 – A lot
Woonbedrijf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
:							
Contractor:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the amount of communication?

	1 – Very little	2	3	4	5	6	7 – A lot
Woonbedrijf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
:							
Contractor:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

#### **Entire process**

**How satisfied are you with the entire process (preparation and execution work)?**

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

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#### **Results of the renovation/maintenance**

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#### Measures

*The new measures must improve the quality of your dwelling. The quality means that the measures do what they have to do and that they are easy to use.*

How well did you expected the quality of your dwelling to improve due to the measures?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How well did the measures actually improve the quality of your dwelling?

1 – Very little	2	3	4	5	6	7 – A lot
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the improvement of your dwelling?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

### Costs

*Energy-saving measures ensure that your energy consumption is reduced. On the other hand, you have been able to opt for additional measures against a rent increase.*

What were your expectations about the monthly costs after renovation/maintenance compared to before the renovation/maintenance?

	1 – Much more expensive	2	3	4	5	6	7 – Much more inexpensive
Energy bill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rent increase	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How did your monthly costs actually change after the renovation/maintenance?

	1 – Much more expensive	2	3	4	5	6	7 – Much more inexpensive
Energy bill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rent increase	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the change in monthly costs?

	1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
Energy bill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rent increase	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

### Comfort

*The measures influence the level of comfort of your dwelling.*

How did you expected the comfort to change after renovation/maintenance?

1 – Much worse	2	3	4	5	6	7 – Much better
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How has the comfort been improved after the renovation/maintenance compared with before?

1 – Much worse	2	3	4	5	6	7 – Much better
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you with the comfort of you dwelling?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

#### Entire results

How satisfied are you with the results of the renovation/maintenance?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

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#### Entire renovation (process and results)

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How satisfied are you with the entire renovation?

1 – Very unsatisfied	2	3	4	5	6	7 – Very satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

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#### Energy consumption

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Are you interested in saving energy?

1 – Not at all	2	3	4	5	6	7 – Very much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Did the renovation/maintenance process change you view on energy saving?

1 – Not at all	2	3	4	5	6	7 – Very much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Do you think that the measures provide the opportunity to save energy?

☐ Yes ☐ No

Do you feel you can change the energy consumption of your dwelling?

1 – Not at all	2	3	4	5	6	7 – Very much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How hard do you think it is to save energy?

1 – Very hard	2	3	4	5	6	7 – Very easy
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

Are you willing to answer a few additional questions in a separate interview?

Name:

Telephone number:

Email:

## 2.2. Dutch version

### Vragenlijst tevredenheid en energieverbruik

Als onderdeel van mijn onderzoek, ben ik benieuwd naar uw verwachtingen en bevindingen met de renovatie/het groot onderhoud van uw woning.

Deze vragenlijst bevat een aantal algemene vragen over u en uw woonsituatie. Vervolgens zijn de vragen opgedeeld in vragen over het proces en het resultaat van de renovatie/het groot onderhoud. De vragen over het proces gaat over de periode voorafgaand aan en tijdens de werkzaamheden. De vragen over het resultaat gaan over de woning na renovatie. De vragenlijst sluit af met enkele vragen over energieverbruik

Voor verschillende onderwerpen wordt gevraagd wat uw verwachtingen waren en uw daadwerkelijke beleving. Vervolgens wordt gevraagd naar de tevredenheid van het onderwerp. De vragenlijst bevat ook vragen over uw tevredenheid met het gehele proces, de resultaten van de werkzaamheden en de gehele renovatie/het gehele onderhoud in totaal. U wordt gevraagd antwoord te geven door een waarde te kiezen op een schaal van 1 tot 7. De waarde van 1 en 7 staan gegeven bij de vraag. Kies de waarde op de schaal die het best past bij uw verwachting, bevinding of tevredenheid.

Algemeen						
Wat is uw leeftijd?						
<input type="checkbox"/> 18-24	<input type="checkbox"/> 25-34	<input type="checkbox"/> 35-44	<input type="checkbox"/> 45-54	<input type="checkbox"/> 55-64	<input type="checkbox"/> 64-74	<input type="checkbox"/> 75+
Wat is uw geslacht?						
<input type="checkbox"/> Man	<input type="checkbox"/> Vrouw					
Hoe ziet uw huishoudsamenstelling eruit?						
<input type="checkbox"/> Alleenstaand	<input type="checkbox"/> Koppel zonder kind(eren)	<input type="checkbox"/> Koppel met kind(eren)	<input type="checkbox"/> Alleenstaand met kind(eren)	<input type="checkbox"/> Anders		
<u>Uw woning:</u>						
Hoelang woonde u al in uw woning voordat het renovatie-/onderhoudsproces begon?						
..... jaar						
Hoe tevreden was u voor de renovatie/het groot onderhoud met uw woning?						
1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hoe gehecht was u aan uw woning voor de renovatie/het groot onderhoud aan uw woning?						
1 – helemaal niet	2	3	4	5	6	7 – heel gehecht
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hoe tevreden was u met Woonbedrijf voor de renovatie/het groot onderhoud?						
1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hoe was uw houding tegenover renovatie vóór de start van het renovatie-/onderhoudsproces?						
1 – heel negatief	2	3	4	5	6	7 – heel positief
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<u>Uw wijk:</u>						
Hoe gehecht ben u aan de wijk waarin u woont?						
1 – helemaal niet	2	3	4	5	6	7 – heel gehecht

☐ ☐ ☐ ☐ ☐ ☐ ☐

Heeft u deelgenomen aan de/één van de klankboordgroep(en) die zijn opgezet voor het project? D'Ekker & Breeakker

☐ Ja ☐ Nee

Heeft u zelfstandig (of met familie/vrienden) WoonConnect ingevuld of met behulp van Woonbedrijf? Eckart

☐ zelfstandig ☐ Woonbedrijf

Gekozen maatregelen:

Heeft u gekozen voor maatregelen met huurs- of servicekosten verhoging?

