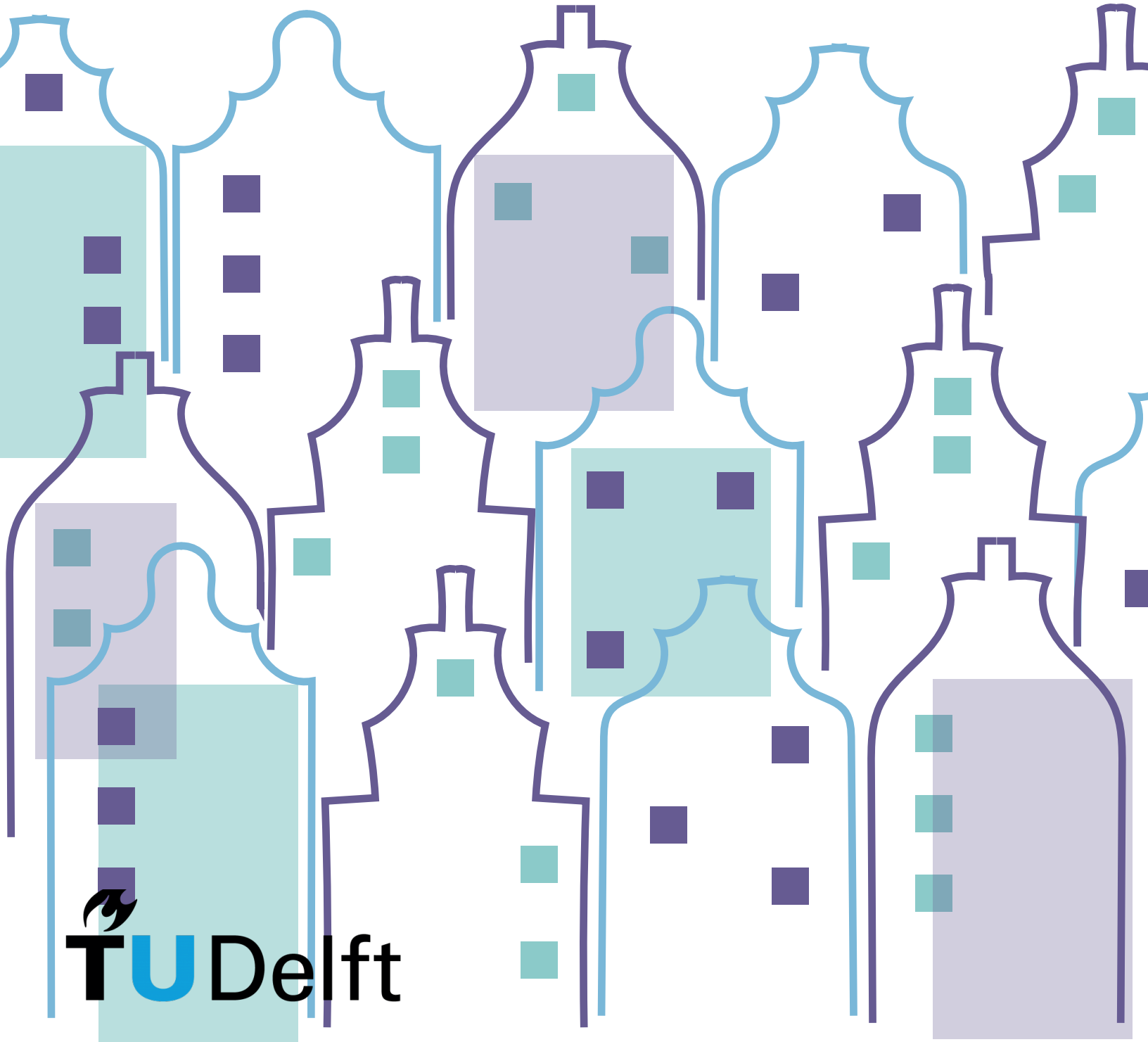
Business model innovation to enable energy efficiency in Dutch residential buildings

Carolina Bedocchi



TU Delft

Business model innovation to enable energy efficiency in Dutch residential buildings

by

Carolina Bedocchi

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Cometee members:
Hanieh Khodaei, TU Delft, TPM, daily supervisor
Kas Hemmes, TU Delft, TPM, supervisor
Henk Visscher, TU Delft, Architecture and the Built Environment, chairperson

TU Delft

DE ENERGIEBESPAARDERS

EXECUTIVE SUMMARY

In the Netherlands, the residential building sector accounts for 20% of energy consumption and 14% of carbon emissions. To reach the ambitious National targets of decreasing energy consumption and to stop this sector's reliance on natural gas, a wide renovation of the building stock is needed.
Residential buildings' energy performance has to improve, approximately 7 million dwellings need costly renovations. To meet the National targets the number of yearly renovations should steeply increase from how it is currently.

This research makes use of the theories of business model and business model innovation to tackle this issue, evaluating how companies offering energy efficiency renovations should adjust their business model in order to improve their effectiveness, therefore unlocking energy efficiency renovations for Dutch residential buildings. This study is one of the first to investigate this topic relative to the Dutch market.
The thesis report contributes to the studies and research about business model and business models innovations to stimulate energy efficiency in residential buildings.

A literature research was conducted to compare the current BM archetypes for energy efficiency renovations developed so far, the available technologies for energy efficiency renovations and the barriers currently blocking these renovations. Further data was collected from homeowners, the end users by performing a survey with 100 respondents, companies, the sellers, and policy makers, through 12 semi-structured interviews.

The research has pointed out that the main business models adopted by Dutch companies offering energy efficiency renovations to residential buildings are One-stop-shop, where one company manages different energy efficiency installations for a dwelling, and Atomised market model, where companies are specialised in one single energy efficiency measure. The main findings show that the barriers slowing down the process of renovations and blocking companies in adopting emerging business model are due to lack of collaboration between companies and stakeholders, lack of political support to stimulate a market for energy efficiency in residential buildings, the high cost of renovations and behavioural problems that dissuade homeowners in purchasing energy efficiency products for their dwellings.

The thesis argues that the above described barriers could be overcome by companies through business model innovation, changing their current value proposition and the way they deliver, create and capture value. Innovative business models are characterised by the possibility of offering complete energy efficiency renovations together with financing options, through one only contact point, resulting in a offer of energy efficiency measures-as-a-service, long term repaying contracts which are structured on the base of the predicted savings from the energy bills thanks to the energy efficiency improvements of the dwelling. However this option is still quite challenging for complete renovations to dwellings due to the current high cost of technologies and

energy prices. The empirical study's main results show that companies, governmental parties and finance provider should improve their collaboration in order to enable energy efficiency in Dutch residential buildings.

Different practitioners can benefit from the findings and suggestions of this study. This research advises Governmental entities to change to a system in which financing options to stimulate energy efficiency within households are offered, increasing collaboration with companies expert in energy efficiency renovation in order to make finance more accessible to homeowners.
Furthermore, this study adds value in managerial knowledge, giving practical advice on how to change companies' business models and organise energy efficiency renovation for Dutch residential buildings. Advising on how companies offering energy efficiency renovations could allow for financing options to be attached to the building instead of the homeowner, or to allow for a transferable contract, to overcome issue linked to homeowners having relocating plans. The idea of having renovations on a neighborhood level appeared to be a success between homeowners that have undertaken the survey presented during this research, therefore is advisable to companies to look into the possibilities of managing collective renovations for neighborhoods.

ACKNOWLEDGEMENT

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Carolina Bedocchi
Delft, November 2019

CONTENTS

LIST OF SYMBOLS

BM	Business model
BMI	Business model innovation
ESCO	Energy service company
EPC	Energy performance contracting
ESC	Energy supply contracting
EPBD	Energy performance of building directive
IEE	Intelligent Energy Europe
ISDE	Investeringssubsidie duurzame energie
nZEB	Nearly zero energy building
OSS	One-Stop-Shop
TLBMC	Triple layer business model canvas

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

"As Europeans, we want to leave a healthier planet behind for those that follow. We obviously cannot turn a blind eye to the climate challenge; we must look to the future."

Jean-Claude Juncker (September 2018)
President of the European Commission

In one of the latest releases of the European Commission : *"A Clean Planet for all"*[35] Europe confirms its commitment to globally lead the climate action. Europe committed to the ambitious plan of achieving a net-zero greenhouse gas emission by 2050.
To achieve this target multiple actions need to be taken in every sector in which energy is consumed.
For my thesis I decided to focus on the building sector, that today accounts for 40% of energy consumption and 32 % of CO_2 emissions in Europe [35], energy efficiency is predicted to play a central role in reducing the energy demand of this sector.
This project will study how can business model innovation enable energy efficiency in Dutch residential buildings.

1.1 BUSINESS MODEL AND BUSINESS MODEL INNOVATION FOR ENERGY SERVICES

Business model (BM) has been defined as *"a conceptual tool"*(Osterwalder,2005)[82] able to express, through its elements and their interconnections, the business logic of a specific firm. Besides, it is able to describe also the value offered to the customers, the structure of the firm and the network of partners to create and deliver value and how the firm captures value. [41].
When there is a change in the configuration of the BM it is considered: Business model innovation (BMI); although different definitions were given on this topic. The BMI working definition provided by Geissdoerfer et al.(2018) [44] defines it as *"the conceptualization and implementation of new business models."*
This can comprise the development of completely new BM, the addition of new BM, the diversification into additional ones or the transformation of one BM into another. The innovation can affect completely or only single elements of the BM. [44]
The awareness about climate change has led to significant modifications in the way businesses are structured, especially in the energy sector, in which many companies had to reconsider their BM[53]. Studies regarding BMI in the energy sector have pointed out common features, such as long-term agreements, win-win formula and financial innovation [107].
Adding *financing options* to the value capture of the BM has the possibility of improving the value proposition of the company, giving incentives for purchasing a certain product or service, overcoming the issue of the up-front payment[52].
Companies that switch from only selling a product to providing a service-based

business, are offering *Long-term agreements*.
Therefore the business changes by not being product-focused anymore but customer-focused [68]. By doing so, the company removes the issue of up-front payments. As a result, customers immediately perceive the benefit generated by the service, and for the firm this is convenient because it receives constant payments throughout the agreement; this is known as a *Win-win formula* [107].
The concept of business as-a-service is used in the energy sector to lease technologies instead of selling them, making them more accessible [107].
In the energy sector innovation, energy efficiency plays an important role. Improving the energy efficiency of a building leads to positive benefits to the environment and improved comfort of the building. To do so, efficient management of the resources consumed is needed, and better results are found when investing in energy services[70].
The commodities used and demanded by a dwelling, (energy, heat generation sources, etc.) are "energy services". The term includes also the activity needed in order to guarantee such commodities therefore it includes energy auditor, project design and implementation of retrofit technology, the maintenance and the operation activities [6].
Firms can be specialised in only a few activities, therefore only delivering one product or offering a certain service. On the other hand, it is possible to find companies offering energy services as a whole package, organizing everything for building renovations, from energy audit to installation and maintenance [16]. The market for energy services in the Netherlands has not fully developed yet, the demand is still quite low compared to what the Dutch Government aims to achieve[54]. Moreover, in the Netherlands the number of companies offering energy services is still at an immature phase, especially when concerning retrofit to residential buildings [113].
Evaluating new possible BMI for companies working in this market could help in filling the gap between demand and supply of energy efficiency measures.[16]

1.2 BACKGROUND

In the building context the term "energy efficiency" refers to the final use of energy by the dwelling , hence the light used, radiated thermal heat or processed heat divided by the actual amount of energy consumed by the end-customer to achieve these comforts. [64]. Therefore the less energy or fuel consumed by the dwelling to produce the same "comfort" deriving from light, heat and other final applications, the higher the energy efficiency of the building will be.

Ideally, every building could have a high energy efficiency, through energy services renovations, although most of the building stock existing today are still suffering of low energy efficiency. The difference between the current energy use and the optimal one is defined as "Energy efficiency gap" [84] Given that most of the buildings of 2050 are already existing today, a large renovation action is needed in order to close the "energy efficiency gap" and to meet the European sustainable targets[35].
To reach the targets, it was estimated that the annual renovation rate should shift from 1%, as it currently is, to 3%. Although the European Commission has released some funds to building renovations there is a financing gap that needs to be covered by private investors [96].

In the Netherlands the residential sector accounts for 22% of the final energy demand, as depicted in figure 1.1, and 14% of CO_2 emissions [18].The Netherlands aims in to decrease the energy consumption by 1.5% per year, as included in the Klimaat Akkoord (2019) [54].

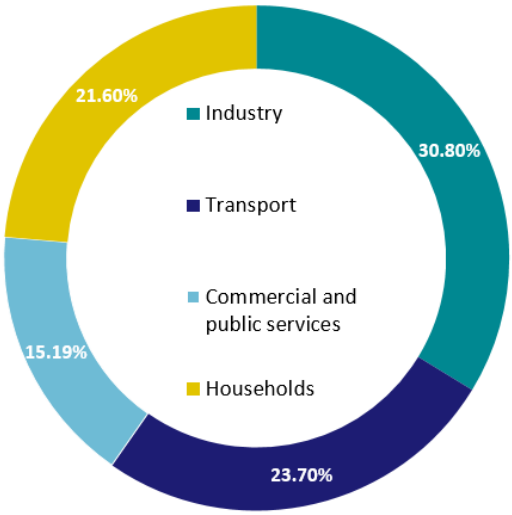

Figure 1.1: Percentage of final energy consumption by sector, data from Eurostat,2017 [38]

European policies regarding energy performance in building are existing since 2002, the European Union has established directives in order to strengthen building regulation and to implement energy performance certification for buildings, through the energy performance directive for buildings, EPBD, [36].
Through the second released EPBD, the definition of nearly Zero-energy building, nZEB was given. A nZEB is a building with very high energy performance, in which the low amount of energy required is cover partly by renewable sources[37].
The directive aim was to give obligations for new buildings, built from 2020, to be nZEB, and to advice on polices for the encouragement of renovations of already existing building to nZEB.
For instance, according to the EPBD, Member states should make compulsory to provide the energy performance certificate of a house in the moment of advertisement for its sale, set minimum energy performance requirement in newly built houses and provide national financial option to stimulate energy efficiency of buildings[37].

The Dutch first energy performance regulations for residential buildings were set in 1995. The performance coefficient bonded to the building is a non-dimensional value. To calculate this value the total expected energy used for heating, hot water, cooking and electricity is calculated and corrected by a neutralisation factor for the size of the dwelling [92]. The energy performance coefficient was tightened over the years, in 2020 the ultimate regulation linked to the EPBD will make sure that all new buildings will be nearly zero-emissions buildings, nZEB[61].
The implementation of renewables in buildings contributes to a better energy coefficient [61]. Moreover, from 2015 onwards each house of the Netherlands has received a temporary "label" going from G to A++ indicating the efficiency of the house, depending on the year of construction and its predicted energy consumption [30]. When the owner of a building decides to sell it, the energy label will have to be proved and provided to the potential buyers.

Despite all the above listed regulations, still a high percentage of Dutch households possess a low energy label, figure 1.2.

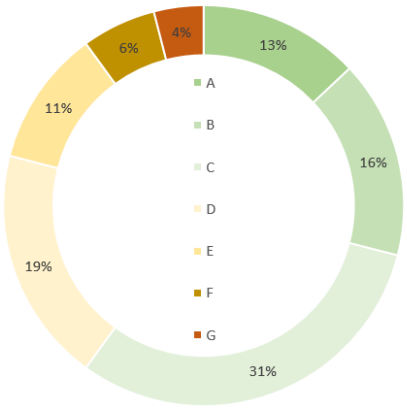

Figure 1.2: Energy labels in the Netherlands, 2017 [88]

On one hand, the regulations will be very helpful to shape the future residential sector, in order to stop the country's reliance on natural gas, that is currently the first fuel source in the country [39].

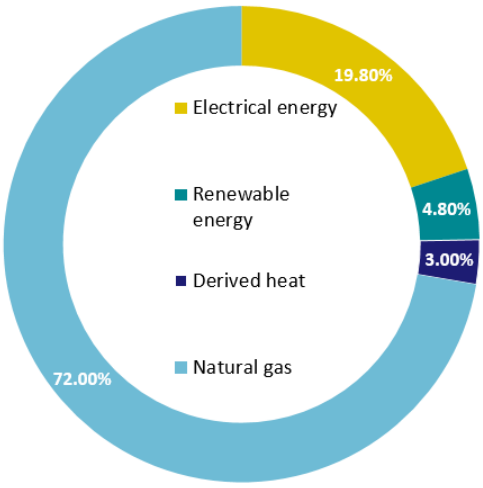

Figure 1.3: Energy consumption per fuel by households, Cbs

On the other hand, there is still a high number of inefficient buildings built before the directives were set, more than 6 million [19], and there are no obligations for homeowners to improve the energy efficiency of their house [60].

1.3 PROBLEM STATEMENT

A large part of the built environment of the Netherlands is energy inefficient, therefore leading to the need for a large scale renovation [54].
Increasing energy efficiency, and the use of decentralised energy generation technologies,

such as solar panels, and energy-storing systems play a central role in cutting down the consumption of energy of this sector [60].
Moreover, to decrease buildings' greenhouse gas emissions, it is urgent to shift the heating system from natural gas, which is the most common fuel source used in the Netherlands, to new heating technologies such as the use of geothermal energy, heat pump systems or district heating. [54]
Renovating a dwelling will not only bring a positive impact on the environment, indeed, it would increase the perceived comfort inside the building by the occupants and lower the bills due to the consumption of fuel and electricity [16].
So far the demand for home retrofits has been lower than what it should be in order to reach the Paris agreement (1% every year instead of 3%)[96].
Therefore, despite the need for large scale renovation, the market for dwelling retrofit still has not reached a high demand[113].
Since for residential buildings, individuals are left to the decision whether to renovate or not, one could argue that the current firms operating in the energy service market should innovate their business model, in order to reach a higher amount of customers [79].

1.4 CONTRIBUTION

Previous studies discussed different BM and BMI configuration regarding the energy services market. However, this research is one of the first studies regarding Dutch energy service market dealing with privately owned households.
Previous to this research, between 2012 and 2015 a project founded by IEE, COHERENO, was performed and had the aim to stimulate the collaboration between enterprises to adopt innovative business models to develop nZEB renovations in owner-occupied single family homes; the Netherlands was one of the five countries taking part of this project.
The outcomes pointed out that the market for energy efficiency renovation was in an emerging phase and, for a further development, it was fundamental for the supply chain to be more compact. The research depicted new types of actors, such as Ones-Stop-Shop, ESCOs, renovations advisors and project managers, that could potentially create opportunities for building renovations [100].
This research aim is to depict which BMI can best help Dutch companies, operating in the energy efficiency renovations market, to overcome the main problems currently affecting it.
The research gathers the available knowledge from previous studies and focuses on the particularities of the Dutch market, considering current issues faced by companies that have adopted new BM like the ones depicted in the COHERENO project, evaluating potential stakeholders of the market and depicting the barriers affecting Dutch homeowner in renovating their homes.
Thanks to this work, value will be added in the academic community, by enriching research on BM and BMI in the energy efficiency renovation market. Moreover, value will be added to managerial knowledge, and potentially could be applied in practice, indeed the most suited BMI for Dutch companies operating in the energy efficiency renovation market will be depicted and discussed, and recommendation will be provided on how

to adapt the BMI, enabling in the further development of energy efficiency renovation market.

1.5 RESEARCH QUESTIONS

BMI could allow companies dealing with energy services to overcome the main barriers holding back customers from investing in building renovation. This Master thesis aims to identify a successful business model for companies providing energy services to Dutch homeowners, to overcome the major barriers that this market suffers.

The main elements for the success of the business model will be investigated by following the main research question:

How business model innovation can help Dutch companies offering energy efficiency renovations for residential building in being more effective?

Investigated with the use of the following subquestions:

1. What are the current business models in the energy efficiency renovation market for residential buildings?
    a) What are the current business models in the Dutch energy service market?
    b) Who are the main stakeholders involved?
2. What are the barriers for the implementation of energy efficiency renovations in residential building?
    a) Which BMI best fits Dutch companies offering energy efficiency renovations for residential buildings?
3. What are the current technologies employed in energy efficiency renovations for Dutch residential buildings?
    a) What are the enabling technologies that best fit the BMI for Dutch companies offering energy efficiency renovations?

1.6 THESIS STRUCTURE

The thesis is structured as follow: the methodology selected to conduct this project can be found in chapter 2, where the main research methodology, design and data collection method are described. The chapter ends with the structure of the research strategy. In chapter 3 the literature review is reported. It is divided into four sections, which are researching BM and BMI, BM for energy efficiency renovations, the available technologies to achieve energy efficiency renovations and the barriers blocking this market.
The results from the empirical study are reported in chapter 4. Discussions about the gathered results are found in Chapter 5 and the thesis ends with a chapter describing the conclusions of the research, the limitations of the research and a personal recommendation.

2 METHODOLOGY

This chapter provides a detailed overview of the research methodology, research design, data collection method and research strategy undertaken to answer the research questions. Resulting in the methodology of this research project.

2.1 RESEARCH METHODOLOGY

Saunders et al.,(2009) [93] have classified the purpose of a research in three kinds, exploratory, descriptive and explanatory.
An **Exploratory research** aims to understand a problem, assessing it from a different perspective in order to get new insights [89].
For **Descriptive research** the scope of research is to seek an accurate description of persons, events or situations. For this typology of research is important to have a clear picture of the phenomena before collecting data [93].
Explanatory research studies the possibilities of relations between variables [93].

For this project a combination of a descriptive and exploratory research was chosen. Indeed, the problem of energy efficiency in residential building was assessed first through a descriptive research depicting the barriers affecting energy efficiency renovations and the existing business model dealing with energy services. Secondly a exploratory research is made on the aim of expanding the current understanding of the problem depicted through the descriptive research.
The next phase of defining a research methodology is to appropriately select the research strategy in order to answer to the research questions reported in section 1.5 *"Research questions"*. For this research the strategies were **Survey** and **Multiple case study**.

2.2 RESEARCH DESIGN

"A research design is the logic that links the data to be collected, and the conclusion to be drawn, to the initial question of study" (Yin,1998) [118].
This research was structured by following the elements described by Yin (1998)[118]:

- Study's questions
- Unit of Analysis
- The logic linking the data to the research questions
- The criteria for interpreting the findings

STUDY'S QUESTIONS

The study questions that will be assessed in the empirical study are of exploratory

nature.
These questions have already been described in the section 1.5 *"Research questions"*.

UNIT OF ANALYSIS

The unit of analysis was based on the definition of energy service by selecting companies operating in the Netherlands and offering a complete package of energy services. To fully answer the research question the unit of analysis was extended to actors involved in the energy services market, and often key partners of companies operating in the energy service market. Homeowners, as potential customers, were included as unit of analysis.

THE LOGIC LINKING THE DATA TO THE RESEARCH QUESTION

The qualitative data from the case study was interpreted by a cross-link analysis[91]. While the data from the survey was interpreted using a quantitative approach[93].

THE CRITERIA FOR INTERPRETING THE FINDINGS

The research would first involve a literature study, on the base of the first findings the data from the case studies and the survey will be compared and interpreted.

2.3 DATA COLLECTION

The data was collected through different methods: literature review, semi-structured interviews and a survey. In this section the methods are described.

Literature review

The objective of the literature study was to understand fully the problem and to investigate to what extent the research for BMI in the energy efficiency renovation market was developed.
The main barriers for the energy efficiency renovations found, were the base to develop the multiple case study and the survey's questions.
The main information sources were articles, thesis and academic books. Moreover documents released by the Dutch government were important in order to analyse the Dutch situation regarding energy efficiency renovation for the residential sector.
An analysis of the definition of BM and BMI was conducted. So that the framework of BM and BMI could be used in the further stages of the research.
Finally, the available technologies for energy efficiency renovations were depicted and their level of development was described.

Case studies: Semi-structured interviews

After defining the unit of analysis for the multiple case study 12 interviews were conducted. The interviews can be divided into two groups: Companies and Actors. The actors can be divided in subgroups of Policy makers, Banks and Municipalities. The interviews were structured as follows: first, an introduction about the interviewed, depicting the BM model used, if applicable. Secondly, their location inside the ecosystem of the Dutch energy services market was described. Finally, open questions

were assessed about the barriers and opportunities perceived. A first pilot case study was conducted with the company "De Energiebespaarders" in order to test the interview questions, to see if they were understandable and to make sure that the length of the interview was not too long.
Thereafter, successive interviews were conducted. The table below summarises the data collected.

Table 2.1: Summary of interviews

Group	**Name of Company/ Stakeholder**	**Interviewed**	**Length of interview and medium**
Company	De Energiebespaarders	Founder	30min, face-to-face
Company	ESCOplan	Development director	30 min, telephone
Company	OVVIA	Director	40 min, face-to-face
Company-Initiative	WarmteKoude Den Haag	Project coordinator	1 hour, face-to-face
Policy Makers	Ministry home affairs	Senior policy officer energy transition builtr environment	1h 30 min, face-to-face
Policy Makers	Ministry economic affairs and environment	Senior policy advisor	1 hour, face-to-face
Municipality	Eindhoven	Project manager	40 min, telephone
Municipality	Economic board Utrecht	Manager financial instruments	40 min, telephone
Municipality	Cooperation within Nijmegen, Arnhem, Leeuwarden and Haarlemmermeer	Project manager	40 min, telephone
Bank	ABN AMRO	Head of the project finance team	1 hour, face-to-face
Bank	Triodos	Head of Private Banking Mortgages	1 hour, face-to-face

Survey to homeowners

The majority of data of the survey was quantitative. The survey was divided in 4 parts: first general information about the person taking part of the survey.
Following, a section dealing with the degree of knowledge of the interviewed person about the financing options for housing renovations. A third part of the survey was formed by questions for interviewed that have had renovations to their dwelling, therefore analysing how they organised it, what were the main barriers faced and their opinion about the process. People that had not renovated their dwelling received questions in order to valuate their barriers.
The survey ends with a section regarding value propositions, delivery and creation of BM, that for what emerged from the literature can enable, energy efficiency renovations.
The survey has closed and open question, in order to have a quite broad number of interview. The survey was first held at the station of Utrecht since a lot of people from different part of the Netherlands come through this station. Secondly it was sent through a Facebook page with mainly Dutch homeowners on.
The survey was performed by 100 respondents.

Evaluation of technologies

In order to study if the possibility of paying back the installations through the generated energy savings is feasible, calculations were performed. Evaluating the main technologies for housing renovations, listed in section 3.3, their cost and their influence on the energy consumption of the dwelling, and the generated reduction of CO_2 emissions.

Answer to research questions

Table 2.2 reports which data collection method was used to answer the different research questions.

Table 2.2: Methodology on how to answer research sub-questions

Sub-question number	Sub-question	Data collection Method
Q1.	What are the current business models in the energy efficiency renovation market for residential buildings?	Literature study
Q1.a	What are the current business model in the Dutch energy service market?	Semi-structure interviews, survey
Q1.b	Who are the main stakeholders involved?	Semi-structured interviews
Q2.	What are the barriers for the implementation of energy efficiency renovations in residential buildings	Literature review, survey semi-structured interviews
Q2.a	Which BMI best fits Dutch companies offering energy efficiency renovations for residential buildings?	Literature review, survey, semi-structured interviews
Q3.	What are the current technologies employed in energy efficiency renovations for Dutch residential buildings?	Literature study
Q3.a	What are the enabling technologies that are best fitting the BMI for Dutch companies offering energy efficiency renovations?	Valuation of Technologies

2.4 RESEARCH STRATEGY

Figure 2.1 summarizes the research strategy followed. The research was divided in 5 steps. First research design, in which the problem was analysed and research questions were elaborated on. Subsequently, a literature study was performed using a combination of academic and non-academic studies. In phase one the survey and the multiple case study, through interviews, were performed and results were gathered and analysed. Following, in phase two the calculations dealing with the different technologies for energy services were performed. Finally, in the last phase of the research, the results were discussed, conclusions and recommendation were made.
Figure 2.1 depicts also at which phase each of the research questions were answered.

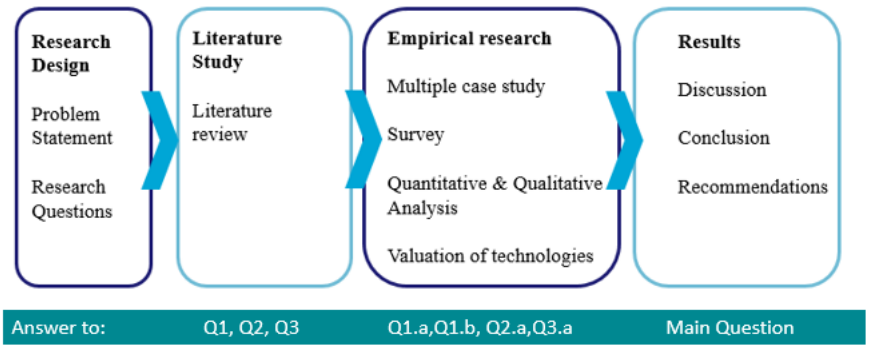

Figure 2.1: Summary of the research strategy

3 LITERATURE REVIEW

The purpose of this chapter was to define to what extent academic research about BM and BMI of energy efficiency renovation for residential buildings has been made. The chapters begins with section 3.1 in which current definitions of BM and BMI are provided, following section3.2 presents the main findings from the available studies made so far about BM frameworks for residential energy efficiency renovations, within the section, existing BM of energy efficiency renovations are provided and explained. In section 3.3 the available technologies for building renovation are reported. The chapter concludes with section 3.4, indicating the main barriers that are affecting implementation of energy efficiency renovations.

3.1 BUSINESS MODEL AND BUSINESS MODEL INNOVATION

Multiple studies have presented different perspectives of BM and BMI. When the term "business model" started to be adopted, the first studies regarding it, were giving a definition and classification (Timmers, 1998)[105], (Rappa, 2001)[47].
The description of business model was successively extended by adding the component that the BM owned.(J. Magretta, 2002) [72], (Amit and Zott, 2001)[1].), (Chesbrough, 2002)[20].
The issue generated by the various definitions of business model, inspired on different types of businesses, allowed for the formation of academic research about business model theory with the aim of evaluating a common pattern among BM in order to find a general definition.
Osterwalder formed a business model ontology, his research was based on scientific foundation, by analyzing the past literature about business models. This resulted in an universally applicable business model definition:
"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams." (Osterwalder,2005) [82].
Moreover, by combining all the studies about BM, nine building blocks have emerged, representing the main components of the business of a firm [81]:

- Value proposition: express firm's offer of products and services.
- Customer relationships: Explains how a firm establishes its links to its different segmented customers.
- Customer Segments: Describes the target customers to whom the value should be offered to.
- Channels: Expresses the different mediums a firm could use in order to reach its customers

- Key activities: Describes how and which activities and resources are arranged by the firm.
- Key resources: Depicts the main competencies required in order to execute the firm's BM.
- Partner Network: Describes the key partners to execute firm's BM.
- Cost structure: Gives information about the costs of the firm.
- Revenue model: How the company generates revenue.

To capture BM component in a logical structure Richardson (2008)[87] studied a framework able to combine the components of the BM around the concept of value. The framework is divided in three blocks:

Figure 3.1: Conceptual business model framework, adapted from Richardson (2008) [87], Osterwalder (2010) [81]

Changes occurring in the business model are defined as business model innovation, or also found as dynamic business models, various studies have been done regarding the definition of this term, table 3.1 represents all the different definitions provided to this term.
The definition adopted by this research is the one provided by Geissdoerfer et al. (2018) [44] *"the conceptualization and implementation of new business models. This can comprise the development of entirely new business models, the diversification into additional business models, the acquisition of new business models, or the transformation from one business model to another. The transformation can affect the entire business model or individual or a combination of its value proposition, value creation and deliver, and value capture elements, the interrelations between the elements, and the value network"*.

Table 3.1: Definitions of Business model innovation (BMI). Adopted from Foss and Saebi (2016) [42]

Authors	Definitions of BMI
Mitchell and Coles (2004)	"Process of developing and replacing value proposition with new products or services"
Markides (2006)	"Discovery of a different BM in an existing business"
Santos et al. (2009)	"Reconfiguration of the activities of the existing BM"
Aspara et al. (2010)	"Creation of novel value"
Gambardella and McGaham (2010)	"The firm adopts a different approach of commercializing its assets"
Yunus et al. (2010)	"To find new value proposition, generating new revenue source"
Sorescu (2011)	"Change in elements of the BM, and their interdependences"
Amit and Zott (2012)	"Redefining content and changing the structure of the BM"
Buscherer et al. (2012)	"Process of changing the main elements of a firm and its business logic"
Abdelkafi et al. (2013)	"When at least one of the value dimentions is improved"
Aspara et al. (2013)	"Corporate business model transformation, change in the way the "value" is created"
Berglund and Sandstrom (2013)	"Introduction of a new BM, with the purpouse of creating revenue"
Casadesus-Masanell and Zhu (2013)	"The search of new ways to generate revenues and redefining value propositions for customers, suppliers and partners"
Khanangha et al. (2014)	"Changes in BM by redefining individual elements, extending the BM, or replacing the existen BM with a different one."

Sustainable business model

When facing the issue of climate change, rising global population and resource scarcity, the need to renovate the current capitalist society becomes fundamental.
Business as usual, mainly focusing on revenues should rethink their structure, adding in their BM sustainable elements, such as environmental and societal benefits, considering the costs and benefit not only from the stakeholders point of view but also towards environment and society [9].
Sustainable business models have been defined as:
"business model that seek to go beyond delivering economic value and include a consideration of other forms of value for a broader range of stakeholders" (Bocken et al., 2014) [7] .
Tools expressing sustainable business models were elaborated, for instance the business model canvas described by Osterwalder et al.(2010) [81], was extended to a triple layered business model canvas (TLBMC) (Joyce et al.,2016) [66] by adding at the usual

economic business model canvas, a "Environmental Life cycle BM canvas" and a " Social stakeholder BM canvas".
Both of the added canvas are divided in 9 elements equivalent to the one of the economic BM, although they evaluate the damage and the benefit caused by the production of good/service towards the environment, and the society.
The TLBMC gives a integrated approach on how to present the sustainable business model of a firm.
Bocken et al. (2015) [8] elaborated on Richardson and Osterwalder conceptual BM framework, to define a *"Sustainable business model framework"*, figure 3.2, the concept of value is shifted from purely economic mean to a comprehensive view of the ecosystem formed by economical, societal and environmental factors.

Figure 3.2: Conceptual sustainable business model framework, adapted from Bocken et al. (2015)[8].

Therefore, a sustainable BMI is defined as an evolution in the way business is done, generating benefits to the company, the environment and the society (Bocken et al., 2014) [7].
According to the research of Boons and Ludeke-Freund (2012)[13] sustainable business innovation can take place in three main contexts: technological, organizational and social.
A Business model is an intermediary between the technology of production and the way the product is consumed or the service is used. Therefore, when there is an innovation in this context, a business can adapt a new type of technology. The business model can change the way the same technology is offered, or a new technology can enter the market by using a new innovative business model[13] .
An innovation in the organization of a firm is induced when the business model changes its settings according to environmental and societal values[13] .
Innovations dealing with how the company can change its value proposition bring changes in the social context. Switching its focus from profit maximization to self sustainable businesses that have positive impact on environment and society[13] .

Ecosystem business model

When a business is articulated between different actors, it becomes difficult to express the business through a simple BM, that is indeed focused on only one actor. Therefore studies have addressed this issue and defined the concept of "ecosystem business model", EBM, that allows in expressing interrelations of different actors within the business ecosystem [3].

For the first time, in 1994, was suggested that the term "industry" had to be exchanged with the term "business ecosystem", since it indicates a community of economical nature, ruled by interactions between organizations and individuals[78].
The concept aims in pointing out that, as in natural ecosystems, firms cannot be successful alone, more actors rely on each other for their performance and durability [58]. This concept gives the possibility of properly understanding the way in which value is generated, delivered and captured, going also beyond the firm's boundaries[120].
Different tools can be used in order to represent how actors cooperate between each other and how revenues and cost structures are interdependent between one firm and the other. Mapping can be the first tool used in order to represent and understand how the overall business network is structured, Maniak R. et al (2015) [3] proposed a framework for mapping different actors inside and ecosystem, in this way the financial flow, positive and negative externalities are represented, figure ??.

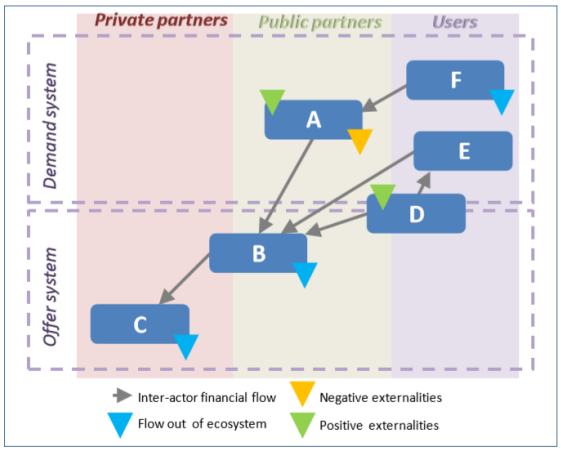

Figure 3.3: Ecosystembusiness model mapping example, adapted from Maniak R. et al (2015) [3]

In order to show how different actors contribute in the ecosystems and depict the monetary and externalises flow between the actors a more detailed toll was elaborated by Maniak R. et al (2015) [3], the ecosystems business model matrix. Enabling to easily understand how each actor contributes and benefits from a business, figure 3.2.

Table 3.2: Matrix ecosystem business model example, adapted from Maniak R. et al (2015) [3]

		Beneficiaries									
		Actor 1	Actor 2	Actor 3	Actor 4	Actor 5	Negative externalities	Costs	OPEX	CAPEX	Contributions
Contributors	Actor 1										
	Actor 2										
	Actor 3										
	Actor 4										
	Actor 5										
	Positive externalities										
	Gains										
	Results										

3.2 BUSINESS MODELS ARCHETYPES FOR BUILDING RENOVATION

In the Netherlands more than 6 million houses and one million buildings are still energy inefficient and dependent on gas. Therefore, aiming for the ambitious decarbonization plan, they need to be renovated [54].
In the *"Klimaatakkoord"* [54], the key points on how the Netherlands is planning to reduce its emission of 49% by 2030 are described.
To reach the National targets 50,000 houses should be renovated by 2021, with a renovation rate of 200,000 properties per year by 2030. By doing so it was predicted that the CO_2 emission will be reduce by 3.4 Mt in 2030 compared to the business as usual scenario[54].
Even though the renovation to nZEB of a dwelling could improve the comfort and reduce the energy bills, the market demand for this service still has not increased as it should.
Analysing the existing business model archetype regarding house renovation can help to understand which problems this type of market is facing and how it can be improved.
In this section the existing business model for building renovation will be analysed, the BM were then compared using the framework given by Bocken et al. (2015) [8], Figure 3.2.

Table 3.3: Business model archetypes,value proposition, adapted from Brown D. (2018) [16] and from Moschetti R. et al (2016) [79]

BM Framework		**Atomised Market**	**Market Intermediation Model**	**One-stop-shop**	**Esco**			
					Energy Supply Contracting (ESC)	Energy Performance Contracting (EPC)	On-bill Financing	On-tax Financing
Value Proposition	Value Proposition	Estimated savings in future energy bills and improvements of comfort indoor. Decrease of pollution and energy consumption	Estimated savings in future energy bills and improvements of comfort indoor.	Comprehensive or partial renovation of a dwelling. Emphasis on higher comfort and lower costs due to energy use.	As for One-stop-shop. Plus: guarantee of energy saving through ESC Reduction of financial risk Managed energy bills	As for One-stop-shop. Plus: guarantee of energy saving through EPC. Reduction of ffinancial risk	As for EPC	As for EPC
	Costumer segment & relationship	Private owners of dwellings. They receive private assistance	Private owners of dwellings. Only one contact to link the costumer, to different energy service provider.	Private or public owners of building. Contractors organize home –view and create customize solutions.	Private or public owners of building Contractors accept financial risk in exachange of montly payment through long term agreements	Private or public owners of building. Contractors accept financial risks in exchange of montly payment, calculated up-front based on the predicted energy savings	Private or public owners of building, renters. Contractors accept financial risks in exchange of montly payment collected through energy bills	Private or public owners of building, renters. Contractors accept financial risks in exchange of montly payment collected through taxes
	Value for Customer Society and environment	Decrease of pollution, and decrease in energy demand by residential sector	Decrease of pollution, and decrease in energy demand by residential sector	Decrease of pollution, and decrease in energy demand by residential sector	Decrease of pollution, and decrease in energy demand by residential sector	Decrease of pollution, and decrease in energy demand by residential sector	Decrease of pollution, and decrease in energy demand by residential sector	Decrease of pollution, and decrease in energy demand by residential sector

Table 3.4: Business model archetypes,value creation and delivery, adapted from Brown D. (2018) [16] and from Moschetti R. et al (2016) [79]

BM Framework		Atomised Market	Market Intermediation Model	One-stop-shop	Esco			
					Energy Supply Contracting (ESC)	Energy Performance Contracting (EPC)	On-bill Financing	On-tax Financing
	Key activities	Renovation work/ installation of the product/service offered	Advices on energy service measures for a dwelling (Energy Audit) Intermediation between cosrumer and installer Advice on financial options	Renovation works, construction/project management, building inspection and energy audits, post renovation information/ support to customers	As for One-stop-shop Plus: Finance & managing of energy bills Managing of energy generation, storage and demand-side management.	As for One-stop-shop Plus: Finance	As for One-stop-shop Plus: Finance	As for One-stop-shop Plus: Finance
	Key resources	Skilled employees, product providers	Skilled employees to calculate dwelling energy efficiency	Project managers, Administration and marketing employees Intaller of energy service Energy auditor	As for one-stop-shop Plus: financing providers Managers of electric generation and distribution	As for one-stop-shop Plus: financing providers	As for one-stop-shop Plus: financing providers	As for one-stop-shop Plus: financing providers
Value creation & Delivery	Channels	Personal contacts, media. Is left to individuals to contact the firm.	Media, municipalities/ governamental sponsored.	Media, personal contact, websites.	Media, personal contact, websites.	Media, personal contact, websites.	Media, personal contact, websites.	Media, personal contact, websites.
	Partner Network	Supplier of products, building owner. Different suppliers do not work in cooperations, left to the costumer to arrange multiple installations	Different installer companies, retrofit can be schedula by the intermediator on behalf of costumer	Building owners Provider of energy services Product suppliers Municipalities (in the case of collaboration)	Building owners Provider of energy services Product suppliers Possible Finance lender entity (Banks, Local Government) Energy providers	Building owners Provider of energy services Product suppliers Possible Finance lender entity (Banks, Local Government)	As for EPC Plus: Energy providers	As for EPC Plus: Goverment or Local Authorities
	Technology and product features	Installation of energy services (heat pump/ insulation / solar panels) or energy audit (service) Upgrade to a dwelling.	Organizing upgrade of the dwelling.	Comprehensive and possibly customize renovation of the dwelling	Comprehensive and possibly customize renovation of the dwelling Managed electricity bills	Comprehensive and possibly customize renovation of the dwelling. Guarantee of success in decreasing energy bills	As for EPC	As for EPC

Table 3.5: Business model archetypes,value capture, adapted from Brown D. (2018) [16] and from Moschetti R. et al (2016) [79]

BM Framework		Atomised Market	Market Intermediation Model	One-stop-shop	Esco			
					Energy Supply Contracting (ESC)	Energy Performance Contracting (EPC)	On-bill Financing	On-tax Financing
Value capture	Cost structure revenue streams	Product costs, Installation costs, Salaries	Salaries Rent	Salaries Rent Products Installations costs Travel costs	Salaries, Rent, Products Installations costs Travel costs Pay back of finance enthity (if applicable) Electricity bills of the dwelling managed	Salaries Rent Products Installations costs Travel costs Pay back of finance enthity (if applicable)	As for EPC	As for EPC
	Revenue streams	Costumer payment for renovation and product	Service fee payed by the costumer and by the installers	Customer payment, Purchased products and services Commission by supplier	Costumer payments for the lenght of the contract. Commission by suppliers When large market, possible to receaive feed in tarifs, sell electricity	Costumer payments for the lenght of the contract. Commission by suppliers	As for EPC	As for EPC
	Value capture of key actors/ env. Society	Embodied carbon of materials and transport Positive benefit generated by lower energy demand and decreased carbon emissions	Positive benefits for environments and society	Embodied carbon of materials and transport Positive benefit generated by lower energy demand and decreased carbon emissions	As for One-stop-shop	As for One-stop-shop	As for One-stop-shop	As for One-stop-shop

3.2.1 Atomised market model

In the *Atomised market model* each energy efficiency measure installer is independent from the other, since there is not a single interface between customer and installer companies, the customer needs to contact each company separately.
First, the customer contacts the energy auditor, to control the energy performance of the house and investigate how to improve the building's efficiency. The auditor gives an estimation on how much the energy bill of the house could be reduced and which renovation can help in reaching energy efficiency. It is up to the costumer to contact the different retrofit companies, however, and no guarantees are given in regards to the energy savings and lower bills. Different finance providers can be chosen for each installation[16].
This model can be seen as a "business as usual", indeed it is the most popular approach found in the renovation market, especially when dealing with small size projects [79]. Considering the Netherlands, there are more then 1400 companies offering pv panels installations [32], and around the same amount of insulating companies [114]. Due to the fact that there are more interfaces between customer and installer company, it becomes more difficult to arrange a complete renovation of the building to a nZEB[16].