☐ Ja ☐ Nee

Heeft u gekozen voor energiebesparende maatregelen?

☐ Ja ☐ Nee

---

**Proces**

*Eckart: U bent door Woonbedrijf uitgenodigd om de renovatie van uw woning te starten. Nadat u had besloten te renoveren, heeft u (samen met Woonbedrijf) keuzes kunnen maken over de maatregelen en de planning via WoonConnect. Via onder andere de werkmap en WoonConnect heeft u informatie gekregen over de renovatie. Voor en tijdens de werkzaamheden er zijn verschillende contactmomenten geweest met Woonbedrijf en de aannemer. De volgende vragen gaan zowel over de periode voor als tijdens de werkzaamheden.*

*D'Ekker/Breeakker: De renovatie/het groot onderhoud aan uw woning begon al voor de daadwerkelijke werkzaamheden. Woonbedrijf heeft u onder andere benadert om de plannen over de renovatie/het groot onderhoud met u te delen, u bent uitgenodigd om deel uit te maken van een klankboordgroep en hebt extra maatregelen kunnen kiezen voor uw woning. Voor en tijdens de werkzaamheden hebben Woonbedrijf en de aannemer u geïnformeerd door middel van bijvoorbeeld het woonbericht, een informatie boekje. Daarnaast zijn er mogelijkheden geweest om vragen te stellen of meer informatie te krijgen. De volgende vragen gaan zowel over de periode voor als tijdens de werkzaamheden.*

*Tivoli: Het groot onderhoud aan uw woning begon al voor de daadwerkelijke werkzaamheden. Woonbedrijf heeft u onder andere benadert om de plannen over het groot onderhoud met u te delen, zijn bij u op bezoek geweest en u hebt extra maatregelen kunnen kiezen voor uw woning. Voor en tijdens de werkzaamheden hebben Woonbedrijf en de aannemer u geïnformeerd door middel van bijvoorbeeld het woonbericht, een informatie boekje. Daarnaast zijn er mogelijkheden geweest om vragen te stellen of meer informatie te krijgen. De volgende vragen gaan zowel over de periode voor als tijdens de werkzaamheden.*

Invloed

*Tijdens de voorbereiding van de werkzaamheden heeft u invloed gehad. Dit betekent dat door uw gemaakte keuzes of door vragen/opmerkingen iets is veranderd. Het kan bijvoorbeeld zijn dat de uitgevoerde werkzaamheden zijn veranderd of de manier waarop werkzaamheden werd uitgevoerd is veranderd.*

*Eckart: U heeft het moment waarop de renovatie startte kunnen kiezen, welke maatregelen werden uitgevoerd (basispakket en/of aanvullende werkzaamheden) en heeft u invloed gehad op de planning.*

*d'Ekker: Tijdens de voorbereiding van de werkzaamheden heeft u deel kunnen nemen aan een klankboordgroep. Verder heeft u mogen kiezen welke extra werkzaamheden werden uitgevoerd.*

*Breeakker: Tijdens de voorbereiding van de werkzaamheden heeft u deel kunnen nemen aan een klankboordgroep. Verder heeft u mogen kiezen welke extra werkzaamheden werden uitgevoerd.*

*Tivoli: Tijdens de voorbereiding van de werkzaamheden heeft u mogen kiezen welke extra werkzaamheden werden uitgevoerd.*

Hoeveel invloed had u verwacht te hebben in de renovatie/onderhoud voorafgaand aan de werkzaamheden?

1 – geen      2      3      4      5      6      7 – heel veel



☐ ☐ ☐ ☐ ☐ ☐ ☐

Hoeveel invloed had u daadwerkelijk gehad in de renovatie/onderhoud voorafgaand aan de werkzaamheden?

1 – geen      2      3      4      5      6      7 – heel veel  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Hoe tevreden bent u over de invloed die u heeft gehad in het proces?

1 – heel      2      3      4      5      6      7 – heel  
ontevreden                                    tevreden  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Opmerking:

#### Tijd

*Voorafgaand en tijdens de werkzaamheden heeft u tijd moeten investeren in het renovatieproces/onderhoudsproces. Voorbeelden hiervoor zijn bijvoorbeeld het verdiepen in de keuzemogelijkheden of het plannen en aanwezig zijn voor afspraken met Woonbedrijf of de aannemer.*

Hoeveel tijd had u verwacht te moeten besteden aan de renovatie/onderhoud?

1 – weinig      2      3      4      5      6      7 – veel  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Hoeveel tijd had u daadwerkelijk moeten besteden aan de renovatie/het onderhoud?