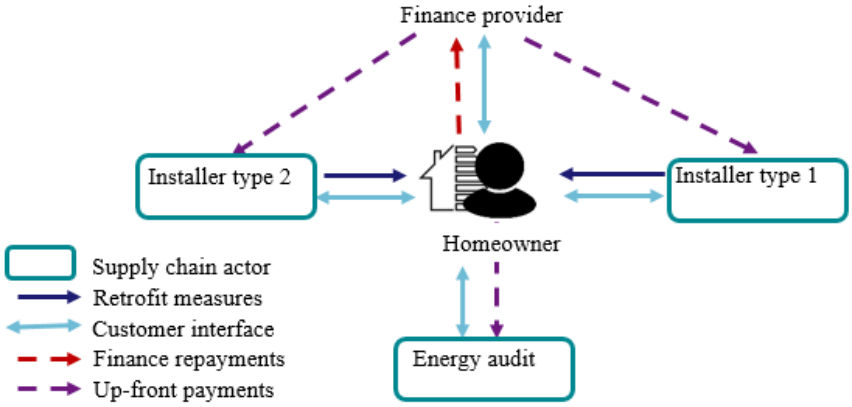

Figure 3.4: Atomised market model, adatpted from Brocken et al. (2018) [16]

Therefore more than one BM can be found, concerning which type of product the installer offers. Although an overall business model can be analysed:

VALUE PROPOSITION It offers energy saving and better comfort for the dwelling, adding value to society and the environment by decreasing the emissions of the dwelling. The customers targeted are usually homeowners, or real estates and the relationship with their customers is left to the market[79].

VALUE CREATION AND DELIVERY Each installers is specialized in the delivery and installation of its technology, the energy auditor only offers the service of evaluating the energy efficiency of the dwelling. Therefore each installation is unbounded and requires limited coordination, that is up to the customer to manage [79].

VALUE CAPTURE The cost due to the installation and product itself are payed directly to each installer and it is left to the customer to pay up-front or to arrange a loan [79].

3.2.2 Market intermediation model

The *Market intermediation model* differs from the previous business model due to the simplified interface between customer and the installer companies. The organisation, presented in figure 3.5 as "market intermediary", can offer the service of energy label consultancy and project manager (it is often run by local authorities or NGOs offering financing assistance) information about the possibilities of retrofit for the buildings and consultancy. Usually this scheme can be used for local housing providers, and it doesn't always involve a comprehensive retrofit but rather on specific measures. So far, this model has worked using government subsidy schemes[16]. An example of this business model in the Netherlands is the following: each municipality has its own energy assistant desk in which home owners can get advice on which insulation and heat system best fit their house and then be directed to the companies operating in these renovations. Moreover, it can also provide information about the subsidies and loan options [76].

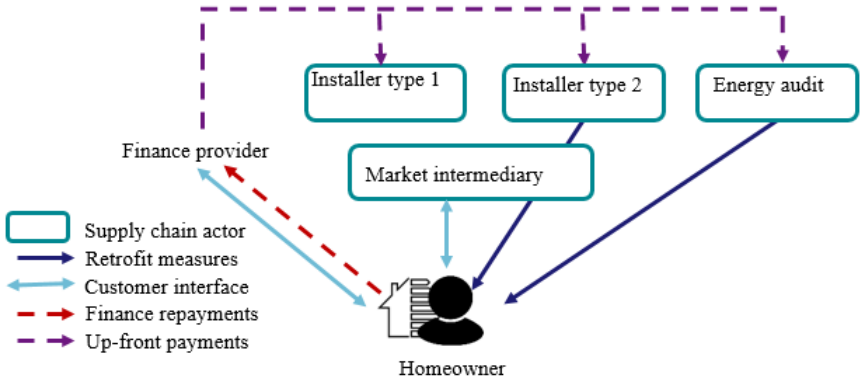

Figure 3.5: Market intermediation model, adatpted from Brocken et al. (2018) [16]

VALUE PROPOSITION

Their value proposition aims to estimate cost saving and higher comfort due to energy efficiency measures. Resulting in a benefit for the environment and society [16].

VALUE CREATION AND DELIVERY

The intermediary acts as a contact point to promote and contact installers, resulting in a easier way for the customer to realize innovations. Therefore the key resources in the BM are the service of basic energy auditor and the connection between customer and installer. Their partners are the companies offering and installing retrofit technologies[16].

VALUE CAPTURE

The market intermediary business model is usually run by local authorities, therefore just offering a service for the citizens or through NGO's. The finance is organised by a third party with small involvement in the retrofit process[16].

3.2.3 One-stop-shop

It was described by Mahapatra et al. (2013) [73] as a business in which a single actor, an entrepreneur, offers a holistic shop for the costumer, providing information about energy renovation for a building and offering all the services needed in order to accomplish it. It differs from the market intermediation model, in which a list of improvements for the house is given, by offering a detailed design for a comprehensive residential retrofit plan. Finance can be added to the revenue model, to engage more homeowners [16]. The up-front payment can be paid back through the money saved thanks to a lower electricity bill. Only seven Dutch companies were found with this business model[25],[40], [33], [50], [102], [104],[117].

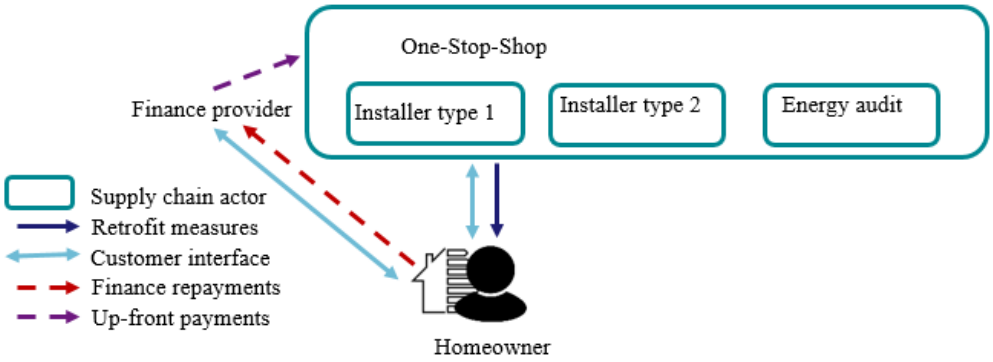

Figure 3.6: One-stop-shop model, adatpted from Brocken et al. (2018) [16]

VALUE PROPOSITION

The value proposition of the One-stop-shop BM stresses the benefits the renovation would bring to the dwelling, like higher indoor comfort and lower energy bills [16]. Moreover, with this business model the hassle of contracting more than one installer is removed, since the company offers a holistic and customized package of energy services, dealing with all the activities from energy auditor to installer[11]. Additionally, financial advice is given [11].
The targeted customers are private owners and real estates[73].

VALUE CREATION AND DELIVERY

The one-stop-shop model usually collaborates with different installers but it maintains the role of project manager, organizing an holistic renovation[16]. Therefore the actors that it mainly collaborates with are companies involved in installations of single energy service measures. By organizing the renovation the One-stop-shop facilitates the work of the installers by providing them with clients, making the renovation process more efficient[73]. the channels that it generally engages costumers through are media, their websites and personal contacts [79].

VALUE CAPTURE

The one-stop-shop receives the pre-agreed price from the customer, comprehending the cost for the products and their installations and the commission for the company, generating a profit[11].
Not only the company gains from the renovation but it is also beneficial for the

environment, due to the decrease in emissions by the dwelling, less pollution and green house gasses are generated.

3.2.4 ESCO

Energy service companies, ESCOs, are defined as " A company that provides specific facilities to improve energy efficiency of users' property, and accepts, at the same time, some degree of financial risk. The remuneration for the offered services relies (either entirely or partly) on the accomplishment of energy efficiency improvements and on other agreed performance criteria" Moschetti, (2016) [79].
Therefore, in other words, ESCOs are one-stop-shops that offer finance to their clients and offer a guarantee of the future efficiency. When a company organizes complete energy efficiency renovations to buildings, and accepts some degrees of financial risks while guaranteeing a certain degree of performance, it can be considered a energy service company, ESCO.
Different studies were made about this BM, since it has the potential of speed up the renovation process, giving a possibility to all homeowner to renovate [5], [111], [73], [70], although generally ESCO's costumers are more frequently commercial buildings or public buildings instead of private dwellings, due to the fact that it is more challenging to predict future energy consumption of privates in their own homes[79].
Depending on the method chosen as finance and on efficiency guarantee different business models can be found. The main two business models used by ESCOs are Energy supply contracting (ESC) and Energy performance contracting (EPC). In the ESC model, ESCO becomes a supplier of energy for the building, of electricity and heat, indeed it becomes in charge of the energy bills of the dwelling for the length of the contract [79]. While in EPC, the ESCO is paid back by the costumers through constant payments for the length of the contract. The payments are calculated on the base of the up-front predicted savings from a lower energy bill[71]. The EPC model can change on the base of how the ESCO gains back the initial investment, it can be collected by direct payments, through on-tax payment or on-bill payments. Table **??** gives a comparison between the different BMs. In the Netherlands were depicted about fifty ESCOs company [113], although their main customers are commercial and public buildings, there are few examples of ESCO working for social housing and real estates, but so far the Dutch ESCO market has not extended to residential houses homeowner-occupied.

ESCO: Energy Supply Contracting

In this BM archetype The ESCO takes charges not only on the design, delivery and installation of energy services, but also becomes in charge of the energy bills, through a energy supply contract.
Therefore in this case the ESCO is completely in charge of the energy of the building[16]. In the Netherlands the government has founded a trial for this approach for social housing, known as Energiesprong[31].

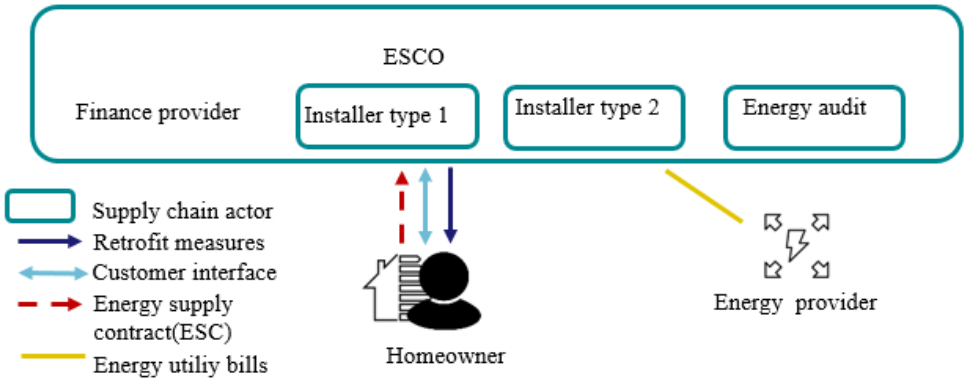

Figure 3.7: Managed energy services agreement, adatpted from Brocken et al. (2018) [16]

VALUE PROPOSITION

Their value propositions stresses the value of electricity and heat provided, since the ESCO takes care of the utilities on behalf of its customers, guaranteeing a certain heat quality (ex. indoor temperature) and guarantees the savings on energy bills [16].
Moreover, the finance is provided by the ESCO and also the energy bills are managed. The costumers agrees in paying back the service through fixed price payments for the length of the contract signed (5 to 25 years) usually 5 to 10% lower of the customer's current energy bill [12].
Their costumers are usually real estates or industries and private building owners [79].

VALUE CREATION AND DELIVERY

By offering a comprehensive retrofit of buildings, ESCOs' activities are quite various and deal with every stage of energy services. From energy audit to house view and installations of retrofits[16].
This market model requires collaboration of the ESCO with the different providers of technologies and with the energy providers. Moreover, since it requires an initial capital, collaboration with a finance entity such as banks or Government or other funds. Therefore the tasks of the ESCO, are to design, install and manage energy services, dealing also with energy bills [16]

VALUE CAPTURE

Their revenue are due to their supply contracts, they can have a length between 5 to 25 years [29]. Moreover, due to the fact of being managing the local generation of energy, ESCOs can sell generated energy and can control demand-side management of their contractors[79].

ESCO: Energy Performance Contracting (EPC)

In this BM the ESCO offers an holistic renovation of the dwelling and it gives a guarantee of the future energy saving through long term contracts (EPC), the finance is provided by the ESCO and the payments are calculated on the base of the predicted energy savings[98]. The ESCO visits the buildings and designs a energy efficient solution, that

later on will be applied to the building by installing the required retrofit. The saving generated from the energy efficiency upgrades are then used to pay back the ESCO, generally in a period of five to twenty years payback[16].
Example of ESCO can be found in France were the state owned railways company, SNCF, also subsidizes social housings, ICF.

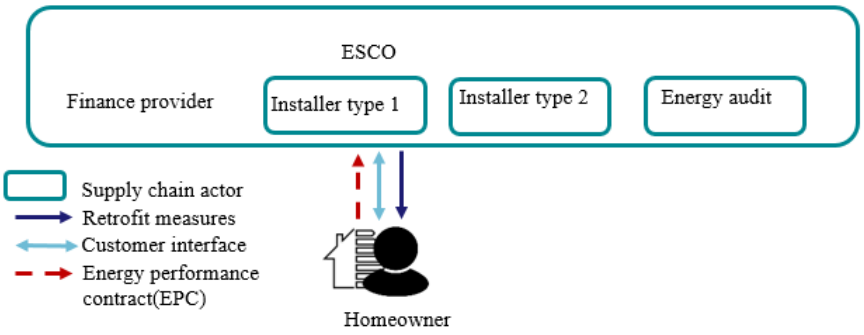

Figure 3.8: Energy service agreement, adatpted from Brocken et al. (2018) [16]

In figure 3.9 we can see a scheme of the EPC payment. The savings are predicted upfront, therefore the efficiency retrofit can be sold as-a-service by the ESCO [96].
Although it can be argued that, especially for residential building, the energy consumption is not easy to predict and it is hard to set a fixed monthly pay for the return of investment[110], although the way it is done now is that the building is analysed by the energy audit of the company, so the energy use of the house is transcribed and the future energy consumption is calculated on the base of the products offered by the ESCO. After the installation of the energy saving measures, the ESCO monitors that the results are as predicted, the customer can then enjoy the higher comfort and the lower energy bills [65].

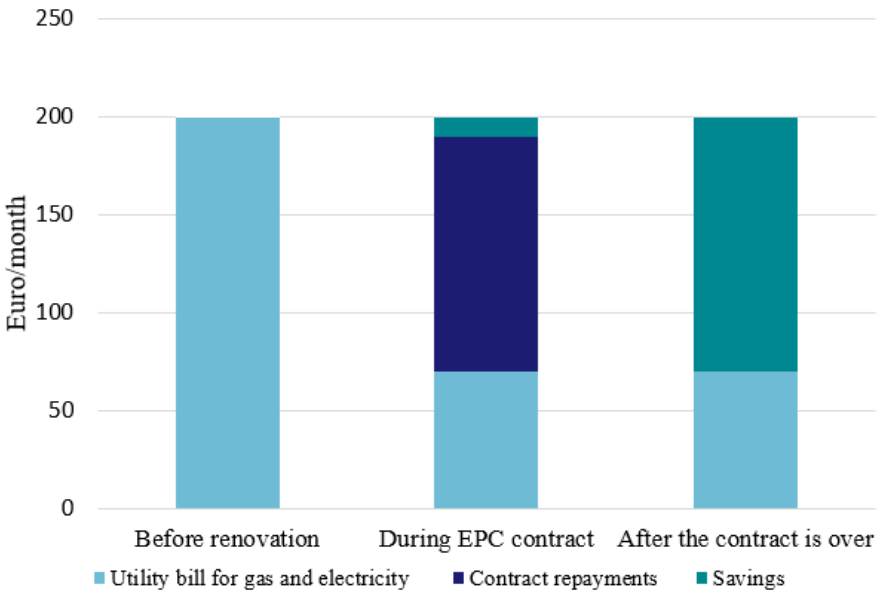

Figure 3.9: simplify vision of loan pay-back by customer through EPC

VALUE PROPOSITION

The value proposition of the EPC BM is the same as for the One-Stop-shop although in this case finance is also provided, taking all the risks due to the investment away from the costumer [98].
Between the company and the customer a long term contract is signed, the selected costumer are private or public building owner, although Usually the targeted costumers are large energy consumers such as industries and public building (schools, hospitals etc..) where the calculation of energy consumption can be estimated more precisely[12].

VALUE CREATION AND DELIVERY

Also in this case the BM is similar to the one of One-stop-shop firms, although for this case financial institution are required as partners and contracts with costumers are managed[12].

VALUE CAPTURE

The renovation is provided by the ESCO, possibly through external finance and the constant payments for the length of the contract have the purpose of repaying the loan provided by the ESCO, generating profit [12].

3.2.5 On-Tax Financing

A form in which EPC can be organized is by collecting the payments through the taxes. In the On-tax financing scheme, the investment can be recovered from taxes payed by the owners or the resident in the property [79].
In this case the Government is involved in the renovation plan, collecting together with the general taxes also the ones to repay the renovation funds, making it possible for the business to constantly re-pay itself.
Similar schemes are already used in Australia, Environmental Upgrade Agreements, and U.S., Property Assessed Clean Energy[60]. Inspired by the American financial program, in Europe has been developed the platform: EuroPACE, financial platform helping in paying for energy efficiency retrofit for homes, including installation of renewable energy sources and water conservation treatments [96].
The EuroPACE model funds completely the home renovation and the payback time is up to 20 years, it attaches the financial plan to the property and not the owner, in this way anybody leaving in the renovated building is eligible to pay off the loan.
The project was founded by the European union and has being applied already in four Countries: Spain, Italy, UK and Poland, supported mainly by municipalities, investors and energy consultancy agencies [59].

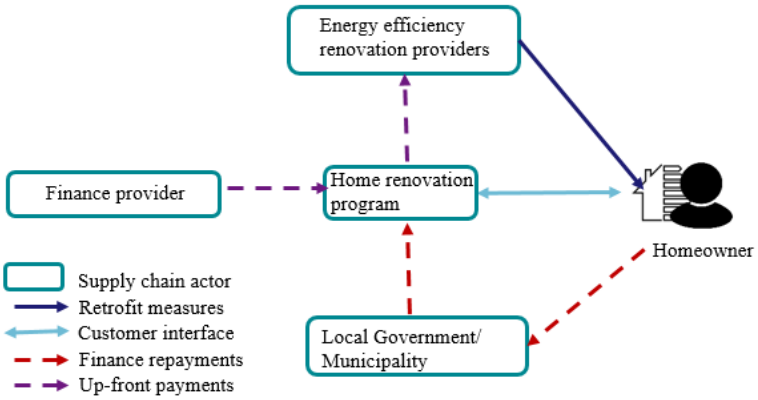

Figure 3.10: On-tax financing scheme, adapted from smartEN,2018 [96]

VALUE PROPOSITION

As One-stop-shop, the value proposition of this BM stresses the added value for the dwelling after the renovation for higher comfort and lower energy bills [96]. Moreover, the risk due to the initial investment is overcome by the provided finance option. The payments are collected through taxes and are linked to the dwelling so even in case of moving or renting the property the tax will stay linked to the building [12].
The payments through taxes are calculated up-front and based on the expected energy savings, so that the total monthly expenses are equal or lower then the pre-retrofit ones [12].

VALUE CREATION AND DELIVERY

This BM requires a large network of collaboration between ESCO and financial partners and governmental institutions in order to arrange the tax repayments [12].

VALUE CAPTURE

Revenues are build on the regular amount payed by the customer [12].

3.2.6 On-Bill Financing

On-Bill Financing is a type on loan in which the investment gave to improve the energy efficiency of the building is payed back through the electricity bills[12]. This financing strategy has been used in the United States since 2013[119]. This financial model is organised in different programs, differing for interest rate, for lender entity, administration or for how has access to the program.
The program can be available for residential and non residential buildings depending on the state, and be administrated by the utility company, NGOs or from the government.
Different grants can cover different retrofit technology.
Large installation of the financing model will require to change the way in which the utility bills is structured, requiring more coordination between utility companies, financier of the projects and building owners[96].
The renovation combined with the described financial method, ensures a lower energy bill. In some financing program the bill-neutrality is add as a constrain. Therefore the building owner are more inclined to take part in the renovation program, and access is easy also for low income customers[119]. The bill neutrality policies ensures that the

new energy bill together with the pay back of the loan will never be higher than the bills before the renovation, however the bill neutrality cannot be guaranteed when the costumer energy consumption changes.
This kind of loans are usually "tied-to-the-meters" meaning that the load does not necessarily is attached to a person but to the property or the utility meter. Allowing, for example renters to pay back the loan for their stay in the building, therefore the owner will not have to pay back the investment and, moreover, once the loan is payed back the building would have gained value[119].
Although, to tie a loan to an object can become hard from an administrative point of view. In order to have a high demand for retrofit the loan interest rate is kept below 2%, causing the need for governmental source of funds, In U.S. the federal funds consist in the primary support [119]. The UK had attempt to offer this financial product, the Green deal, although due to the high interest rates, 7-9%, its complexity of organisation, the low accessibility to homeowners and the fact that the renovations had to be payed through the energy savings resulting in a restriction on the possible options to install the program was not successful [94].

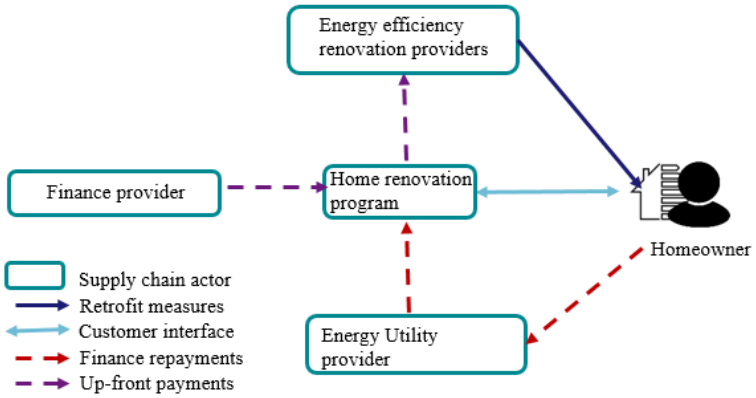

Figure 3.11: On-bill financing scheme, adapted from smartEN,2018 [96]

VALUE PROPOSITION

Customer can benefit from higher comfort of dwelling, the finance can be provided by the ESCO and re-payed through energy bills, allowing the repayments to be tied to the property and not the customers [12].

VALUE CREATION AND DELIVERY

This BM requires a large network of collaboration between ESCO and financial partners and energy provider companies [12].

VALUE CAPTURE

Revenues are gained through the regular amount payed by the customer [12].

3.3 ENERGY SERVICES TECHNOLOGIES

According to the UE definition (2006) [106] the term "energy service" describes as *"the physical benefit, utility or good derived from a combination of energy with energy efficient technology and/or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract and in normal circumstances has proven to lead to verifiable and measurable or estimable energy efficiency improvement and/or primary energy savings"*.
In a building energy is used for different purposes, the most energy consuming are: heating, cooling, domestic hot water, ventilation and lighting. Less energy consuming but important components to cite are also cooking, washing, refrigerating, computers and televisions [23].
The energy provided for these purposes is given by energy carriers. The main ones in the Netherlands are electricity, for lightening, electric machines and other appliances, and natural gas, for what concerns heating, therefore also for hot water, cooking and heating of the environment[39].
The average Dutch house consumers $1600m^3$ of natural gas per year and 3500kWh of electricity per year [74]. Natural gas is a fossil fuel, mainly formed by methane, CH_4, when it oxidizes, for instance for cooking purposes or when heating water, the combustion reaction produces carbon dioxide and water, equation 3.3 [112].

$$CH_4 + O_2 \Rightarrow CO_2 + 2H_2O \tag{3.1}$$

Natural gas is the main energy carrier consumed by Dutch residential sector, the carbon emission factor is equal to 1.78 kg_{CO_2}/m^3 [90]. Moreover, energy from renewable sources still has a small share on the total energy production on the Netherlands, hence the electricity used by buildings is as well source of pollution, currently 0.45 kg_{CO_2}/kWh are emitted[22][116].
Therefore a typical Dutch house consumes around 4.8 tonnes of CO_2 per year.
Energy services focus is to improve the energy efficiency in dwelling, decreasing the pollution generated, in order to do so different measures can be taken. This chapter will analyze the main technologies used in the Netherlands today, technologies that are already at an advance stage in the market will be considered [75].
There are no current standard for building renovation to nZEB, the regulations are mainly for new building[100]. Leaving uncertainties on the degree of renovation to be reached by already existing buildings, generally companies offer options to make homes free from natural gas, aligned with the Government targets of the Klimaat Akkord [54], or to energy neutral renovations[117].

Reduce of energy consumption

INSULATION

Heat balances can be done over a building, between the interior and the external environment. Gain of heat are due to heating systems, solar loads and internal heat loads while the heat losses are due to mainly three causes: transmission through surfaces, ventilation and infiltration. Roof, walls and windows are the main carriers of the heat [28].
Improving the building request for either heating or cooling requires a decrease in

heat losses; in order to do so it is possible to improve the thermal insulation, adding insulating material on the building "shell" and decreasing air filtration [45].
Improving the insulation of a dwelling can improve the comfort due to the inside temperature. Thanks to this retrofit the heat losses are lower therefore the need for heating during the winter season and of cooling during the summer time decreases[17].
Windows are as well source of heat loss, it can be improved by substituting the glass with a double or triple-glazed. It is possible also to use higher insulating materials for the frames surrounding the glass. Moreover the use of gasses like Argon between one glass and the other helps in improving the insulation of the material [45].

VENTILATION

Ventilation of building is important in order to remove the exhaust air from the environment and provide fresh air inside the dwelling, it can be done through air filtration or with the use of ventilating system. By improving the insulation of a building, the air entering through filtration will be nearly zero, therefore raising the importance of ventilation. Although obsolete vents are a source of heat loss [28].
The energy required by this technology is mainly due to the mechanical request to move the air and due to the energy needed by the ventilation system to heat the entering air to the building. In order to decrease the energy demand for ventilation natural sources can be used for the air motion for example wind or the chimney effect due to different temperature of the dwelling, where the warm air rises and leaves the building , in this case the ventilation is defined "natural" [49].
It is challenging to add it to a dwelling as retrofit. The natural ventilation can be achieved by the introduction of a ducted system in which air enters and exits at different heights. The opening of windows usually provides a ventilation effect [2].
When natural ventilation is either not sufficient or possible, mechanical ventilation can be used. The airflow is controlled by extracting it from the indoor, also the inlet of air can be controlled by the ventilation systems [49].
Extract only ventilation, MEV, in residential building is usually set in toilets, bathrooms and kitchen due to the main need of a constant ventilation rate, removing moist and stale air with the use of fans[14].
It can be centralized (C-MEV), the unit is set usually in the roof and extract continuously small amount of air, the system consumes less amount of energy compared to traditional MEV and it causes less heat losses [14].
In order to reduce mould dust and condensation, positive input ventilation can be added as retrofit, usually the unit is set in the hallway and in introduces heated air from the roof, redistributing it to the dwelling [14].
Mixed system can be used when air is extracted and supplied, the heat of the warm exiting air can be recovered through a heat exchanger in which the air at the inlet is heated before being supplied in the building, or cooled during summer, reducing need for heat/cooling. This ventilation system is usually called Mechanical Ventilation Heat Recovery (MVHR) system[14].
Moreover, in order to limit the energy consumed, sensors in order to regulate the amount of ventilation needed were created. The sensor can check the amount of CO_2 in the building and regulate the ventilation needed [2].
In the ventilation technology market are available MVHR combined with sensors, enhancing the energy saving of the system. Natural ventilation is energy neutral, although it causes heat loss and natural ventilation retrofit are not always possible

due to building constrains. On the other hand buildings can be retrofitted in a hybrid ventilation system, in which mechanical ventilation systems are used together with natural one, and the energy demand is kept as low as possible[2].

LIGHTENING

Lightening usually is responsible for the 10 to 20% of the electricity consumed by a home. A simple way in optimizing the lightening system is the use of light emitting diode (LED) technology, those lights are 80% more energy efficient than traditional lightning. The 95% of the energy consumed by those light is converted into energy, only the 5% is discarded as heat. Led lights have also a longer life than conventional lights and are environmentally friendly [97]. On the other hand, it exist an even more energy efficiency solution : solar light tubes, they allow natural light to be projected inside the dwelling, therefore limiting the amount of electricity needed by a dwelling.
The light tube captures the daylight from one of its extremity, that lays on the roof of the house and is made of a water proof plastic globe. The light is projected thanks to the sheet metal tube and reflected to a diffuser, at the end of the tube were the light is distributed [28].
In the Netherlands there are no installer of such technologies but they can be easily bought and installed by the owners/renters, the technology price is around 400 euro [56].

Heat system

Freeing neighbourhoods from natural gas is one of the Dutch government's first concern [54], in this chapter the main alternatives to this fossil fuel adapt for a dwelling will be analysed.

HEAT PUMP

A Heat pump is a technology that transports heat from a colder body to a warmer one, with the use of a refrigerant, working medium[28]. This device has 4 main components: Evaporator, compressor, condenser and expansion device [34].
The refrigerant is heated from liquid phase to gas by the heat exchange with the heat source (water, ground, air..), the gas is then compressed in order to increase its temperature, that will be exchanged to the heat sink by the condenser in order to heat the dwelling or the water, once the refrigerant has been condensed it passes by an expansion valve and starts once again the cycle. Electricity is the source of power of this device and therefore, it does feed on fossil fuels [28].
One of the advantages of this sustainable heat system is its low price, high COP (coefficient of performance) and low maintenance needed. From an input of 1kWh of electricity the heat pump produces 4kWh of heating energy [34].
The main types of heat pumps available are: Air-source and Ground-source, the first utilises the outdoor air as heating source in winter and as heat sink during summer. The ground-source heat pumps find their heating agent in the ground. The air- source pumps are cheaper and more diffused then the ground-source ones, although less efficient [62].
Heat pumps can be used in combination with solar energy plant, in this way the heat produced by a solar thermal connector can be used as energy source for the air/ water

heat pump. [34].
The unit price for heat panel is between 250 and 300 EUR, while hybrid thermal PV panels cost around 1800 to 2000 EUR/kWp [21].

ELECTRIC BOILER

Central heating boiler, are a solution to usual gas boilers and can be installed together with the heat pumps system in order to back up moments in which the outside temperature is too cold.
The boiler produces hot water with the use of electricity, therefore it does not consume any fossil fuel such as traditional boilers. The heating element can either use electrical resistance, small applications of 1-2 MW, or three phase electrodes. The temperature range is flexible [43].

HYBRID HEAT PUMP

An hybrid heat pump consists in a combination of a boiler and a heat pump, the operational system of the device makes sure that the most cost-effective heating option is chosen, considering gas and electricity price, internal and external heat and water demand. Therefore heat pump only mode, will be chosen when temperatures are mild; when the outside temperature decrease further the boiler will be switch on. The lower the temperature the more the boiler becomes the main heating source, until reached cold climates in which only the boiler is used[21].

SOLAR DISTRICT HEATING

A collective option for freeing neighborhoods from natural gas can be organized by municipalities or real estates and consist in solar district heating. Large solar connectors can be installed and heat a liquid in order to transfer heat to the different homes. Although the system requires an additional heat generation capacity in order to ensure to satisfy the demand for heat at any time , using heat boilers of combined heat and power plants or a storage system[43].

GEOTHERMAL

The heat conserved underground can be used thanks to a heat exchanger, although heat reservoirs are located in very deep location. In a district heating system the warm water (around 80°C) is transferred from the heat exchanger to the district network of building, once cooled the water from the dwelling is re-injected in the underground reservoir (10 to 20 °C) [43].

Decentralised energy generation and storage

After increasing energy efficiency and switching heating system it is important to consider the possible solution for a residential building to produce energy on site, indeed a nZEB has optimal energy efficiency and part of the modest amount of energy required is partially cover by renewable sources[37].

SOLAR PANELS

Solar irradiation can be converted into electricity thanks to photovoltaic (PV) panels,

and heat through solar collector [28].
PV panels are usually made of semiconductors materials,usually silicon placed between a positive and negative electrode generating an electric field. Once the photon of the sunlight hits the cell, the electrons are promoted to higher valence boundaries and therefore are able to flow towards the negative electrode, generating a potential over the cell, that is transferred through wires to the load [85]. Usually PV panels also require inverters due to the fact that the electricity generated must be converted from direct current (DC) to alternate current (AC) [85].
Today the efficiency of PV panels is between 12-20 % but it is predicted to increase, while its price has broadly decrease over the last decade and it is predicted to drop even more [86]. Moreover very thin version of PV panels have been developed therefore they can be placed not only on roofs but also been included in facades, balconies and developments are being made on photovoltaic cell connected to the windows.
By generating electricity the energy demand by the dwelling will be partially auto-generated, decreasing the need to purchase electricity. Usually one single panel can generate between 250 to 300 W [85].
The more effective way of placing solar panels in the northern hemisphere is by orienting them towards south, in order to catch as much light as possible [28].
As described in section 3.3 *"Heat Pumps"* sunlight can be used also as a collector of heat, to provide hot water and heat for the dwelling.
A combined version of the two panel exists and can be easily placed on roofs, both steep and flat roofs [21].

SMALL SCALE WIND TURBINE

Small wind turbines work in the same way, as general wind turbines, hence converting the mechanical energy, generated by the motion of the rotor under the wind force, into electricity [116].
Although not all location are suitable for this kind of application and even if they are, the roof should be strong enough to sustain the forces due to the wind. Generally they can generate from 500W to 1500W[95].
Some wind turbines have already incorporated battery systems enabling to save the overproduced energy for moments of need. Although it can be argued that this technology requires high maintenance and it has a high cost, leading to long payback times, moreover by being placed in relatively low locations usually the wind power is generally not as strong [24].

3.4 BARRIER FOR LARGE SCALE BUILDING RENOVATION

The barriers for residential building renovations can be divided in five groups.
First **structural barriers**, dealing with the way the market for house renovation is structured, therefore in this category the main issues do not involve individuals and potential customer [55]. Between these barriers we can find the lack of supply infrastructure, therefore the limitations that energy providers can face, such as scarcity of resources[70]. Energy saving uncertainties also are a negative factor, indeed the price of energy is quite difficult to predict, especially in the residential sector, making it difficult for energy services providers to guarantee certain energy bill saving results[55].

Lack of collaborations between stakeholders can lead to bad distributed information and could decrease the performance of the energy services retrofit[69].

Another cluster of barriers contains the barriers of **political reason**, indeed the lack of funds and policies for residential retrofit. In this category the barriers can be identified both for homeowners and for companies.
In the case of the Netherlands the incentives provided by the Government and private collaboration from banks, have generated a fund of 300 million EUR, the National energy efficiency loan[103]. The fund covers from 2500 to 25000 EUR of expenses on energy efficiency renovation for a building. The pay back period can range between 7 to 15 years at a 2% rate[103].
The fund is available for financing the following measures:

- Improving insulation of the dwelling
- Solar water heating
- Heat pumps
- Solar panels
- Improved ventilation (heat recovery function)

Although the fund is not available for low income household and people that are already involved in paying back a loan are less likely to be accepted. Therefore leaving a part of the population without the possibility to access the funding [116].
Also subsidies are available, the Sustainable energy investment subsidy scheme,ISDE, can partly pay back the owner that improves his heating system by switching from gas with sustainable options such as solar boiler, heat pump, biomass boiler or pellet stove [48], but the first investment needs to be done by the homeowner.
Moreover, the lack of policies or standards supporting the renovations act as a barrier, for example in countries such as French and Italy there are schemes called " white certificates" that facilitates the formation of a market for energy efficiency. The white certificates are tradable " Titles of energy efficiency", their aim is to demonstrate the achievement of savings in the final energy consumption, through energy efficiency upgrades and similar projects[46]. No such system is used in the Netherlands.
There are no obligation from the Government to change households behaviours. Despite the fact that municipalities have set some target such as "Amsterdam and Rotterdam free from natural gas by 2025" or "Province of Utrecht energy neutral in 2040" , no actual laws have been implemented to make those targets more effective, still remains unknown which strategy will be best suited to reach the ambitious National targets[116]. The only incentives provided so far by the Government were taxes to decrease energy consumption on the energy and on gas used by small costumers (until 10000kWh/year)[99].
Finance remains the most frequent barrier in the studies, blocking homeowners to invest in energy efficiency renovations, due to the high up-front payment that is considered a risky investment or, in some cases, not-affordable[5]. Often the payback time of energy service technologies are quite long[12].
In the Netherlands since 2013 it is possible, when buying a property, to apply for a higher loan in order to finance an energy efficiency up-grade for the building. The mortgage of the building can be increased up to 9000 EUR. This extra mortgage is available only for households with an yearly income higher then 33000 EUR [116].

The last two cluster found, deal with barriers caused by **customers' behaviour** and beliefs.
Customer behaviour barriers are characterized by the homeowners believes and personal interests[55]. Therefore the main barriers in this context are due to homeowners ignorance about the topic of energy services and the lack of information about it[16].
Most of the homeowners also incline to be satisfied with what they have, and they believe they do not need those renovations, or simply have other priority in mind[55].
Moreover, a part of the barriers is also due to the Landlord/tented dilemma, were the homeowner does not want to invest in a dwelling were he/she is not in enjoying the comforts due to the renovations, the solutions could be to increase the rent although it is not always possible[96].
As last cluster **social behaviour** comprehends barriers due to lack of trust from the homeowners towards energy services technologies and providers[83], and barriers due to the fact that in general people tend look for peer confirmations and therefore, resulting in slowing down the process of renovation[55].

In July 2019 was realised the WoON summary for 2018,[109], it consist in a survey to Dutch homeowners, for this edition more then 67,500 people were interviewed, in which different research topic were assessed, for instance data about income and assets of household, information about allowances received by households, the value of the homes and their energy quality[109].
A particular section of this research dealt with the energy quality of the building stock, and the willingness of the residents to invest in energy efficiency measures.
The survey showed that 92% of people investing in the energy efficiency of their home used their own savings and did not use any subsidies/ loan or extra-mortgage in order to do it[109].
The survey showed that natural gas is still the main form of heating supply for homes, nearly 90%. The measures that have been taken so far are mainly installing CV Kettles, still relying on natural gas, double glass windows, insulation and solar panels, mainly in owner-occupied home[109].
From the survey it emerged that the main barriers affecting potential customer for energy efficiency renovation were behavioural, by the fact that people believed their home was efficient enough and they were satisfied with it, although even homes with high energy label are still eligible for energy efficient renovation. Financial problems were barriers depicted as well in the Woon survey, followed by the issue of insufficient amount of savings to devote in home renovations. The rest of barriers were dealing with behavioural issues such as lack of knowledge about the available possibilities for home renovation, or not caring about the topic[109].
A barrier not found in the literature and depicted in the WoON survey was the issue of homeowners having relocating plans[109].

Table 3.6: Depicted barriers in different articles

Article	structural			Political			Finance		Behaviour				Social behaviour	
	Supply Infrastructure	Energy savings uncertainties	Lack collaboration	Lack funds	Policies Standards	Policies Uncertainties	high up-front cost	Long payback times	Lack information	Other priorities	satisfied with current situation	Renting home Relocating plans	Lack trust	Peer-comparison
Hakkinena T. et al 2016[51]			x				x		x					
Kuusk K. et al 2016[69]			x	x	x									
Hesselink L. X.W. et al 2019[55]	x	x			x		x		x	x	x		x	x
Moschetti R. et al 2016[79]							x							
Howarth R. et al 1993[57]									x					
de Fejiter F. et al, 2019 [26]			x		x				x					
Brown P., 2018 [16]			x				x		x	x	x		x	
Boo E. et al,2015 [12]					x		x	x	x		x			
Beroldi P. [4] et al 2017			x		x		x	x					x	
Patari S., et al. 2013[83]			x	x	x		x	x					x	
Soroya k., 2010 [98]							x	x	x				x	
Suhunen N.,2013 [101]							x		x	x				
Kindstrom D. et al, 2016[67]							x						x	
Mahapatra K. et al, 2013[73]											x			
Labanca N. 2015 [70]	x		x		x	x	x		x			x	x	
Brower J. et al. report, 2017 [15]	x		x		x				x					
WoON Survey 2018 [109]							x		x	x	x	x		

4 RESULTS

This chapter sums up the results from the empirical research performed. In section 4.1 the results from the multiple case studies can be are provided, the section concludes with a cross-case analyses between the different case studies. In section 4.2 are presented the results from the survey to Dutch homeowners. The chapter end with section 4.3 in which the results from the evaluation of technologies are presented.