1 – weinig      2      3      4      5      6      7 – veel  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Hoe tevreden bent u over de totale hoeveelheid tijd die u heeft besteed aan de renovatie/ het groot onderhoud?

1 – heel      2      3      4      5      6      7 – heel  
ontevreden                                    tevreden  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Opmerking:

#### Ongemak en overlast

*Een renovatieproces/onderhoudsproces en de werkzaamheden brengen ongemakken en overlast met zich mee.*

Hoeveel ongemak en overlast had u verwacht te ervaren tijdens de werkzaamheden?

1 – heel      2      3      4      5      6      7 – heel veel  
weinig  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Hoeveel ongemak en overlast heeft u daadwerkelijk ervaren tijdens de werkzaamheden?

1 – heel      2      3      4      5      6      7 – heel veel  
weinig  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Hoe tevreden bent u over de het ongemak en de overlast tijdens de werkzaamheden?

1 – heel      2      3      4      5      6      7 – heel veel  
weinig  
☐ ☐ ☐ ☐ ☐ ☐ ☐

Opmerking:

#### Informatie

*Tijdens het gehele proces zijn verschillende manieren gebruikt om u te informeren over het proces en de inhoud van de renovatie/het onderhoud. Bijvoorbeeld doormiddel van de nieuwsbrief (Woonbericht) en het informatieboekje.*

Hoeveel informatie had u verwacht te ontvangen vooraf en tijdens de werkzaamheden?

1 – heel weinig	2	3	4	5	6	7 – heel veel
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoeveel informatie had u daadwerkelijk ontvangen vooraf en tijdens de werkzaamheden?

1 – heel weinig	2	3	4	5	6	7 – heel veel
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe tevreden bent u over de hoeveelheid informatie die u hebt ontvangen?

1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Opmerking:

#### Communicatie

*Naast het informeren, heeft Woonbedrijf en de aannemer verschillende momenten gecreëerd om met u te communiceren over de renovatie/het onderhoud. Dit betekent dat u de mogelijkheid heeft gehad om vragen te stellen over en/of opmerkingen te plaatsen bij verschillende onderdelen van de voorbereiding, de werkzaamheden en het resultaat. Voorbeelden hiervan zijn huisbezoeken en het spreekuur.*

Hoe veel communicatie had u verwacht te hebben met Woonbedrijf en de aannemer vooraf en tijdens de werkzaamheden?

	1 – heel weinig	2	3	4	5	6	7 – heel veel
Woonbedrijf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
:							
Aannemer:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe veel communicatie had u daadwerkelijk gehad met Woonbedrijf en de aannemer vooraf en tijdens de werkzaamheden?

	1 – heel weinig	2	3	4	5	6	7 – heel veel
Woonbedrijf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
:							
Aannemer:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe tevreden bent u over de hoeveelheid communicatie met Woonbedrijf en de aannemer vooraf en tijdens de werkzaamheden?

	1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
Woonbedrijf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
:							
Aannemer:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Opmerking:

#### **Gehele proces**

**Hoe tevreden bent u over het gehele proces (voorbereiding en werkzaamheden)?**

1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Opmerking:

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**Resultaten van de renovatie/het groot onderhoud**

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### Maatregelen/werkzaamheden

*De nieuwe maatregelen/werkzaamheden moeten de kwaliteit van uw woning verbeteren. De kwaliteit betekend dat de maatregelen/werkzaamheden doen wat ze moeten doen en dat ze gemakkelijk te gebruiken zijn.*

Hoe goed had u verwacht dat de kwaliteit van de woning zou verbeteren door de maatregelen/werkzaamheden?

1 – heel weinig	2	3	4	5	6	7 – heel veel
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe goed hebben de maatregelen/werkzaamheden de kwaliteit van de woning verbeterd?

1 – heel weinig	2	3	4	5	6	7 – heel veel
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe tevreden bent u over de kwalitatieve verbetering van uw woning?

1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Opmerking:

### Kosten

*Energiebesparende maatregelen zorgen ervoor dat het uw energieverbruik naar beneden gaat. Daarnaast heeft u ervoor kunnen kiezen om, tegen een huurverhoging, extra maatregelen toe te passen.*

Wat waren uw verwachting over de maandelijkse kosten na renovatie vergeleken met voor de renovatie/het groot onderhoud?

	1 – veel duurder	2	3	4	5	6	7 – veel minder duur
Energie rekening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Huur verhogin g	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe zijn uw maandelijkse kosten daadwerkelijk veranderd te opzicht van voor de renovatie/het groot onderhoud?

	1 – veel duurder	2	3	4	5	6	7 – veel minder duur
Energie rekening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Huur verhoging	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe tevreden bent u over de verandering van de maandelijkse kosten?

	1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
Energie rekening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Huur verhogin g	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Opmerking:

### Comfort

*De toegepaste maatregelen hebben ook invloed op het comfort van uw woning.*

Hoe had u verwacht dat het comfort in de woning zou veranderen na de werkzaamheden ten opzichte van voor de renovatie/het onderhoud?

1 – veel slechter	2	3	4	5	6	7 – veel beter
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe is het comfort verbeterd na de werkzaamheden vergeleken voor de werkzaamheden ten opzichte van voor de renovatie/het onderhoud?

1 – veel slechter	2	3	4	5	6	7 – veel beter
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe tevreden bent u met het comfort na de werkzaamheden.