4.1 CASE STUDIES

The interviewed are reported in the following sections.

4.1.1 Case study: Companies

SINGLE CASE STUDY:DE ENERGIEBESPAARDERS

"De Energiebespaarders" [25] is a Dutch online company that organizes home retrofit on behalf of residential homeowners, their value proposition stresses the value they offer by organizing a complete retrofit for the dwelling, removing the hassle for the customers to contact different installers.
The dwelling are inspected by the company's employees, that will then elaborate a customize design, including the selected products by the customers, for then organizing the installation in a relatively short time. So far, the company has worked on a one-time sell base, the customers need to provide the initial finance, although subsidies and extra allowances for mortgages exists for energy efficiencies improvements for dwellings.
Their value capture is generated by the commission of the company for organizing the energy services for the dwelling. Due to their managing and marketing on behalf of the energy service installers, the cost of the products and installation are purchased at a lower price. Therefore the homeowner can purchase a complete retrofit for the dwelling at a lower price compared to what he/she would have payed if managed each energy service separately and the firm gains profit from the sell.
Although, as one of the founder of the company states, the market is still small compared to its potential. In his view, to add financing options, by offering renovations as-a-service could help in enlarging the market for homeowners.

Table 4.1: summary of interview at De Energiebespaarders

Typology	Interviewed opinion	Citation
Barrier	Financial reasons	"homeowners see those renovations as too expensive and they believe that they are not able to invest"
Barrier	Lack of knowledge	"Secondary barriers are lack of knowledge about the need of renovations and the available technologies and the not-willingness of investing time in this service, that is seen as risky and that requires a lot of effort."
Barrier	Behavioural	"Many homeowner do not care about their house since they will be moving soon"

SINGLE CASE STUDY: ESCOPLAN

The company organizes renovation for new building and existing public building or Industries. Their main activities are energy efficiency renovations, offering energy performance contracting. In order to be eligible the customers finance is controlled and needs to be sufficient and "healthy". The contract lasts 15 years.
Second activity of the company is to organize district heating network between industries and building, focusing on North part of the country. In this case the company organizes renovations, mainly insulation, and the supply of cold and heat from industries to the building, cold and heat are then payed by the customer in GJ consumed.
The main partners are depending on the project, the main financing party is the bank Rabobank.

Table 4.2: Summary of interview at ESCOplan

Typology	Interviewed opinion	Citation
Barrier	Political	"Municipality or Government do not support ESCO's activity, they do not stimulate a demand"
Barrier	Lack of knowledge	"Banks could be possible finance provider although they are not familiar with ESCOs activities and therefore, their interest rates are still quite high"

SINGLE CASE STUDY:KOUDE WARMTE DEN HAAG

The project aim is to study how to organize heat network in the Netherlands in order to decrease the natural gas consumption within the built environment, mainly working in the residential sector with social housing/ vvE. For heat network in intended any source of heat generation, such as geothermal energy, or waste heat, today the main source of heat are biomass, coal and natural gas power plant. Although it is a very expensive connection to make for a dwelling.
The project director expressed her positive feeling about realizing pv panels and insulation installment as a service, but offering the connection to a heat network for homeowner, in her view, is still not a possibility, first of all regulations do not allow

for the heat prices to stay constant, therefore making difficult to predict the payback of the investment. Moreover there is not a known procedure on how to gather people consent for making such a renovation. Since the infrastructure costs are very high, a whole neighborhood should be involved, and the costs for heat is still comparable with natural gas.Therefore it is hard to make a business plan based on the concept of repaying through the generated energy savings.
While for the social housing sector it might work since there is a already an established procedure in order to make renovations. 80% of residents needs to give approval, it is all mediated by a coordinator party that is experienced while on single household there is no experience on how to do it. neither an established procedure. Moreover every house is different and should receive different options.

Table 4.3: summary of interview at Koude Warmte Den Haag

Typology	Interviewed opinion	Citation
Barrier	Political	" regulations do not allow for the heat prices to stay constant, therefore making difficult to predict the payback of the investment"
Barrier	Lack of experience	" Renovating a whole neighborhood is something that has not being done and, unlikely for social housing or vvE, there is not a procedure to follow"
Barrier	Behavioural	"Many homeowner do not care about renovating their home, they have other worries"

SINGLE CASE STUDY:OVVIA

The director of OVVIA, an ESCO company dealing mainly with real estates and commercial and public entities, gave his view about the barriers that today ESCO companies face in the Netherlands, and his view on expanding his business to homeowners.
His business' main activities are to analyze the current situation of a building, a software analyzes the building and depicts the right solutions for sustainable renovations. Secondly, finance can also be offered. The energy efficiency options offered are differing for the type of target to be reached (certain CO_2 reductions, Paris agreement, general renovations, only pv, etc..). Once the options are installed to the building, the company monitors and validates that the results are as expected. The company gains its revenues from one time sell, repayments and feed in tariffs.

Table 4.4: summary of interview at OVVIA

Typology	Interviewed opinion	Citation
Barriers	Political	"Although the EU is raising pressure about the issue of energy inefficient building and stressing the importance of ESCOs developments, the Dutch government is still not supporting the market for national ESCOs. There is a lack of awareness about this market on behalf of governmental parties, and therefore little importance is given to the formation, stimulation and support of this market."
Barrier	Lack of knowledge	"ESCO market has a very stable business case, energy savings are quite easy to predict, but there is little awareness on this topic by building owner and entities that could bring financial support. Banks are not aware of ESCO and energy performance contracting, usually they get the feeling that it is too complex"
Barrier	Lack of collaboration	"Banks, politician, Escos all know that something should be done but not talking together causing long waiting times for a market to form."
Barrier	Lack of trust	"Potential customers often believe that the ESCO business model is " too good to be true", therefore the lack of trust issues. "
Barrier	Lack of infrastructure	"Possible that, if the market grow, it will have to face a lack of infrastructure."

4.1.2 Case study: Policy makers

MINISTER OF HOME AFFAIRS

Despite what emerged from the company's interviews, Dutch government wrote in his last release of the Klimaat Akkord, its targets in reaching the Paris agreement.
One of the analysed topics was the building sector. The Dutch government expressed its view about energy efficiency renovations for the next 30 years, stating that its first goal is to renovate 50 thousand homes per year, already from 2020, for then reaching the rate of the energy efficiency renovation of 200,000 homes per year in 2030. Increasing every year the amount of household renovated in order to successfully renovate, by 2050, the 6 million energy inefficient houses, making sure that the residential sector is natural-gas free by 2050 [54]. One of the options in order to support this plan is to offer a heat fund, of around 50 million euro per year, in order to financially support homeowner for their house renovations.
In the Klimaat akkord is also discussed the possibility of linking this fund to the building instead of the persons requesting the fund, removing the barrier of imminent moving from the house [54].
Linking the heat fund offered by the government to the business of a company offering energy services could help implementing the BMI of financing option to the core of the company, and help the Dutch government in achieving its objectives.
To study this possibility an interview with the ministry of home affairs was conducted, the minister interviewed is an expert about the Heat fund described in the Klimaat akkord [54].
In the interview more insight into the proposed fund were given, the heat fund is intended to be accessible also for people with low income rate. Moreover they are

studying possible ways to enable this financing product to be linked to the building renovated and not to the homeowner, gebowndefinanceer. The interests in developing a neighborhood approach for organising dwellings renovating were also expressed.
The minister listed the barriers currently faced for setting up the heat fund.

Table 4.5: Barriers by policy maker

Typology	Interviewed opinion	Citation
Barrier	Lack of legislation	"Linking finance to building instead of persons is very complex from a legal perspective to organize, also organizing repayments through taxes is quite complex, times for organizing it are very long. "
Barrier	Lack of structure	"Until now every municipality has developed different financing schemes, would be better to find a collective solution for the Netherlands."

MINISTER OF ECONOMIC AFFAIRS AND ENVIRONMENT

The senior policy adviser interviewed is working on how to reach the goals that the government has set for 2050, of reducing the emissions of 95%, focusing on the building environment, for what concerns industries and commercial offices.
He is not involved in the residential sector although, together with him, the main barriers for the formation of a ESCO market were analysed. According to his view a market for ESCO, for what concerns the commercial buildings is being created by the new policies about energy labels of offices, although there are still some barriers affecting the market:

Table 4.6: Barriers by policy maker

Typology	Interviewed opinion	Citation
Barrier	Lack of finance	"Bank don't usually want to get involved in this market since the capital provided to the ESCO, will then be used to provide finance to third parties that banks do not have control on, generating, a potentially risky situation. "
Barrier	Political	"It is believed that the government should be the risk taker, generating subsidies to stimulate the formation of a market. Although why should we generate earning for banks and ESCOs? wouldn't a subsidies scheme be more efficient?"
Barrier	Lack of collaboration	"Finance providers and ESCO should work together in order to join their knowledge about finance and energy efficiency measures."

4.1.3 Case study: Municipalities

Unlikely the Dutch government, minor municipalities have started their own fund in order to enable energy efficiency renovations, 3 interviews were taken with the municipalities of Eindhoven, Utrecht, and the project of Woonwende, a collaboration of the municipalities of Nijmegen, Arnhem, Leeuwarden and Haarlemmermeer,(NALH).

EINDHOVEN TENDER

The Municipality of Eindhoven made a tender in order to select ESCOs able to offer energy efficiency renovations as a service, with energy advises and guarantees of the achieved energy savings. The service can be extended until 30 years, and it is comprehending also operational and maintenance costs. The municipality is involved by contributing to the initial funds, around 200,000.00 euro, the rest should be provided by the ESCOs, generally though a bank loan. The reasons behind this tender are due to the fact that the municipality wants to make the energy transition achievable by all homeowners of the municipality *"We see that there is large group for homeowners that cannot be included in the energy transition of how it is now. Changing house is only for rich people. We do not want to put gas more expensive if it is not possible to make something about it"*(Project manager, 2019). The main barriers that this project is facing are reported below.

Table 4.7: Summary of the barriers perceived by the project manager for the sustainable transition of Eindhoven

Typology	Interviewed opinion	Citation
Barrier	Collaboration	«The tender requires that the service provider have a wide range of offers, a lot of parties are specialised in particular actions, a stronger collaboration is needed»
Barrier	Lack of finance	«In order to work, service providers need to find finance, banks not yet willing to cooperate»
Barrier	Technologies prices	«As of it is now, generally cheapest technologies are available, although they are not the most efficient ones, in order to be able to guarantee energy savings, at a good price very challenging»

ECONOMIC BOARD UTRECHT

The first project started in Amersfort, with a homeowners association(Vve). The Project offers renovations as a service, contract are for 30 years. The people living within the Vve were gave the choice of participating on the renovation plan and to select the energy efficiency plan they preferred, the plans were differing of the amount of energy efficiency achieved. the average price for apartment was of 60,000.00 and was planned to be payed back on a 30 year base, the Vve is in charge of collecting the repayments, making it possible to link the repayments to the building instead of the homeowner. The pilot was funded by Bank Nederlands Gementee. At the moment more pilots are being developed and a framework of National adaptation is being studied. The project started since the first apartments renovated were on top of a shopping mall that needed to be renovated, and to develop an affordable solution for the resident in the Vve, the project was initiated. The main barriers for a large scale implementation of this project homeowners focused, which are not linked to a Vve, are shown in the table below.

Table 4.8: Summary of the barriers perceived by the project manager for the sustainable transition of Utrecht economic board

Typology	Interviewed opinion	Citation
Barrier	Lack of structure	"With HOE the repayments are easier to organise since it is already existing a structure that allows in organizing the renovations and collecting the repayments. With homeowners and neighborhood more challenging since there is not such a structure."
Barrier	Legal	"Challenging to organise renovations linked to buildings instead of persons, there is not an already existing legal structure for it "
Barrier	Risk	"ESCOs could be the actors involved in collecting the repayments although their activity is seeing as risky and need some sorts of guarantees funds in order to make it possible.
Barrier	High costs	"The cost are still very high, making repayments linked to the energy savings is quite of a challenge since usually general maintenance of the building is added to the renovation, increasing the costs"

NIJMEGEN, ARNHEM, LEEUWARDEN AND HAARLEMMERMEER PROJECT

A cooperation of the four municipalities decided to create a financial solution for those homeowners that have not the financial possibilities to invest in their own dwelling. The municipalities offer to pay the mortgage on behalf of the homeowner, becoming the new owner, moreover the municipalities finance also energy efficiency renovations for the dwelling. Therefore, municipalities will be in charge of collecting from the homeowners repayments for the mortgage and for the energy efficiency renovations of their dwellings. The project takes care of organising the renovation plan for the dwellings, contacting local installers, stimulating local economies. The renovation lasts maximum 1 month time.
Energy savings can be controlled by smart meters, and guaranteed by extra existing insurances that allow in making sure that the energy prices will not differ from what agreed upon. The finance is linked to the building instead of the homeowner, therefore he/she can sell the house and move any moment. The project started in order to make energy transition accessible to everybody, this solution is mainly for homeowners with a high mortgage that still needs to be re payed and low income, moreover the project stimulates local economies.
the main barriers faces are reported in the graph below.

Table 4.9: Summary of the barriers perceived by the project manager for the sustainable transition of the project between the four municipalities

Typology	Interviwed opinion	Citation
Barrier	Legal	"There are some legal barriers to overcome, for instance how to make sure that these new typology of repayments are deductible from taxes such as when homeowner are paying back a mortgage"
Barrier	Financial authorities	"Unsure how to organise a cooperation with banks that want to cooperate"

4.1.4 Case study:Banks

Little bank approval and lack of finance appear to be one of the main barriers, therefore two representatives from banks were interviewed.

ABN AMRO

ABN AMRO is involved in stimulating energy efficiency renovations by offering

financial services to homeowners such as extra mortgage. There are no political obligation for homeowner in order to renovate their dwellings therefore is up to banks to decide whether they are willing to offer their services to finance energy efficiency renovation or not. With the Head of the project finance team it was discussed the potential interest of banks in collaborating with companies offering energy services to homeowners, ESCOS, and the main barriers. During the interview was expressed that in order to have a collaboration with banks ESCO should have a better structure strategy, an economy of scale and payback times shorter then 15 years for getting a loan, and 30 if interested in a fund provision, although in this case an ESCO should also provide a starting capital to the main investor/fund in order to provide a guarantee.

Table 4.10: Summary of the barriers perceived by the head of the project finance team

Typology	Interviewed opinion	Citation
Barrier	Risk	"ESCO will not be able to be funded if they refuse to contribute with an equity. Bank should have a guarantee that in case ESCO is not able to repay they will still have returns"
Barrier	Unorganised structure	"Escos first prepare a financing plan for the customers, then they demand for a loan. Banks don't agree with ESCO's credit scoring system. High risk perceived"
Barrier	Too long payback times	" Banks are able to finance loan ideally up to 15 years, maximum 20. Current payback times too long for loans"

TRIODOS

The Head of private banking mortgages was interviewed. He contributed in the Klimaate akkord by giving a perspective by the legal and mortgages provider. His views about the barriers affecting possible collaborations between banks entities and energy efficiency renovation provider are listed above.

Table 4.11: Summary of the barriers perceived by the head of the project finance team

Typology	Interviewed opinion	Citation
Barrier	Legal regulations	"Netherlands the country with the most personal debt and very strict rules about mortgages. Hard to create a structure that allows people that would not be eligible for loans to be put more in debt. Also attaching a loan to an building instead of a person challenging"
Barrier	Unorganised structure	"At the moment different expertise do not cooperate with each other"

4.1.5 Cross-case analysis

The results from the interviews were compared performing a cross-case analysis between companies and within the other stakeholders' inteviews[91].

Companies

Thanks to the interviews the companies were categorized, according to the business models archetypes for building retrofit given by Brown et al. (2018)[16] and their business model was studying according to the framework of Bocken et al. (2008)[7].
The BM of the companies considered are: One-stop-shop, ESCO and Market intermediation model.

Companies	Business model archetype	Value proposition	Value delivery	Value capture
De Energiebespaarders	One-stop-Shop	Hassle-free house renovation Tailor made solution for homeowners House more sustainable, lower energy bills and higher comfort.	Manage and design of house renovation, marketing, Energy auditing Partners: Installers	One-time sell Acquisition costs
ESCOplan	ESCO energy performance contracting (EPC) ESCO energy supply contracting (ESC)	Tailor designed renovations for building and finance provision to public or commercial building. Connection to district heating and dealing of heat costs on customers behalf Reduction of emissions and lower energy bills. Guarantee of energy savings	Manage energy audit, design and installations. Manage of heat/cold cost of their customers. Partners: Banks and installers, heat producers	One-time sell Repayments (contract lasts around 15 years)
Koude Warmte Den Haag	Market intermediation model	Reduction of the consumption of natural gas in buildings. Enabling in making build environment more sustainable Organised mainly for social housings and organisations of homeowners (Vve)	Campains to enrich knowledge of homeowners about sustainability in the built environment. Mapping of the possible heating systems available. Offering advice on how to organise connection to district heating. Partners: Heat producers, municipalities, Vves and social housing organisations	Non-profit organisation
OVVIA	ESCO energy performance contracting (EPC)	CO_2 emission reduction by implementing energy efficiency solutions. Tailored design for building, lower energy bills Offered finance Guarantee of savings Offered to commercial/public buildings, real estates.	Manage of building audit Installation of technology After installation control of energy efficinecy achieved Managing of finance provision, credit scoring and monitoring of repayments.	One-time sell Repayments Feed in tariffs

Table 4.12: BM of the companies interviewed

Tables 4.13 and 4.14 depict the main barriers found in the case studies. The main barriers deal with **lack of Knowledge and experience** , " homeowners usually don't know about technologies and believe they cannot afford them" (Founder of De Energiebespaarders). Moreover, companies offering energy efficiency options have not organised yet a precise procedure for scaling up their offer to a large amount of homeowner, for example on a neighborhood level, since similar procedure do not exist yet in the case of the Netherlands *"...while for the social housing sector it might work since there is a already an established procedure in order to make renovations, 80% of residents needs to give approvals and it is all mediated by a coordinator party that is experienced while on single household there is no experience on how to do it"*(Project coordinator of Koude Warmte Den Haag).
Lack of experience/knowledge acts as a barrier affecting also stakeholders, that could potentially be involved in the market. For instance, possible finance provider, *"Banks could be possible finance providers although they are not familiar with ESCOs activities and therefore, their interest rates are still quite high"*(Director of ESCOplan).

Other behavioural barriers affecting companies are the **Lack of time** by homeowners and their lack of interest in renovating their home. **Low political support** since the market for energy services providers is believed to be not stimulated enough. **High costs** of technology remain an issue indeed it makes it unfeasible to organise district heating for homeowners as a service, *"Heat will still has a cost comparable with natural gas, with today prices, and price for installation and maintenance are high, therefore it will take long time to payback such an investment. Today, main way to do it is if homeowners form a corporation and finance it themselves"*, (Project coordinator of Koude Warmte Den Haag).
Lack of trust is also blocking the development of the energy service market. Indeed when finance is provided to customers and savings are guaranteed, it is often believed to be *"Too good to be true"* (Director of OVVIA). This factor also leads to a **lack of collaboration**, mainly between policy makers, finance provider, energy services providers and local/National Government,*"Banks, politician, ESCOs all know that something should be done but they are not talking together"* (Director of OVVIA).
People with **relocating plans** are most likely to not being interested in committing in such a renovation process.

Table 4.13: Cross-case analysis of the barriers from companies

	Stuctural			Low political support			Financial
Name company\Barrier	Lack of collaboration	Lack of Infrastructures	Lack of stucture for the renovation chain	Not stimulating market	Unfavourable Regulations	High costs	Risky investments, little finance providers collaboration
De energiebespaarders						x	
ESCOplan				x			x
WarmteKoude Den Haag			x		x	x	
OVVIA	x	x		x			

Table 4.14: Cross-case analysis of barriers. Second part

Interviewed\Barriers	Behaviour			Social Behaviour
	Lack of knowledge/ experience	No time,other priorities	relocating plans	luck of trust
De Energiebespaarders	x	x	x	
ESCOplan	x			x
Koude Warmte Den Haag	x	x		
Ovvia	x			

Stakeholders

Different stakeholders currently involved in the energy efficiency transition for the built environments were interviewed. The interviewed were asked questions about their function inside the ecosystem of energy efficiency renovations and the main driver for taking part in the system, their view on the topic and eventual barriers for their projects and in their view, how could the barriers be overcome.

Table 4.15 depicts the barriers, divided in the main groups found in the literature, plus one that was added thanks to the empirical study, *Legal Barriers*. The most common barriers, depicted by more then 4 interviewed are the **lack of collaboration**, mainly between policy makers, finance provider, energy services providers and local/National Government; *"Banks and energy services company talk in different languages"* (Head of project finance at ABN AMRO).