1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Opmerking:

### **Gehele resultaat**

**Hoe tevreden bent u met de resultaten van de renovatie/groot onderhoud?**

1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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### **Gehele renovatie/groot onderhoud (Proces en resultaat)**

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**Hoe tevreden bent u met de hele renovatie/groot onderhoud?**

1 – heel ontevreden	2	3	4	5	6	7 – heel tevreden
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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### **Energieverbruik**

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Bent u geïnteresseerd in energie besparen?

1 – Helemaal niet	2	3	4	5	6	7 – heel erg
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Heeft het renovatieproces/het onderhoudsproces hierop invloed gehad?

1 – helemaal niet	2	3	4	5	6	7 – heel veel
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Denk u dat de werkzaamheden de mogelijkheid geven om meer energie te besparen?

☐ Ja ☐ Nee

Heeft u het gevoel dat u de mogelijkheden (kennis, informatie) heeft het energieverbruik kunt veranderen?

1 – Helemaal niet	2	3	4	5	6	7 – Heel erg
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hoe moeilijk denk u dat het is om energie te besparen?

1 – Heel  
moeilijk

2

3

4

5

6

7 – Heel  
makkelijk

☐

☐

☐

☐

☐

☐

☐

Opmerking:

Bent u bereid om nog enkele aanvullende vragen te beantwoorden in een apart interview?

Naam:

Telefoonnummer:

Email:

### 3. Radiation database selection

Real amount of radiation (Siderea, n.d.):

	Radiation <i>kWh/m<sup>2</sup></i>
July 2018	203
August 2018	147
September 2018	108
October 2018	70
November 2018	30
December 2018	15
January 2019	21
February 2019	49
March 2019	71
April 2019	135
May 2019	148
June 2019	184

Amount of radiation per database per year (European Commission, n.d.-c) and comparison with real radiation measurement period:

	May-June		June		July-December		Feb-May		Mar-Apr	
	<i>kWh/m2</i>	% of real radiation	<i>kWh/m2</i>	% of real radiation	<i>kWh/m2</i>	% of real radiation	<i>kWh/m2</i>	% of real radiation	<i>kWh/m2</i>	% of real radiation
PVGIS_SARAH radiation database										
2005	340	102	185	101	513	89	369	92	177	86
2006	315	95	176	96	509	89	344	85	181	88
2007	285	86	147	80	466	81	414	103	245	119
2008	323	97	158	86	440	77	400	99	189	92
2009	319	96	169	92	506	88	385	95	204	99
2010	316	95	183	99	495	86	384	95	221	107
2011	316	95	148	80	477	83	444	110	241	117
2012	289	87	136	74	493	86	385	96	192	93
2013	264	80	142	77	505	88	330	82	178	86
2014	294	89	156	85	480	84	395	98	217	106
2015	333	100	178	97	501	87	411	102	215	104
2016	295	89	137	74	519	91	402	100	201	97
PVGIS-ERA5 radiation database										
2010	315	95	179	97	471	82	392	97	222	108
2011	316	95	151	82	466	81	435	108	233	113

2012	296	89	138	75	500	87	403	100	203	98
2013	284	86	150	82	490	85	374	93	199	97
2014	303	91	155	84	473	83	415	103	226	110
2015	319	96	168	91	483	84	420	104	224	109
2016	293	88	141	77	503	88	411	102	213	103
<b>PCGIS_COSMO radiation database</b>										
2005	346	104	186	101	455	79	384,5	95	186,9	91
2006	309	93	169	92	461	80	366,8	91	192,1	93
2007	261	79	123	67	411,5	72	408,8	101	240,1	117
2008	306	92	144	78	424,8	74	398	99	191,1	93
2009	317	95	166	90	449,1	78	390,1	97	210	102
2010	321	97	182	99	434,1	76	391,4	97	219	106
2011	311	94	145	79	404,5	71	422,2	105	224,5	109
2012	280	84	135	73	446,4	78	376,5	93	191,6	93
2013	277	83	150	82	468,7	82	366,2	91	203,1	99
2014	296	89	152	83	420,1	73	407,7	101	224,5	109
2015	321	97	173	94	429	75	402,8	100	218	106