Secondly, the main barrier is of **financial** entity, indeed caused by the "risk of the unknown", banks, according to the interviews, consider energy efficiency renovations provider's business as very risky. Especially when talking about ESCOs in banks' opinion the credit scoring performed by the energy service company should entail more factors then simply the savings generated on the energy bills. *"If you as ESCO go to a bank to have money to invest then, the bank invests in company ESCO A. Although A will invest in B , company B is not controlled by the Bank. In this way the bank does not own the investment. And cannot for instance take back installation in case company B goes bank rapt. Government should take over this risk on their view but how? and why?"* (Senior policy adviser at Ministry of economical affairs and environment). Moreover a problem faced by companies is the fact that in order to be attractive for banks the business of offering energy efficiency renovations as-a-service needs to be economically easy to scale, *"You need to think bigger, the economy of scale needed. The same amount of work I need to put in a structure with 10 people need to be the same amount of work with a structure of 200 people"*,(Head of project finance at ABN AMRO). Moreover, a general solution for the Netherlands should be developed *"Each munuicipality is developing something different, would be better to find a collective solution for the Netherlands"*(Senior policy officer energy transition built environment). Moreover, the **high costs** are causing **long payback times**, making it unfeasible for energy services companies to receives loans (maximum of 15 to 20 years).
Other important barriers are **lack of structure** on how to organise the renovations of households on a large scale. Indeed, the interviewed share the same concern emerging from the lack of experience. Since there is no party that so far, is able to be intermediate between the households and the energy services providers. *"Hard to organise a finance related to the dwelling for traditional neighborhoods,HOE organizes the repayments for associations of homeowners, there is no such structure for households."*(Project manager at Utrecht economic board).
Lack of legislation is also blocking the development of the energy service market. Indeed the current legislation is interfering with the possibilities of linking finance to the building , *...for instance how to make sure that these new typology of repayments are deductible from taxes such as when homeowner are paying back loan to their house*(Project manager of N.A.L.H project).

Table 4.15: Cross-Case analysis stakeholders.

Interviewed\Barriers	Stuctural		Financial			legal
	Lack of Collaboration	Lack of structure for the renovation chain	High costs	Risky Investment	Long payback times	Lack of legislation
Ministry of home affairs	x					x
Ministry economical affairs and environment	x			x		
Eindhoven municipality	x		x	x		
Economic board Utrecht		x	x	x		x
4 municipalities cooperation	x					x
ABN AMRO	x	x		x	x	
Triodos	x					x

The main reasons leading local and National Government project are the Dutch targets of **reducing of 95% the** CO_2 **emissions** by 2050, those are the drivers also that generally give incentives to commercial and public buildings owners to renovate.
For what concerns homeowners there are not obligations for them to cut their emissions therefore banks can decide if they want to offer services or not in this field.
Banks invest in sustainable projects because they also share interest towards reducing CO_2 emissions. Local communities projects were lead by the willingness to make energy efficient renovation **accessible to everybody**.
The different interviewed pointed out that if a structure was created, in which a **"Middle entity"** could provide homeowners with energy efficiency renovations and collect the repayments for the finance provider, many problems due to the lack of structure would be solved.

Increasing the collaboration will also be fundamental since was depicted as one of the main problems, by the policy makers, by banks (Triodos and ABN AMRO) and by the different project in order to increase the energy efficiency in dwellings (Utrecht, Eindhoven, etc..).

New legal structure are needed in order to enable to have renovations as services linked to buildings.
Developing a **Neighborhood approach** in order to treat single homeowner with similar procedure as it is already done for associations of apartments, could potentially create a structure for energy efficiency renovations, enabling in having a business of scale and getting finance providers approval.

4.2 SURVEY

In this section the main results of the survey are reported, the characteristic of respondents are reported in appendix A, while the survey itself with the relative answer is in appendix B.

4.2.1 Motivations and Barriers

Respondents that invested in energy efficiency renovations to their home received a set of different questions compared to respondents that did not commit such investments yet. Both of their answers will be analysed in the results.

INVESTORS

To the investors, 57% of respondents, was asked how was the finance organised, moreover, it was asked to select the reason why a loan/mortgage was not their selected financing method. The results can be viewed in figure 4.1 and 4.2.
The results given are similar to the results from the WoON survey,[109], the majority of respondents used their own savings in order to finance the renovation, followed by subsidies. Only a smaller percentage used an extra mortgage or loan.
The main reason why respondents did not use any financial option is because their saving were enough, 22% of respondents believed it was too much of a hassle while 15% believed they were not eligible for loans.

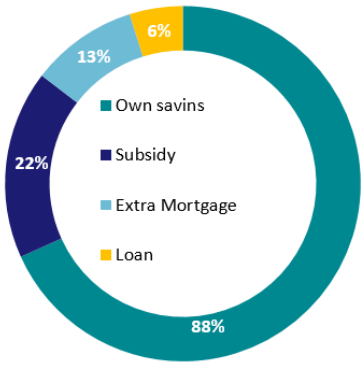

Figure 4.1: Respondents source of finance for renovation

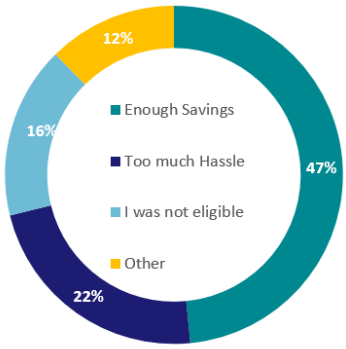

Figure 4.2: Reasons for not choosing financing options

More then half of the respondents made the installation themselves, 25% by contacting a One-Stop-Shop, while 22% contacted each installer separately, as in atomised market model, figure 4.3.

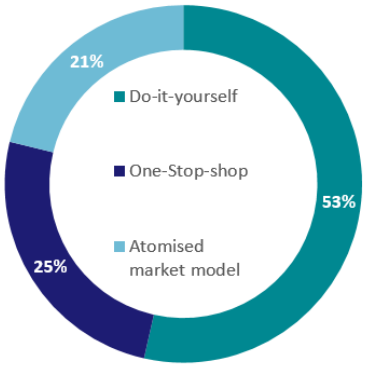

Figure 4.3: How the renovation was organised

On a scale from 1 to 10 is was asked how much the respondent found difficult to find the right products (1), to find trustworthy installers(2) and to organize the finance (3). In general the process of renovation was not perceived as difficult by the respondents, figure 4.5.

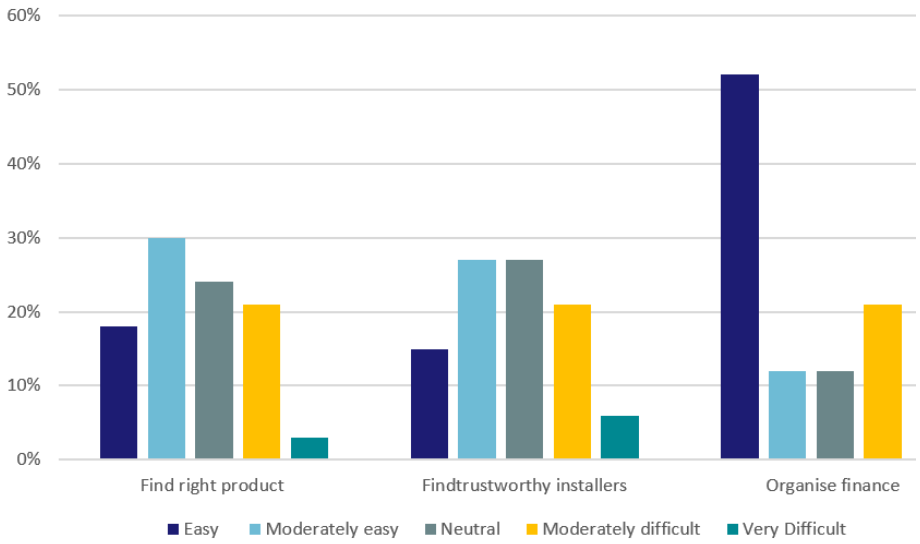

Figure 4.4: Difficulties during renovation process

Moreover the respondent had the opportunity to express what, in their view, was challenging about the process. The answers dealt mainly with the dwelling typology, for instance the difficulties in working with old buildings, the time required for evaluating the best options fitting the house, the high costs and the time to understand how the subsidies worked.

NON INVESTORS

The respondents that did not renovate their dwelling with energy efficiency technologies, 43%, had to rate on a scale from 1 to 10 their degree of agreement with different statements about the potential barriers for investing in their dwelling. The questions are shown in the table below.

Table 4.16: Barriers for dwelling renovations

Question number	Proposition	Mean value
Q1	I do not want a debt in the form of a loan or mortgage	7.1
Q2	Too busy, no time	5
Q3	I don't think I am eligible for financing options	4.5
Q4	I am satisfied with my current home	6.3
Q5	I do not trust companies that offer energy-saving solutions	5.3
Q6	It is difficult to find installers	4.1
Q7	Hard to find the right installations	4.8
Q8	I was not aware of the existence of loans	4

The highest agreement were for the prepositions 1, regarding the wish of not getting in debt, and 4, the feeling of satisfaction in their current dwelling. Followed by propositions 2, being busy, 5, not trusting companies offering energy savings and 7, hard to find the right installations.
The propositions regarding lack of knowledge on financial possibilities, 8, difficulties in finding the right installations, 7, and not being eligible for financing options,3, are the most disagreed upon.

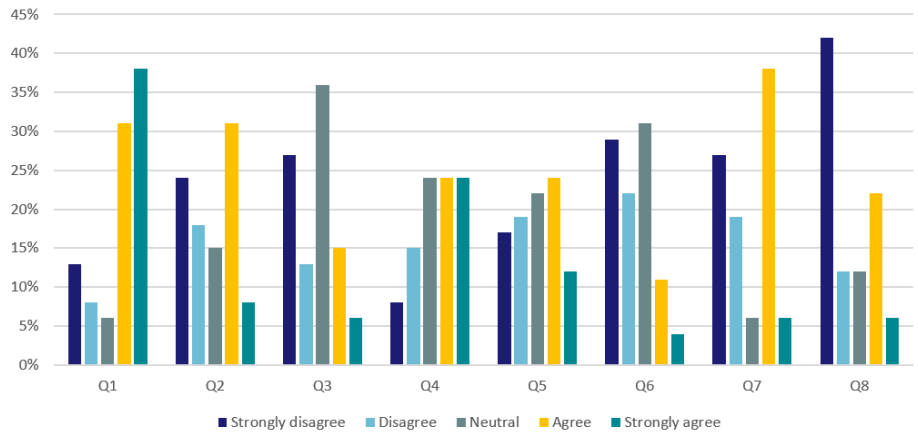

Figure 4.5: Barriers of non-investors

Moreover, at the end of this section respondent could write other factors that were stopping them from renovating their dwelling.
Out of the 19 answers given, four were dealing with moving issues, since respondents were planning on moving in the future. Three respondents stated that their dwelling was already sustainable at the moment of purchase, three believed that their house did not allow renovations. The homeowners association, Vve, was listed as a barrier by two respondents. The rest of answers were dealing with behavioural barriers, such as age of respondents, two answers, stating that they were too old and not willing to commit in such a renovation. Two respondents expressed their low trust in the fact the the house value grows after energy efficiency renovations. Listed by only one respondents were the barriers caused by not caring about the issue, hassle of committing such a renovation and the belief of pv panels to be anesthetic.

Table 4.17: Barriers for house renovations, open questions

Barriers	%
Moving soon	21
Current home sustainable	16
Not possible to renovate house	16
Vve	11
Old age	11
Lack of trust	11
Careless	5
Hassle	5
Aesthetic reasons	5

4.2.2 Favouring energy efficiency renovations

Elaborating the barriers from the literature review, possible factors, enablers [108], that could facilitate the implementation and use of energy efficient technologies were elaborated and tested in the last section of the survey. It was asked to rate the respondents' interest in propositions regarding the enablers depicted.
Results are shown in the graph below, figure4.6.
From left, the first proposition dealt with the concept of financing option, therefore

giving the possibility to everybody to get renovations to their dwellings (Q1). In the second question the concept was better explained, indicating that the repayments would be depending on the generated savings on energy bills (Q2).
Third question was about finance linked to building (Q3), in this case in case of moving the repayments would have to be payed off by the next owners, followed by a question regarding the interest on paying energy bill and repayments together to the same entity (Q4). The fifth question evaluated the interest on renovation on a neighborhood level (Q5), followed by a question regarding the possibility of having a transferable contract, for the next homeowner(Q6).
Moreover, in was demanded how important was for the respondent to be able to select the products to be installed (Q7).

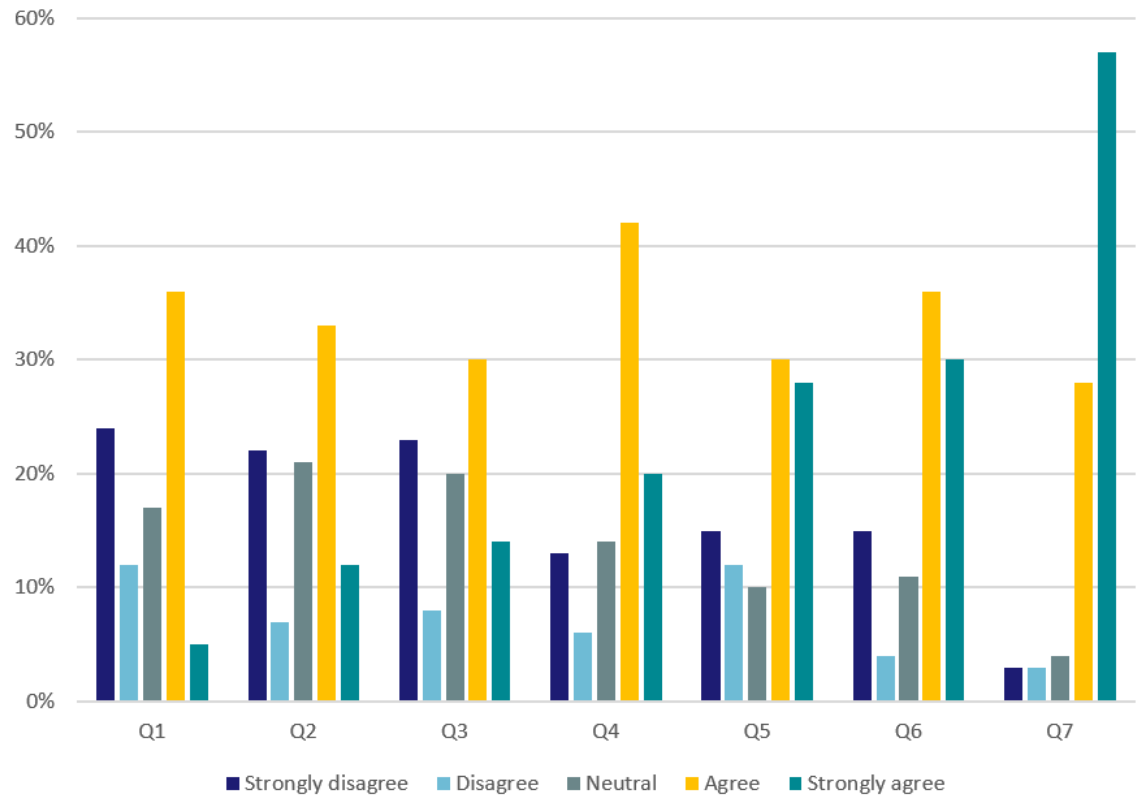

Figure 4.6: Results from survey, final section

4.3 EVALUATION OF TECHNOLOGIES

First, the prices for different technologies were researched, mainly through the website of Milieu Central, a website founded by the ministry of environment in order to provide Dutch citizens with information about sustainable living[75] and of Nibud [80]. For the calculation only households owner-occupied were considered, apartments collaborations were not considered.
The households considered were divided into three typology: townhouse, corner house, detached house. The groups were due to the fact that energy efficiency retrofit and generated savings are dependent on house typology and are difficult to generalize.
Gas consumption in home generally depends upon the size of the household,

while electricity consumption on the number of inhabitants, the average household composition is 2.2 persons in the Netherlands[80]. Therefore the following assumptions were made for each type of dwelling:

Table 4.18: prices of different energy efficiency technologies[75]

Building typology	Townhouse	Corner house	Detached house
Gas consumption (m3)	1350	1580	2410
Electricity consumption (kWh)	3000	3000	3000
Energy bill (Euro/month)	158.25	175.7	238.6

In order to calculate the energy prices the data of July 2019 were used [80], considering gas price of 0.91 Eur/m3 and electricity of 0.2235 Eur/kWh. The main technologies considered are represents in the table below, reporting also indicative prices.

Table 4.19: prices of different energy efficiency technologies[75]

Technology	Price (Euro)		
	Townhouse	Corner house	Detached house
Roof insulation		4700	
Cavity wall insulation	800	2100	3100
Floor insulation	1400	1600	2800
HR++ windows	3100	3500	4700
Pv Panels	3100	3100	6260
Heatpump air		14000	
Heat pump ground		19500	
Heatpump ground collective		11000	
Hybrid heat pump		4600	

Electric boiler were not considered since their energy consumption is very much higher compared to what the other technologies are using [43], heat network and solar district were not considered in this study since each household has a different history and heat networks are more likely to be organised by municipalities in spite of privates[43]. Solar heaters can only be used on a small annually based in the Netherlands and usually need a back up of heating systems using gas [43]. Other technologies still at their early stage of development were not included in the calculations[75]. On a base case, the technologies were evaluated for their generated savings, based on current energy prices and predicted savings thanks to the appliance of energy efficiency measures[75], and the generated CO_2 emissions, comparing them to the ones of a typical Dutch house. The pollution generated by the electricity is considered to be 0.355 kg CO_2/kWh[22], for natural gas 2.18 kg of Co_2/m3 of gas[115]. Figure 4.7 shows the results, with the above described data the most promising technologies are heat airpumps and ground pumps linked to pv panels, since there is no consumption of gas and part of the energy required

is self-generated. Also insulation linked to pv panels shows high generated savings and low CO_2 emissions.

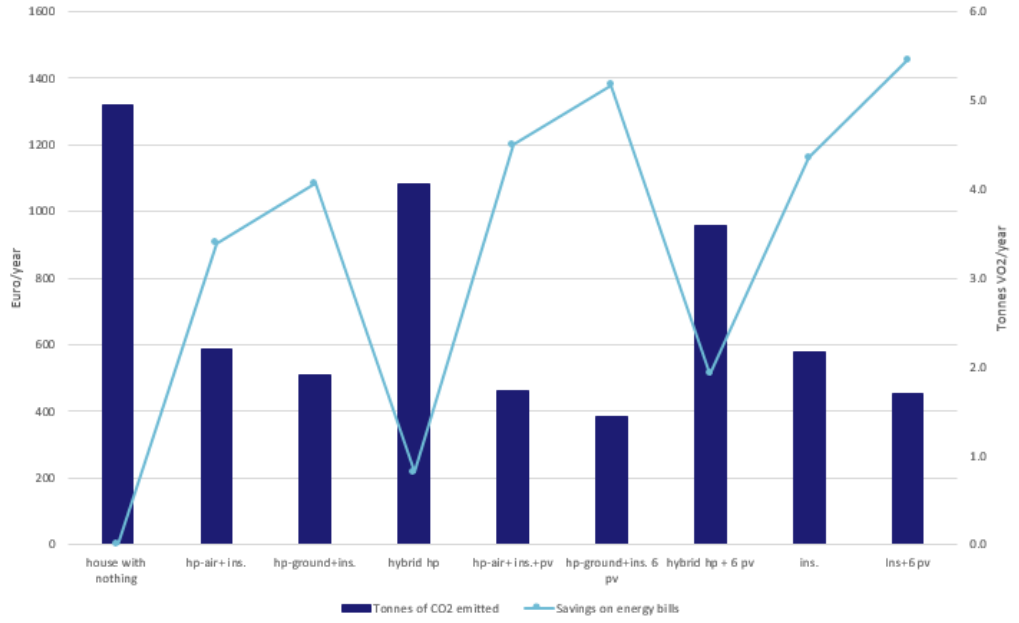

Figure 4.7: Comparison of different technologies, the line indicates the achieved energy savings thanks to the measures reported, the columns indicate the Tonnes of CO_2 emitted in a year by the dwelling

Considering the possibility to offer financing options to homeowner in order to renovate their dwelling, a evaluation was made considering the above described typology of dwelling considered. Figures 4.8, 4.10, 4.9 show the results.

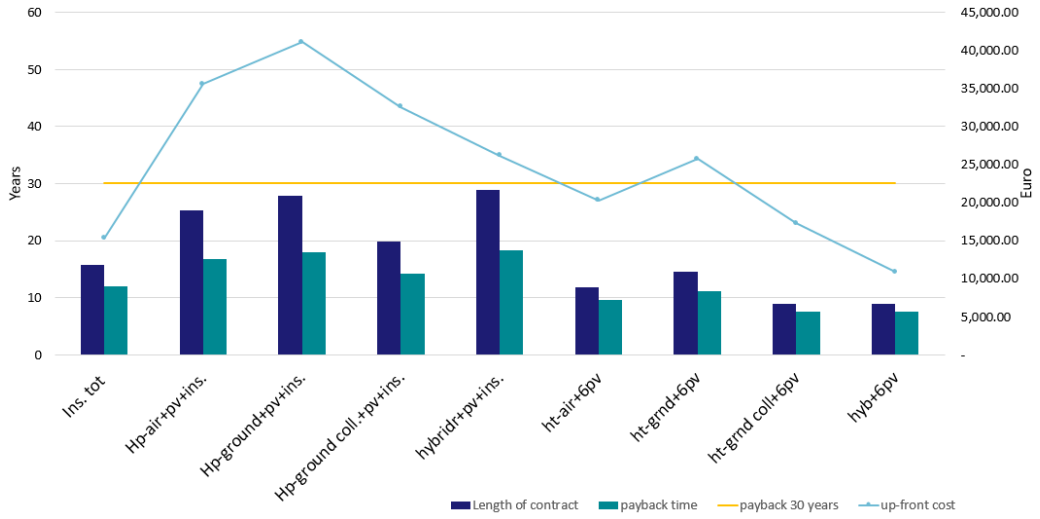

Figure 4.8: Evaluation of payback times, length of contracts and up-front cost for a detached house

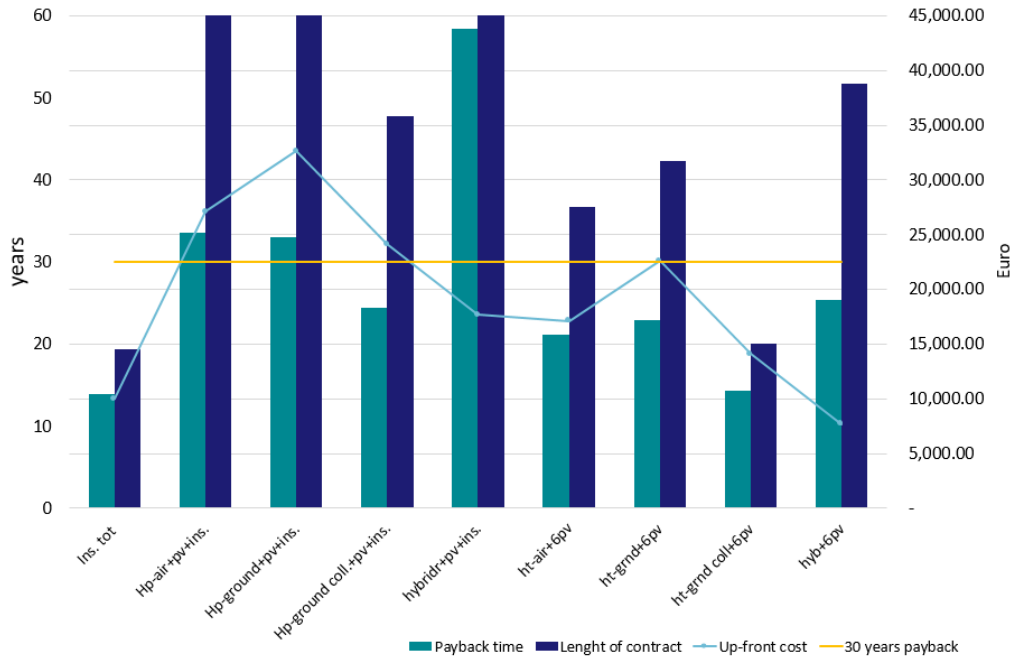

Figure 4.9: Evaluation of payback times, length of contracts and up-front cost for a townhouse

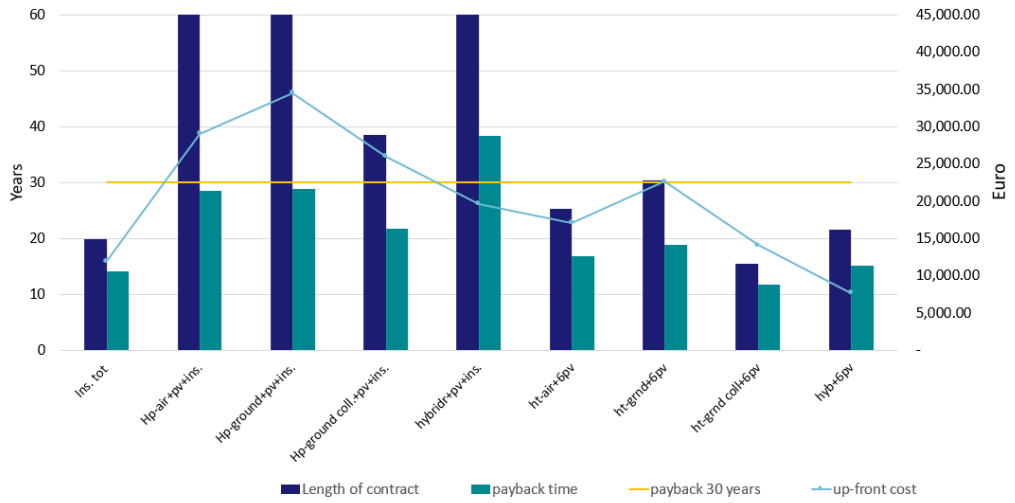

Figure 4.10: Evaluation of payback times, length of contracts and up-front cost for a corner house.

5 DISCUSSION

This thesis aim was to study how BMI can improve the effectiveness of companies offering energy efficiency products for Dutch residential building.
It was calculated that 6 million households are still energy inefficient and needing renovation[54], due to the National targets of carbon reduction, the market for energy services should be a on-growing market, although, the situation in the Netherlands does not yet look promising[113].
Previous studies to this project, studied BM in the energy efficiency renovation market, using BM as a *"...powerful tool for understanding the challenge of improving energy performance and reducing carbon emissions in residential buildings"* (Brown et al., 2018)[16].
The studies have shown that innovative BM that include:

- Value proposition focused on comfort, aesthetics, health provided by the installations and guaranteed energy savings.
- An integrated supply chain, in order to offer a complete tailor-made energy efficient installation to the dwelling.
- One only point of contact
- Financing options to be offered to customers, including low-cost repayment systems, linked to the generated energy savings.
- Coordination of all the activities above described.

Have to potential to enlarge the market for companies offering energy efficiency renovations. Although this study was performed by taking into consideration the UK. Leaving the doubts on what the Dutch situation could look like, which barriers could Dutch companies face and which BM could best fit for the case of the Netherlands.
In order to continue previous research on this topic the particular situation of the Netherlands was studied, by first, evaluating which BM are mostly diffused in the Netherlands, for companies offering energy efficiency renovations and having as customers homeowners. Moreover the stakeholders acting in the market ecosystem of energy efficiency renovations were depicted, and interviewed. Thanks to the research, an accurate map of the current Dutch energy efficiency renovation market was performed.
Followed by a study over the barriers and possible options in order to overcome those, gathered by literature study, interviews to company and stakeholders and a survey to homeowners.
Finally, different technologies for energy efficiency renovation were compared, considering costs, carbon emissions and energy savings achieved, in order to depict the most indicate set of technologies that companies could offer to enable energy efficiency in the residential sector.
The findings are significant since they investigate the Dutch situation of the energy efficiency renovation market and advice which BMI could increase the effectiveness of companies offering energy efficiency renovation measures, enabling energy efficiency renovation for the Dutch residential sector. Moreover this paper provides policy makers

directions on how to stimulate this market, and to companies advises on how to innovate their BM. Other involved stakeholders can benefit of this research by gaining a deeper understanding on energy efficiency renovations in the Netherlands and how they could act in regards to it.

From the literature study I discovered that the main barriers faced by companies offering energy efficiency renovations are dealing mainly with structural problems, political issues, high costs of technologies, and the behaviour of homeowners.

The results from the literature were then compared and studied for the case of the Netherlands. The main barriers were depicted from companies operating in the renovation sector, stakeholders and homeowners. Results are quite differing from each category of interviewed. Structural barriers, hence problems due to the supply structure of the company and the lack of collaboration between enterprises are barriers perceived both by companies and stakeholders.

Companies have serious concerns about the lack of political support and stimulation for the market of energy efficiency renovations between households.

High up-front costs and consequently long payback times of energy efficiency products is one of the main issues for companies of this sector, since it causes homeowners' unwillingness to invest in their dwellings, and affects the collaboration with stakeholders.

Companies believed that lack of information/knowledge on behalf of possible customers and possible partners were a problem, although homeowners affirmed to be confident about their knowledge on renovations options, financial offers and renovation system.

Companies effectiveness is also affected by behavioral issues, indeed the survey reflected the literature study findings for what concerns the issue of homeowners having other priorities, being satisfied with their current dwelling and having relocating plans.

Lack of trust remains an issue that blocks homeowners in contacting energy service companies for renovating their dwellings and banks and other potential finance providers in cooperating.

Other barriers depicted during the empirical study were the barriers caused by the risk perceived of banks for companies offering energy services, blocking the possibility of a collaboration. This barrier of the "risk of the unknown" was found in the interviews of both companies and stakeholders. Collaborations between companies and stakeholders are also affected by legislative problems that decrease the possibilities of organising energy efficiency repayments linked to buildings.

During the interviews it was investigated what, according to the interviewed knowledge about the topic, could the company offering energy efficiency renovations to residential builsings add within his BM in order to enable energy efficiency renovations.

From a governmental perspective the solutions offered should be accessible to all households and help Netherlands in achieving its target for 2050. Their last realise of the Klimaat akkord confirms their idea of organising neighborhood renovations, in order to speed up the energy efficiency renovation, no clear structure for this approach is being developed, therefore if companies could organise it, it would higher the changes of interest on behalf of governmental parties. Moreover, for the collaborations with banks or other finance providers such as funds is essential to have a business plan of scale, and payback times lower then 30 years.

Different factors that could, if included between the company offerings and withing its BM, overcome the main barriers were tested in the survey, results show that

homeowners are interested in:

- Having choice on the product to be installed to their home.
- Receiving renovations as-a-service, paying back the finance through the savings achieved on the energy bill, giving the guarantee of the achieved energy efficiency result.
- Having financing options linked to the building or having a transferable contract.
- Paying repayments and energy bills through on the same contact point.
- Taking part on a neighborhood energy efficient renovation plan.
- Slightly more trust if energy services are offered through a party collaborating with banks and municipality

The findings can be combined with the conceptual sustainable business model framework, from Bocken et. al(2015)[10], resulting in the most valuable BMI for a Dutch company offering energy efficiency renovation to implement, for enhancing its effectiveness.

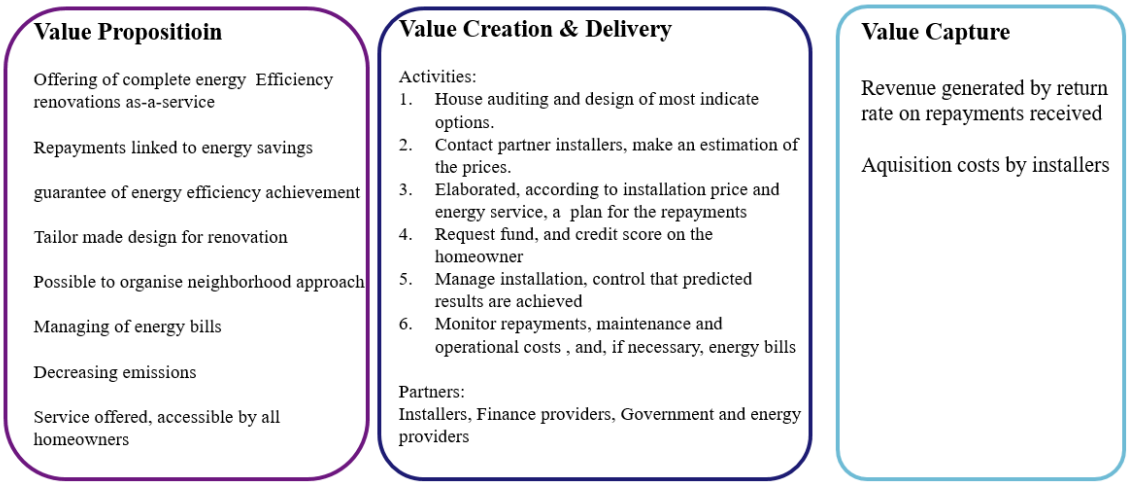

Figure 5.1: Conceptual framework for energy efficiency renovation BM Adapted from Bocken et al. (2015) [7]

6 CONCLUSION, IMPLICATIONS AND RECOMMENDATION

The action in Europe against climate change raised a lot of concerns about the built environment. Indeed, a large share of already existing building is energy inefficient, causing high energy consumption and reliance on natural gas.
The Dutch government aims in decreasing by 95% their emission and to free completely neighborhoods from natural gas by 2050 [54]. To reach the ambitious goals, a significant renovation is needed to the Dutch building sector, 7.4 million buildings were estimated to be needing energy efficiency renovations, of which 6 millions are residential building [54]. For what concerns households, the homeowners are seen as the main investor for the renovation, since they are also the ones enjoying the benefits.
Although the significant need, the rate of yearly energy efficiency renovation still has not reach its optimal value. The thesis has addressed this problem from an economical perspective, resulting in the main research question:

How business model innovation can help Dutch companies offering energy efficiency renovations for residential building in being more effective?

This section summarises the conclusion from the research on BMI in the energy service market, for residential buildings. The main findings and conclusion from each sub-question are reported in the following section 6.1. Following, in section 6.2, a discussion about the completed research, the limitations and possible future follow-up research. The chapter ends with section 6.3 with implication practice and recommendations.

6.1 CONCLUSIONS

This section sums up the main findings of the research by describing how each sub-question was answered.

6.1.1 What are the current business models in the energy efficiency renovation market for residential buildings?

The research question was answered by conducting a literature review study. Mainly 7 business models were found, one was applicable to companies organizing and installing one only energy efficiency product or offering energy audit services, atomised market [16], while in the case in which a company offers energy audit and possible connection to installers is called Market intermediation model[16].

Table 6.1: BM archetypes from literature

BMI\BM	Value Proposition	Value Creation Delivery	Value Capture
Atomised market (AM)	Increased comfort Energy bill savings Reduce pollution	Installment of product offered	One-time sell
Market Intermediation model	As for AM one contact point	Energy audit Possibility of connection to installers	One-time sell
One-Stop-Shop (O-S-S)	As for AM One contact point for the whole renovation Tailor-made advice	Energy audit Manage installation of products collaboration with installers.	One-time sell
ESCO EPC	As for O-S-S Guarantee of savings Financing option	As for O-S-S plus financial experts Maintanance	interest rate on repayments
ESCO ESC	As for ESCO ESC manage of energy bills	As for ESCO-EPC Manage of the energy bills Energy provider: partners	interest rate on repayments Feed in tariffs
On-Bill Financing	Financing option for house renovation Linked to building Energy bill saving Increased comfort	Lend of finance Collaboration with energy providers	interest rate on repayments
On-Tax Financing	As for On-Bill fin.	Lend of finance Collaboration with Government/municipalities	interest rate on repayments

One-Stop-Shop BM refers to companies that organize every step of the renovation on behalf of the homeowner and are the only contact point for every step of the process, resulting in an less complicated procedure for the customer and in a tailor-made design of energy services to retrofit the dwelling[73]. ESCO BM is applied by companies that organize a complete energy efficiency renovation for a building, as One-stop-shop, and that offer certain level of guarantee for the predicted energy savings and finance. The finance can be repayed to the Esco company by the homeowner, and the repayments are equal or lower then the predicted savings, calculated on the base of the dwelling energy use before the renovation, this typology of contract is called Energy performance contracting (EPC) [79]. Some ESCOs can also offer to manage the energy bills, in this case the customer pays a monthly fee to the ESCO including energy bills and repayments for the all length of the contract, Energy supply contracting (ESC)[71]. The last two BM reported in the table below are BM that can be applied by Municipalities, Governmental entities, Energy providers, banks and potentially also ESCOs, the BM On-bill and On-tax financing are dealing with an innovative way on how to organize the finance of energy efficiency products. Overcoming the problems of initial high costs, possible relocating plans of homeowner, indeed the finance is linked to the building and

not to the person. In order to research the Dutch energy service market development the first subquestion was divided into two minor ones:

What are the current business model in the Dutch energy service market?

The semi-structure interviews and the survey enabled in having a clear picture of the Dutch energy efficiency market for buildings. For what concerns the Netherlands, the BM of the companies interviewed were One-Stop-Shop, Intermediate market and ESCO. Although the two ESCO companies interviewed were not interested yet in homeowners as customers since they believed that regulations were not yet supporting the market for residential building. The company interviewed having a market intermediation BM was mainly researching how to implement district heating for housing association, public and commercial entities. Although other similar companies exist in order to assist homeowner in the energy audit of their dwelling and advice which installer contact for the further steps of the renovations. When investigating in the survey on how people that renovated their dwelling did organise it, the main answer was self-arranged and installed, the rest was organised through One-stop-shop and through single installers (atomised market model BM), resulting as the most common BM chosen by homeowners in the Netherlands, the BM are reported in figure 6.1 and 6.2.

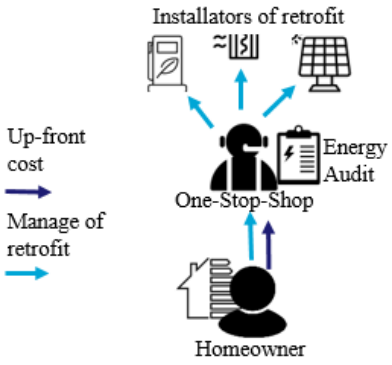

Figure 6.1: One-stop-shop BM

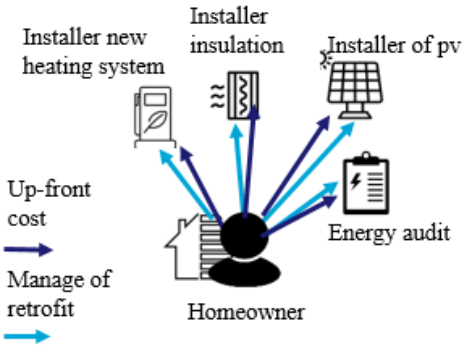

Figure 6.2: Atomised market model

Who are the main stakeholders involved?

The government plays a fundamental role for what concerns energy efficiency renovation for residential buildings. In these regards, the National targets are set to decrease CO_2 emission of 95% and to renovate the already existing building stock with energy efficiency measures by 2050, removing the natural gas network. Drove by this objectives governmental parties, and municipalities have the ability of being fund providers in order to ease the process of renovation for homeowners not able to afford it, or not willing to invest their savings in such a renovation. Currently there are subsidies offered by the government that are only in part covering the costs for new heating systems [48], also a fund is available, National energy saving fund, that allows in lending money to homeowners for making energy efficiency renovations to their dwelling, although it is not globally available to all homeowners.
Also banks are currently offering extra mortgages for homeowners to increase the energy efficiency of the newly bought house.

Some municipalities have started local project in order to make accessible to all homeowners to renovate their dwelling and stimulate local economy, the projects are still on a pilot phase.
Adapted by the Ecosystem business model map of Bahari et al. (2015) [3], and thanks to the interviews and the survey, the different stakeholders in the energy efficiency renovation market I could define a clear picture on what the current Dutch market looks like.
Figure 6.3 is divided in 6 parts. Horizontally are represented public entities, therefore Government for what concerns the demand section, indeed, as pointed out by the interviews to policy makers, the Dutch government is active in researching solutions to decarbonise the building sector.
Governmental entities are also offering financing options, such as subsidies and loan through the national energy saving loan, provided by SVn, its description can be found in the literature review, section 3.4. Few municipalities have express also their interest in developing their own financial scheme for promoting energy efficiency renovations, and making them available for everybody, the projects developed by the municipalities are in a pilot phase.
Eindhoven created a fund, together with financial providers in order to favourite ESCOs for homeowners, while the municipalities of Utrecht and the project of 4 municipalities are aiming in developing financial options linked to the building of homeowners. The 4 municipalities cooperative have developed an on-tax financing scheme, available mainly for low income household.
In the central column are represented the main user considered therefore homeowners, that can decide to finance the renovation themselves, most common option so far, and eventually request for subsidies, or for extra mortgage to bank, or a national energy saving fund from SVn, only 1% of people that have renovated their dwelling chose this option [109]. Homeowner living in the municipalities interview could also decide to take part in the renovation pilot projects and be founded according to the new developed schemes.
After having decided the financing option, homeowners can decide how to organise the renovation from the interviews and survey resulted that the main forms BM for homeowners are One-stop-Shops and atomised market model, moreover more then half of the investors in the survey have made the installations themselves not going to any companies, although this approach is not possible for all technologies.