#### 4. Comments collected during interviews

	<b>Eckart</b>	<b>d'Ekker</b>	<b>Breakker</b>	<b>Tivoli</b>
<b>Information</b>	<ul style="list-style-type: none"> <li>- in modelwoning al ingelicht vooraf over info die ze zouden krijgen</li> <li>- planning klopte niet helemaal</li> <li>- ontevreden over voorlichting</li> <li>- de informatie kwam (als je er zelf achteraan ging) van de aannemer, niet van wb</li> </ul>	<ul style="list-style-type: none"> <li>- weinig verwacht door eerdere renovatie</li> <li>- voor renovatie heel duidelijk, tijdens niet zo goed, planning was niet zo gelopen</li> </ul>	<ul style="list-style-type: none"> <li>- eerdere renovatie gehad en had niet zoveel verwacht</li> </ul>	<ul style="list-style-type: none"> <li>- info die we kregen klopte niet met de werkelijkheid</li> </ul>
<b>Time</b>	<ul style="list-style-type: none"> <li>- zelf veel dingen gedaan (afstoffen &amp; inpakken)</li> <li>- iets uitgelopen wat meer tijd kosten</li> <li>- afdekken/opruimen en schoonmaken werd gedaan (niet verwacht) dus zelf niet gedaan.</li> <li>- informatie was duidelijk over wat zelf te doen + tijd</li> <li>- ik had geen idee wat ik kon/moest verwachten. Dat gaf wel eens onzekerheid over het proces</li> <li>- 2 weken -&gt; 2 maanden</li> <li>- overplaatsen van materiaal heeft wat tijd gekost</li> <li>- eerder begonnen</li> </ul>	<ul style="list-style-type: none"> <li>- zelf achter dingen aan moeten gaan</li> <li>- minimaal laten doen maar nasleep heel veel tijd gekost</li> <li>- zelf achteraf nog veel moeten doen</li> <li>- heel veel moeten schoonmaken omdat dat nauwelijks gedaan was</li> <li>- zelf schilderen etc. aannemer/wb deed niks/niks vergoed, beschadigingen, bij ander wel gedaan maar niet hier</li> <li>- achteraf nog veel tijd gekost</li> <li>- wb heeft 0 geholpen met onkosten (leeghalen woning, water/elektriciteit verbruik)</li> <li>- veel tijd aan schilderwerk</li> <li>- niet op tijd klaar, veel te lang</li> </ul>	<ul style="list-style-type: none"> <li>- thuisblijven voor afspraken maar gaat niet door</li> </ul>	<ul style="list-style-type: none"> <li>- veel tijd kwijt aan voorbereiding (bv. Afdekken meubelen) voor werkzaamheden</li> <li>- duidelijk wat er werd verwacht, het hoort er ook bij</li> </ul>
<b>Communication</b>	<ul style="list-style-type: none"> <li>- door andere woningen verwachting gewekt dat aannemer vaak langs zou komen</li> <li>- aannemer kwam vaak langs om alles in de gaten te houden</li> </ul>	<ul style="list-style-type: none"> <li>- wb brieven vol spelfouten, één richtingsverkeer, plan aanhouden &gt; meer op situatie toespitsen</li> <li>- aannemer (zzp'ers) geen actie/communicatie over fouten</li> <li>- alleen kleine werkzaamheden binnen -&gt; niet in de "standaard"</li> </ul>	<ul style="list-style-type: none"> <li>- kwaliteit contact aannemer slecht, afspraken niet nakomen</li> <li>- problemen vaker direct met aannemer besproken</li> </ul>	<ul style="list-style-type: none"> <li>- bereikbaar (telefoon, lang lopen bij woning) als nodig en werd iets mee gedaan</li> <li>- aannemer meer communicatie als iets geregeld moest worden dan met wb</li> </ul>



	<p>- we hebben meer contact met wb gehad door problemen die de aannemer veroorzaakt had</p> <ul style="list-style-type: none"> <li>- aannemer was super brutaal, schreeuwde tegen mijn ouders over afspraken nakomen terwijl hij dat helemaal niet zelf deed</li> <li>- geen communicatie over veranderingen in planning aannemer, wb benaderd als aannemer niet bereikbaar was, wb meer aanwezig mogen zijn</li> <li>- verschillende aannemers, één wel goed, één verschrikkelijk reactie was wel goed</li> </ul>	<p>trein dus veel onduidelijkheden over wanneer, zelf overal achteraan, aanwezig en vervolgens komen ze niet</p> <ul style="list-style-type: none"> <li>- geen communicatie over gemaakte fouten, elkaar de schuld geven</li> <li>- wb-aannemer communicatie slecht, veel communicatie om iets geregeld te krijgen, veel verschillende mensen</li> <li>- hoofd van aannemer top, werklui wat meer last van gehad, communicatie planning</li> <li>- gehandicapt, wb goed meegedacht</li> <li>- communicatie tussen aannemers kon beter, weinig contact met klankbordgroep,</li> <li>klachten/opmerking meer direct met aannemer besproken</li> <li>- communicatie tussen aannemer en wb slecht</li> <li>- reactie bleef soms uit, wilde geen oplossing bieden</li> <li>- start aannemer positief, wel minder, afwerking liet wensen na</li> <li>- slechte communicatie over tijden etc.</li> </ul>			<ul style="list-style-type: none"> <li>- verbouwing verplaatst i.v.m. operatie, invloed gehad op tijdstip onderhoudt</li> <li>- douche/wc jaar eerder uitgevoerd</li> </ul>
<b>Influence</b>	<ul style="list-style-type: none"> <li>- mate van keuze laag, we wilden een hogere wc bijvoorbeeld en zelf opdraaien voor de kosten, werd</li> </ul>	<ul style="list-style-type: none"> <li>- werd niks met wensen gedaan</li> <li>- wb deed gewoon wat ze wilden doen</li> </ul>	<ul style="list-style-type: none"> <li>- klankbordgroep gemist, meer willen meedenken/eigen wensen bekend maken (bv. Enquête),</li> </ul>		

	<p>niet geaccepteerd terwijl in andere huizen mensen dit wel kregen</p> <ul style="list-style-type: none"> <li>- geen invloed op proces alleen op het resultaat, alleen in het begin</li> </ul>	<ul style="list-style-type: none"> <li>- klusuren niet zelf kunnen inzetten, werd bepaald</li> <li>- meegedacht met situatie</li> <li>- alleen keuze optie, daarna deden ze gewoon wat ze moesten doen, geen invloed tijdens in kleine dingen</li> <li>- alleen in het begin wat keuzes gehad</li> <li>- van wb geen nacontrole geweest, slechte service vanuit aannemer, werken onder tijdsdruk</li> <li>- je werkt met mensen, niet met een woning</li> <li>- klankbordgroep (veel verwacht, weinig gehad)</li> <li>- renovatie is in 2 etappes gedaan, was erg fijn</li> <li>- keuzes wel, geen bewoonde staat</li> </ul>	<p>klankbordgroep</p> <p>voornamelijk</p> <ul style="list-style-type: none"> <li>- klankbordgroep heeft ervoor gezorgd dat bv de borstwering hout bleef (esthetiek)</li> </ul>	<ul style="list-style-type: none"> <li>- wb doet uiteindelijk toch gewoon wat ze zelf willen, aannemer probeerde wel mee te werken maar werd door wb tegen gehouden</li> <li>- aangegeven dat woning in dezelfde staat zou blijven, invloed uitgeoefend op extra werkzaamheden</li> </ul>
Nuisance	<ul style="list-style-type: none"> <li>- zelf veel gedaan dus minder verwacht, onzorgvuldig omgaan/spullen achterlaten</li> <li>- huis voor huis zorgt voor veel stof overlast</li> <li>- fijn om zelf tijd te kunnen kiezen maar wel veel overlast daardoor</li> <li>- ongemak door huis voor huis maar geen erge overlast</li> <li>- rekening gehouden met problemen kinderen</li> <li>- we zijn i.v.m. de huisdieren overdag weinig thuis geweest. Alles werd netjes achtergelaten en</li> </ul>	<ul style="list-style-type: none"> <li>- minimaal laten uitvoeren maar toch veel overlast gehad</li> <li>- afwerking was slecht, alles tegelijk in de woning dus geen ruimte voor opslag</li> <li>- uit huis geweest met werkzaamheden</li> <li>- veel tegelijk</li> <li>- onduidelijk wat wanneer werd gedaan, gestructureerde verwacht</li> <li>- werkzaamheden bij koud weer, geen verwarming, tijdelijke keuken buiten, geen water</li> </ul>	<p>eerdere renovatie gehad en toen veel overlast gehad dus veel verwacht</p>	<ul style="list-style-type: none"> <li>- veel overlast, begin vroeg en veel dingen verspreid over verschillende dagen, gebruik gemaakt van rustwoning na overleg met wb</li> <li>- iets meer compensatie verwacht</li> <li>- weet dat het komt maar toch tegen gevallen</li> </ul>

	<p>geluidsoverlast was daardoor minimaal</p> <ul style="list-style-type: none"> <li>- vooral door lengte tijd werd het erg ongemakkelijk</li> <li>- veel dingen kapot (kast, muren)</li> <li>- schema van overlast gaf veel duidelijkheid van de te verwachte overlast</li> <li>- onzorgvuldig te werk gegaan/opruimen, per woning</li> <li>- doorgang geblokkeerd, verschillende begintijden verschrikkelijk</li> <li>- routes waren geblokkeerd</li> <li>- stof, herrie, verschil begintijd heeft veel overlast veroorzaakt</li> <li>- doorgang versperd door steigers, overlast hoort erbij</li> <li>- jammer dat het hele blok niet gedaan is</li> <li>- veel overlast gehad, ook de planning klopte niet altijd, heel veel stof en rotzooi, elke keer stroom van mij gebruikt enz.</li> </ul>	<ul style="list-style-type: none"> <li>- 4 weken stellage in woonkamer gehad vanwege planning die niet zo was gelopen</li> <li>- waren niet thuis</li> <li>- in de schuur plassen, in de straat douchen, wb had ons niet thuis mogen laten zitten</li> </ul>			<ul style="list-style-type: none"> <li>- voor start onderhoud, wc/keuken en badkamer al gedaan omdat aankondiging veel eerder was dan start</li> <li>- afspraken niet na gekomen</li> <li>- vergoeding gebruikte stroom</li> <li>- wb heeft uitgelegd dat thermostaat max 2 graden verlaagd</li> </ul>
Process	<ul style="list-style-type: none"> <li>- achteraan lopen door fouten die gemaakt zijn door aannemer. Nog steeds niet helemaal verholpen</li> <li>- huis voor huis zorgt dat tevredenheid onvoldoende is</li> <li>- voorbereiding was goed maar uitvoering slecht, en dat telt zwaarder</li> <li>- had efficiënter gekund</li> </ul>	<ul style="list-style-type: none"> <li>- langdurig, snap niet dat mensen in huis moesten blijven in geval van keuken etc.</li> <li>- niet serieus genomen, klachten werd niet of nauwelijks naar geluisterd</li> <li>- zelf veel moeten aangeven, veel fout gegaan</li> <li>- werk goed uitgevoerd</li> </ul>	<ul style="list-style-type: none"> <li>- de tijdsduur en communicatie daarover</li> <li>- onderhoud brengt veel met zich mee</li> </ul>		

	- veel arbeid van mezelf, ook vooraf, wel duidelijk geïnformeerd	<ul style="list-style-type: none"><li>- kleine verbetering omdat alleen buiten gedaan is</li><li>- halve renovatie, minimaal maatregelen uitgevoerd</li><li>- ander type gezien (film, modelwoning)</li><li>- isolatie vloer valt heel tegen</li><li>- keuken nog steeds niet goed</li><li>- sommige dingen wel, sommige niet (kleinere keuken en wc), wel duidelijk wat er ging gebeuren</li></ul>	<ul style="list-style-type: none"><li>- de vloer is niet geïsoleerd (begane grond) en bij de ramen en deuren voor en achter is nog resultaat te behalen</li><li>- jammer dat ze geen zonnepanelen hebben geplaatst</li><li>- nog steeds veel last van tocht bij de voeten</li></ul>	<p>moet worden s 'nachts om kosten te besparen.</p> <ul style="list-style-type: none"><li>- afspraken niet nakomen</li><li>- je moet er zelf veel achteraanlopen</li><li>- 10euro vergoeding weegt niet op tegen gemaakte kosten (elektra/water)</li><li>- sommige werkzaamheden hebben gezorgd dat gebruik van de woning verslechterd is.</li></ul>
Measures	<ul style="list-style-type: none"><li>- had zelf al aangegeven wat gedaan moest worden en is ook gedaan</li><li>- luchtsysteem zorgt voor stof door woning</li><li>- we hadden al een voorbeeld gezien dus we konden het goed inschatten, extra badkamer en wc, materialen die gebruikt zijn, zijn kwalitatief niet goed, afwerking steeds opnieuw omdat het slecht was</li><li>- schade door werkzaamheden, huis voor huis</li><li>- zelf isolatie gedaan al voor de renovatie</li></ul>	<ul style="list-style-type: none"><li>- redelijke hoge huurverhoging, hadden verwacht dat het inbegrepen zou zitten</li><li>- verplaatsen van een pijpje koste 3euro, dat vonden ze niet ok</li><li>- huur: acceptabel bedrag, mede door subsidie</li></ul>	<ul style="list-style-type: none"><li>- huur: % gaat wel snel</li><li>- spouwisolatie verwacht niet gebeurt vanwege oude renovatie</li><li>- energie bepaal ik per jaar, nog geen zicht op</li></ul>	<ul style="list-style-type: none"><li>- verbeterd maar mocht ook wel na 5 jaar</li></ul>
Costs	<ul style="list-style-type: none"><li>- nog niet helemaal duidelijk wat besparing wordt, eind jaar helemaal duidelijk</li><li>- vorige verbouwing meer verhoging gehad</li><li>- dat overzie ik pas bij de eindjaarafrekening</li><li>- het is duurder maar minder dan verwacht</li></ul>			

	<ul style="list-style-type: none"> <li>- huur: vind het een behoorlijke verhoging</li> <li>- van tevoren afgesproken: geen huurverhoging</li> </ul>			
<b>Comfort</b>	<ul style="list-style-type: none"> <li>- luchtsysteem veel lawaai</li> <li>- huis is eindelijk warm</li> <li>- goed uitgelegd en modelwoning</li> </ul>	<ul style="list-style-type: none"> <li>- vloerisolatie zorgde voor problemen houten vloer dus niet gedaan</li> <li>- HR+ glas zou zorgen voor warmte maar merken niks</li> <li>- voornamelijk door eigen werkzaamheden achteraf weinig verschil</li> </ul>	<ul style="list-style-type: none"> <li>- ongewijzigd</li> <li>- geen vloerisolatie, nog steeds kouden voeten</li> <li>- zolder heel erg verbeterd, geen verschil in temperatuur tussen zolder en rest van het huis</li> </ul>	<ul style="list-style-type: none"> <li>- wc en gang meer comfort, woonkamer minder</li> <li>- kouder dan voorheen</li> <li>- nog steeds koud in de woonkamer</li> <li>- niks verandert</li> <li>- overkapping heel fijn</li> </ul>
<b>Result</b>	<ul style="list-style-type: none"> <li>- toch nog extra dingen nodig (douche wand, fornuis)</li> <li>- extra uitleg over gebruik werkzaamheden</li> <li>- naderhand wel tevreden, is mooier en beter geworden</li> </ul>	<ul style="list-style-type: none"> <li>- uitstraling wijk verbeterd</li> <li>- woningen hadden beter gesloopt kunnen worden, te oud/muf</li> <li>- geen verschil met voor renovatie</li> <li>- zolder geen echte kamer door deur</li> </ul>	<ul style="list-style-type: none"> <li>- verwacht/gehoopt op zonnepanelen</li> <li>- gehad over zonnepanelen maar scheen niet mogelijk te zijn i.v.m. bomen etc.</li> <li>- veel last van bladeren van de bomen, regenpijpen zitten nog steeds verstopt</li> </ul>	
<b>Renovation</b>		<ul style="list-style-type: none"> <li>- lager door slechte afwerking</li> <li>- tegen bouwvak aan, dus veel dingen snel en haastig afgehandeld, fase 3 anders dan fase 1</li> <li>- te lang geduurd</li> </ul>		

## 5. Energy consumption data

Case	Actual energy consumption														
	Before			After							Change				
	Primary	Electricity	Gas	Primary	Electricity	Gas	Yield PV	Ratio PV	WoonConnect	Heat pump	Primary	Electricity	Gas	Primary grid usage	Electricity grid usage
	MJ	kWh	m3	MJ	kWh	m3	kWh	%	Independent/ housing corporation	yes/no	%	%	%		
3	80725	3524	1935	70055	2965	1688					-13%	-16%	-13%		
3	72033	5528	1482	65415	3384	1514					-9%	-39%	2%		
3	56918	1678	1447	50546	1535	1280					-11%	-8%	-12%		
3	70600	2196	1783	67972	2324	1695					-4%	6%	-5%		
3	103027	4675	2451	95346	4608	2239					-7%	-1%	-9%		
3	81267	1507	2156	80077	1429	2131					-1%	-5%	-1%		
3	105216	2177	2769	62187	2105	1553					-41%	-3%	-44%		
3	110570	6092	2520	62150	4035	1354					-44%	-34%	-46%		
3	86706	3574	2100	69236	3188	1642					-20%	-11%	-22%		
3	113503	3706	2848	73219	3551	1718					-35%	-4%	-40%		
4	74758	5389	1574	35006	5467	436				yes	-53%	1%	-72%		
4	107316	3598	2683	48076	2794	1081				yes	-55%	-22%	-60%		
4	100014	3236	2512	34820	3259	656				yes	-65%	1%	-74%		
4	81501	2530	2058	37481	2422	818				yes	-54%	-4%	-60%		
4	59067	3128	1359	28421	2320	571				yes	-52%	-26%	-58%		
4	53401	2587	1254	42091	2559	935				no	-21%	-1%	-25%		
4	57746	3996	1233	41684	5425	630				no	-28%	36%	-49%		
1	55117	1145	1450	33558	1049	847	1635	156%	housing corporation		-39%	-8%	-42%	-50%	-151%
1	51394	1653	1292	39986	1699	963			housing corporation		-22%	3%	-25%		
1	65311	2795	1571	34567	3071	668	1635	53%	independent		-47%	10%	-57%	-56%	-49%
1	66655	1779	1713	52974	1511	1352	2589	171%	independent		-21%	-15%	-21%	-35%	-161%
1	49955	1635	1253	56745	1394	1471			housing corporation		14%	-15%	17%		
1	80884	2058	2089	64433	1756	1652	1635	93%	independent		-20%	-15%	-21%	-28%	-94%
2	44175	1298	1123	23661	957	575	1534	160%			-46%	-26%	-49%	-59%	-144%
2	53354	2076	1305	41549	2027	974					-22%	-2%	-25%		
2	53229	2405	1267	34022	2279	734					-36%	-5%	-42%		
2	48697	2141	1166	35034	1813	811					-28%	-15%	-30%		
2	71864	1105	1930	38963	1104	995					-46%	0%	-48%		
2	52909	1673	1333	37062	1611	889					-30%	-4%	-33%		

Case	Theoretical energy consumption																
	Energy label					Energy index			Energy consumption								
	Before	After	Change			Before	After	Change	Primary			Electricity			Gas		
			Min	Max	Av				Before	After	Change	Before	After	Change	Before	After	Change
			%	%	%			%									
3	E	D	0%	-25%	-13%	2,23	2,03	-9%									
3	D	A	-34%	-61%	-49%	1,97	1,16	-41%									
3	D	B	-23%	-42%	-33%	2,04	1,27	-38%									
3	D	A	-34%	-61%	-49%	1,98	1,13	-43%									
3	E	C	-15%	-41%	-29%	2,23	1,43	-36%									
3	G	C	-34%	-72%	-58%	2,46	1,42	-42%									
3	G	C	-34%	-72%	-58%	2,51	1,41	-44%									
3	G	C	-34%	-72%	-58%	2,46	1,44	-41%									
3	D	C	-1%	-33%	-18%	1,91	1,41	-26%									
3	E	B	-34%	-50%	-42%	2,13	1,26	-41%									
4	C	A	-15%	-55%	-37%	1,68	1,01	-40%									
4	C	A	-15%	-55%	-37%	1,67	0,9	-46%									
4	C	A	-15%	-55%	-37%	1,7	0,94	-45%									
4	C	A	-15%	-55%	-37%	1,67	0,92	-45%									
4	C	A	-15%	-55%	-37%	1,79	0,92	-49%									
4	C	A	-15%	-55%	-37%	1,65	1,13	-32%									
4	C	A	-15%	-55%	-37%	1,64	0,93	-43%									
1	D	A+	-56%	-71%	-64%	1,97	0,68	-65%	98286	44198	-55%	1012	1359	34%	2529	900	-64%
1	E	A+	-62%	-75%	-69%	2,11	0,67	-68%	81605	43877	-46%	1087	1751	61%	2035	788	-61%
1	D	A+	-56%	-71%	-64%	1,88	0,67	-64%									
1	D	A++	-67%	-100%	-85%	1,96	0,5	-74%									
1	D	A	-34%	-61%	-49%	1,96	1,01	-48%									
1	D	A+	-56%	-71%	-64%	1,89	0,72	-62%	92617	44508	-52%	1297	1244	-4%	2293	939	-59%
2	D	C	-1%	-33%	-18%												
2	E	B	-34%	-50%	-42%												
2	G	B	-48%	-76%	-66%												
2	F	B	-42%	-55%	-49%												
2	E	B	-34%	-50%	-42%												
2	F	B	-42%	-55%	-49%												