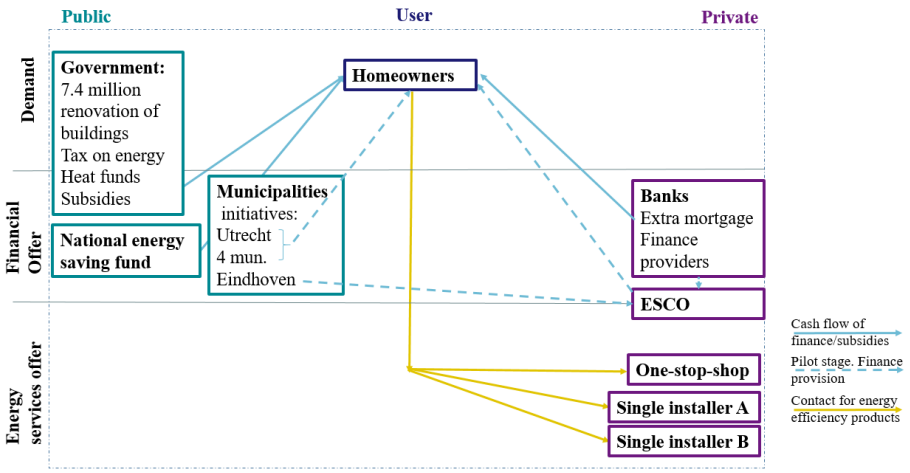

Figure 6.3: Ecosystem of energy efficiency renovations for homeowners map

6.1.2 What are the barriers for the Dutch energy efficiency residential building renovation?

By gathering the literature study findings, surveys to homeowners and interviews to companies and stakeholders, the main barriers affecting energy efficiency renovation of residential building in the Dutch context were found and are presented in figure 6.4. It can be concluded that main barriers blocking companies' success are due to financial issues, the results from the survey have shown that homeowners that had invested already in renovation of their dwelling used their own savings. Although the majority of respondents that did not renovate were blocked in doing it by the fear of getting in debt on a form of a mortgage or loan. Indeed energy efficiency renovations to nZEB or with the aim to change the heating supply of a dwelling are likely to be expensive and to require extra maintenance renovation for the house, resulting in long payback times.
Other barriers analysed are mainly dealing with behavioural problems such as being satisfied with their current dwelling, or having other priorities. The issue of having relocating plans and the difficulty of finding the right products was also depicted, since these factors demotivate homeowners in renovating their dwelling.
Partly due to the relatively recent appear in the market of companies organising complete energy efficiency renovations, such as One-Stop-Shop companies, part of the homeowners taking the survey affirmed their low trust towards these companies and towards predicted energy savings advertised. This barrier was also shared by banks, for their possible collaboration with companies offering energy efficiency renovations.

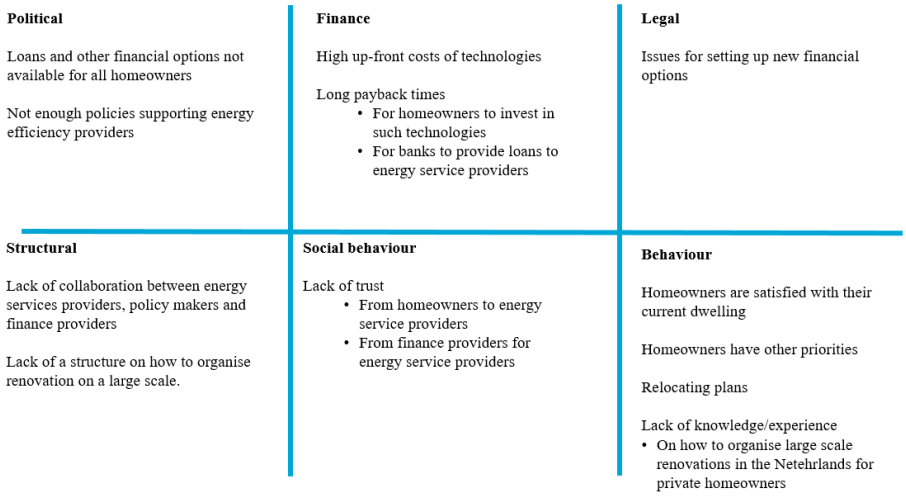

Figure 6.4: Barriers for energy efficiency in residential building

For what concerns barriers affecting companies, besides the low interest of possible customers, homeowners, for the reasons above described, lack of a defined structure in order to set up a National plan for renovating was listed in nearly every interview. So far only municipalities have created their own financial offers and renovating schemes, the current market is lacking a defined structure and seeking more collaboration between different parties, indeed it is believed that from policy maker there is not enough support for companies offering energy efficiency solutions, therefore homeowners are not stimulated in renovating their dwellings, and little recognition and consideration is given for companies that deal with decreasing the energy consumption of the residential

sector.
Moreover, possible finance providers are not recognising potential in companies business therefore are less inclined to collaborate in providing funds.
Innovation in the business model that were depicted in literature that could overcome barriers of homeowners having relocating plans and financial issues such as offering finance linked to the building instead of the person, are currently affected by the Dutch legislation, for instance linking repayments of finance to the building instead of individuals is still challenging to organise for companies. Thanks to the knowledge achieved about barriers and the current Dutch energy efficiency market it was possible to give an answer to the subquestion:

Which BMI best fits Dutch companies offering energy efficiency renovations for residential buildings?

Until now, the main companies offering complete energy efficiency renovations for residential sector have One-Stop-Shop BM, on one hand it improves the time for the renovations since the different renovations are managed by the same entity and this BM allows in engaging different companies offering single measures, increasing the amount of collaboration between small and medium enterprises offering energy efficiency services, found in the project COHERENO to be one of the main factors that could improve energy efficiency renovations for residential buildings privately owned[77]. Moreover it has been shown in the survey that to offer tailor-made products for a dwelling improves homeowners interest in the offering. On the other hand, this BM still requires customers to provide their own finance and has been shown by the research that remains one of the main issues, for these reasons, innovative business model that incorporate financing options within their core are the BM that could best engage Dutch homeowner's in renovating their dwelling, by adding an extra offer that will result in removing what homeowner could perceive as "hassle" [27]. More in particular this research has shown that BM of companies offering energy services that are including:

- A value proposition that offers energy efficiency measures in a tailor-made design for their costumers.
- Stress between the value proposition the possibility of transferring contract or to link it to the building in order to overcome the issue of homeowner having relocating plans.
- To add between offered services a guarantee of the energy efficiency, overcoming the barrier of trust.
- An collaborative supply chain in which customers are able to pay energy bills and service costs to the same account.
- Add between value creation and delivery of BM the offer of energy services renovation on a neighborhood level.
- A financial model, that offers renovations as-a-service, enabling homeowner to renovate their dwelling without the need to use their own savings. The service monthly cost should be based on the calculated savings due to lower energy bills.

Have the potential of improving the company's effectiveness. Between the BM depicted there is not such a BM, although ESCOs offering energy supply contract could be the

most indicate options, since they offer energy services to homeowners and moreover, by taking care of the energy bills, the finance remains attached to the building.
Making the renovation process hassle free for homeowners, figure 6.5 represents the ESCO ESC BM.

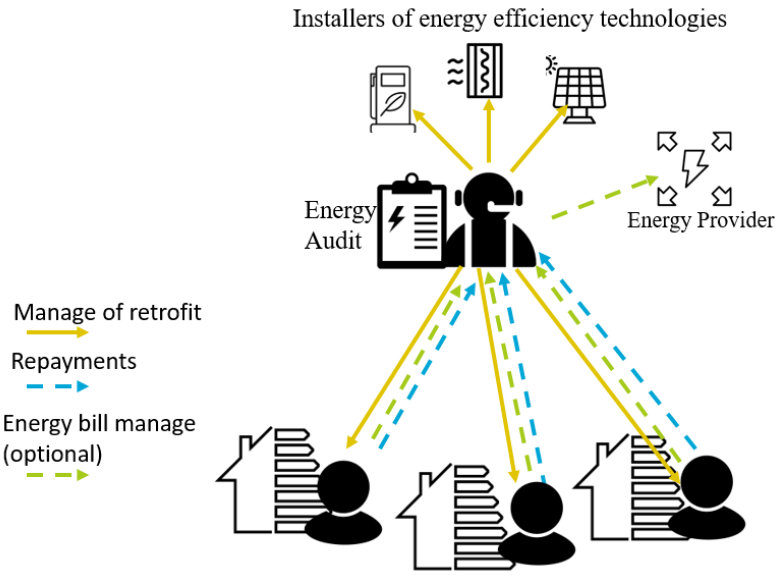

Figure 6.5: Summary of ESCO company performing energy supply contracting on a neighborhood level

Although assuming an ESCO BM could seem the best BM to improve the effectiveness of companies offering energy services, the semi-structure interview argued that setting up an ESCO company remains quite of a challenge since the risk perceived by potential finance provider is high, therefore resulting in very unfavourable environment for an ESCO market to form. Moreover, as result from the evaluation of technologies section 4.3, currently energy efficiency renovations' high costs do not allow for complete renovation to be offered to all typology of dwellings. Indeed, if the repayments had be collected through the generated energy savings the deepest energy efficiency renovation could not be offered to a wide typology of dwellings. Therefore in order for an ESCO BM to be successful for companies offering services to residential building, energy efficiency technologies should be cheaper, also if the taxing on electricity and on gas would change, favouring electricity over gas, then ESCO BM might become profitable for Dutch companies. The current conditions do not allow the formation for an ESCO market for residential building.
ESCO working in Europe are mainly operating with multi-apartments buildings and social housing, ESCOs are repayed through the generated savings on the energy bills through ESC and usually maintenance of products, ESCO offering EPC are more rare in the residential sector. An ESCO market has formed in countries were strong regulations for energy efficiency in buildings were linked to tax relief and white certificate scheme [63].
Despite the unfavorable situation for the formation for ESCO in the Dutch residential sector, the results do not involve that companies should not change their BM. A more collaborative business should be elaborated between companies and stakeholders, to, first of all, create a structure for a large scale renovation of residential building and secondly to overcome the problems of lack of collaboration between parties. Companies,

finance providers and governmental parties should exchange their knowledge and expertise and shape together a new structure supporting a National renovating scheme.

It will increase the effectiveness of companies to offer in their value proposition also the possibility to take care, on behalf of homeowner, of requirement of financial options elaborated by governmental entities, such as the Heat fund [54] and the National energy saving funds [103]. By doing so, the process would result easier and more immediate for homeowner, indeed a recent study was conducted about Dutch homeowner' behavioural barriers for renovating their dwellings, and the study pointed out the perceived hassle of applying for loans or subsidies and researching for solutions for energy efficiency measures [27], therefore by providing a complete renovations with up-front costs covered the homeowners will feel less hassle, this was reflected also by the survey's respondent.
Moreover, there will be less transaction of the fund, since it will be directly issued to the body organising the renovations.
By using this new scheme, the renovations will be seen as-a-service rather then a loan or mortgage, and will gather more homeowner consents.

There are different options in which funds could be re-payed, in order to offer a service rather then a loan, finance should be possible to be linked on the dwelling instead of the homeowner, or should be possible to transfer the contract to the new owner in case of sell of the house. An on-tax structure should be excluded due to legal restrictions, although using on-bill repayment scheme should be possible, therefore the energy provider would charge the repayments to the fund providers on the normal monthly energy bills, such as it already does for the tax payed by homeowners on electricity and gas to the government.
A similar scheme was experimented in UK with the "Green deal" although it was not successful due to the lack of governmental financial support leading to return rates of around 7-9%, moreover the concept of "paying-as-you-save" was limiting the technologies options offered [94]. Paying bills is something homeowners are already used to do, and in this way the service repayments would be linked to the homeowner building. In order not to incur in the same problems as the UK trial of the Green dial, the fund provided should have low return rates.
In this case companies should take care of linking energy providers with the fund releasing entity in order to organise the repayments thorough the usual energy bills. Although the Netherlands has many energy providers, therefore it could result in a complex organisation. An example of this structure in given in appendix C

As second option of collection of repayments, companies could add between their offers also the possibility of collecting repayments for the service from the homeowners, in this way the structure of the financial scheme has a simpler transactions then On-bill financing scheme, and the company will act as an ESCO on the homeowner's view even though that the finance will be provided by a third party involved. An example of this structure in given in appendix D.
Moreover, companies should look into the possibility to offer renovation on a neighborhood level, since the survey showed that homeowner would be interested in it, technologies might be cheaper, for example if installing a collective heat pump for the neighborhood, and this would speed up the renovation of Dutch residential building stock. For Vve there is an already existing procedure to follow when a change wants

to be taken into the buildings, indeed if the majority of homeowners agrees with the changes than the measures are applied, no such procedure exists for neighborhood yet, although this could speed up the process of renovations.

6.1.3 What are the current technologies employed in energy efficiency renovations for Dutch residential buildings?

To improve the energy efficiency of a dwelling, the fist step to be taken is to reduce its energy consumption. In order to do so, insulation of floor, cavity walls, roof and facade are needed. Having insulated window is also important for the limitation of heat transfer in the house [45]. Ventilation should also be optimize in order to allow fresh air inside the dwelling but without allowing an excessive heat transfer[2].
After complete the passive measures, the heating system can shift to a more efficient one, consuming less natural gas, such as hybrid heat-pump. A dwelling can also stop completely his use of natural gas by choosing heating systems that are only requiring electricity such as electric boilers, heat-pump, or solar collector[34],[116].
As final phase of the renovation, products allowing own generation of energy can be installed, such as pv panels or small scale wind turbines[116], [86]. Home batteries can also be added to the dwelling in order to save the amount of energy overproduced [116].
The EPBD directives [37] do not give indications on renovations to be taken for already existing building therefore it is up to homeowners to decide till which degree renovate their dwelling.
Moreover, the BMI of adding financing options and repayments linked to savings on energy bills might affect the possibility of companies to offer complete packages of renovations, arising the problem of which technologies should companies offer in the Netherlands, this topic was investigated through the sub-question:

What are the enabling technologies that best fit the BMI for Dutch companies offering energy efficiency renovations?

When offering a complete range of technologies to a dwellings as-a-service, with the concept of paying back through the generated energy savings some technologies look more promising then others due to the highest achievement of savings produces.
The energy efficiency renovation packages tested were:

- Full house insulation
- With or without full insulation, pv panels and heat pump air
- With or without full insulation, pv panels and heat pump ground
- With or without full insulation, pv panels and heat pump ground collective
- With or without full insulation, pv panels and hybrid heat pump

According to the current energy prices, technologies costs and predicted savings thanks to energy efficiency achievements, the technologies that lead to higher savings on energy bills and lower CO_2 emissions are insulation measures installed with pv panel system, the addition of heat pumps allows, further more, to stop the reliance on natural gas, decreasing the footprint of the dwelling. Air heat pumps are cheaper although consuming more electricity then ground heat pumps [34] hence they lead to

higher energy bills, for some neighborhoods ground-heat pumps are possible to be shared, allowing in decreasing the cost of the technology [75].It can be concluded that hybrid heat-pumps do not allow for high energy savings and their are still cause for high quantity of emission therefore should not be included in the offers of a ESCO in the Netherlands.
A conclusion can be made for each typology of dwelling considered, townhouse, corner-house and detached house. Offering energy services as-a-service is possible for each dwelling, although if the repayments are intended to be equal to the energy savings, keeping in mind that the loan should be returned after no long then 30 years, it can be a challenge with the current energy prices. Considering a payback rate of 2%, similar to the National energy saving fund return rate, the payback times were calculated.
Detached house are eligible for this service since their higher surface allows in having more space for providing pv panels. All the technologies above described can be offered as-a-service.
For what concerns townhouse, renovation as-a-service with repayments linked to the saving is an option only when a collective ground heat pump is offered together with solar panels, adding to the equation also insulation makes the cost of the renovation too expensive to be repayed within 30 years.
For corner house the possible technologies to be offered, through a pay-as-you-save concept, are installment of pv panels and a heat pump, air or ground are both possible, and a hybrid heat pump.

6.1.4 Main research question: How business model innovation can help Dutch companies offering energy efficiency renovations for residential building in being more effective?

To conclude, the findings allowed in depicting the most enabling innovations to add to the business model of Dutch companies, offering energy efficiency renovations for residential buildings.

VALUE PROPOSITION

Companies should stress their offer of complete energy efficiency products to the dwellings, delivered through a tailor made design, according to homeowners preferences. Stressing the achieved energy savings, the higher indoor comfort and the lower footprint generated by the dwelling.

VALUE CAPTURE

To speed up the process of renovation in this sector, it is important for companies to offer their products including financing options, therefore allowing costumers in receiving the energy efficiency measures up-front and subsequently to re-pay the installation through monthly fees.
When possible, repayments should be structured on the achieved savings on energy bills. While for highly costly renovations, for instance when full insulation of the house are applied together with other measures, a guarantee of the achieved performance should be given.
And the possibility of offering finance to homeowner through funds with low return

rates. Therefore the revenues will be based on the commissions of the company for organizing the energy efficiency renovations to the dwellings and the commission for being the middle figure of the financing structure.
With the above-described BMI the cost structure will involve also the costs for employees involved in the new activities of the company.

VALUE DELIVERY

The most efficient way on how to organize this, would be for companies to cooperate with Governmental and private entities in order to offer financing options through one of the existing funds for energy efficiency renovation, or new funds of created, in this way low return rate would allow in accessible repayments for homeowners, and the fact that the finance are included within the renovation packages would decrease the hassle perceived by homeowners on the renovation process.
Therefore Companies should include between their activities, besides marketing, design and manage of energy efficiency renovations to also offer maintenance and to provide to the fund issuing entities the energy audit on the dwellings to be renovated and the installations costs. Moreover companies should act as the middle entity between homeowners and the fund, taking care of the long term contracts and collecting the repayments to the fund. Enabling in a more efficient structure.
Activities that should be more closely be looked into by companies are to offer renovations on a neighborhood level, that could increase the homeowners' interest in renovations, as it was shown in the survey, and to organize repayments linked to the energy bills of the dwelling, allowing in having finance linked to the building instead of the person.
Key partners should be local installers of energy efficiency measures, and National or local governments, in order to support their activity and provide funds, private finance is also required when aiming in renovating large size of residential building, therefore collaboration with private capital providers are also important.
Between the products to offer it is adisable to offer energy efficiency renovation that provide higher energy savings on dwellings.

6.2 LIMITATIONS & FUTURE RESEARCH

The ambition of starting this thesis was to deepen the knowledge about the issue of energy efficiency renovations on the level of residential buildings. Evaluating how BMI could enable companies offering energy efficiency renovations in being more effective, enabling those renovations between the Dutch residential sector. Conclusions were made about this topic thanks to literature research and empirical research comprehending an exploratory-descriptive case study, a survey to homeowner and a validation of technologies. Some limitations are although affecting the results, and will be presented in this section.

Semi-structure interview

The research was performed in a limited amount of time, therefore limiting the amount of interviews to be possibly conducted. Only one company dealing with homeowners as customers was interviewed, in the case of a longitudinal study, more interviews could be performed with other One-stop-shop companies and single installers, to have a more precise view of the current BMs adopted by companies in the Netherlands and their

main barriers.
Also for what concerns energy providers companies should be interviewed, since their view on this topic is also important, due to the fact that they could be key partners of companies offering energy renovations, although this will limit the freedom of customers in selecting their own energy provider.

Survey
The survey was performed among 100 homeowners, if the respondent were more, results would have been more accurate and representing better homeowners view.

Validation of technologies
During the phase of validation of technologies it was challenging to make a prediction of payback times and future saving of dwellings, since little data was found on this topic, and that every dwelling has its own history. A lot of factors should be taken into account in order to make a real prediction about the dwellings, such as the number of people living inside it, the age of construction, the energy label of the house and the dimensions. For my calculation I have assumed to have standard size of dwellings of the typology corner-house, townhouse and detached house. With the average amount of people living per house in the Netherlands, 2.2 [80]. All the rest of affecting factors above described were not taken into considerations, the calculations were made considering energy efficiency renovations to be either with or without full insulation. For these reason the results might be affected by the assumptions made.
Moreover when reporting price of technologies the acquisition costs were not taken into consideration. When a company such as a One-stop-shop offers services, it usually performs part of the acquisition process on behalf of the installers partners, therefore resulting in a cheaper cost of the service. This factor was not taken into consideration.

Homeowners behaviour
For this research, possible changes in the energy consumption due to the homeowner behaviour were not taken into consideration. This factor should be more closely researched when designing a BM for a company offering energy efficiency technologies, for instance how can over-consumption of energy due to homeowner behavior be faced by companies offering energy efficiency renovation as a service, or how to treat cases in which the number of inhabitants changes inside the dwelling, for example if a couple have a new baby, the energy consumption of their dwelling will change, therefore a new structure of repayments should be elaborated.

For **future research** I would recommend in performing a feasibility study about the business of energy services provider in the Netherlands, taking in consideration a single neighborhood. In order to calculate the profitability, the issues that could arise by organizing a complete renovation of a neighborhood level.
Moreover I would recommend to use tools as the ecosystem business model matrix or the histogram ecosystem developed by Maniak et al. (2015)[3]. to evaluate gains and contributions by different stakeholders when contributing into a collabotative structure for renovation.
I would also suggest to look into the best feasible way on how to organise repayments for energy efficiency renovations, what procedure homeowner prefer, what configuration is the most efficient and to look into the possibility of finance linked to the building.

6.3 IMPLICATION PRACTICE AND RECOMMENDATIONS

Based on this study, the most indicate way in which a company offering energy efficiency renovation could change its BM could be to offer the renovation including financing options. Based on the research, different BM configuration could be used in order to realise this. With the current regulation the most indicate would be for companies to collaborate with Governmental fund organisations, such as SVn funds and Heat fund, funds with low interest rate, in order to be able to assist homeowners in requesting for these funds. By doing so, the process of renovations would result more immediate on the eye of homeowners, allowing for a increased effectiveness of the companies. Adapting the BM into this configuration requires a high level of cooperation between the company and financing entities. Indeed, the fund structure should be changed in order to allow companies to be responsible for requesting on behalf of their customers for loan provisions.
This will make the process easier for homeowners, having one only contact point for the whole renovation. If companies would also take care of the collection of the repayments the renovation scheme could be easily extended to neighborhoods, in which the repayments would be linked to the achieved energy saving therefore not exceeding the households current energy price.
Although , offering complete energy efficiency renovation for homeowners remains challenging in the current Dutch residential sector. There is a trade off between the possible technologies for energy efficiency to be offered and global accessibility of the renovation. With the current energy prices and technologies costs the most complete renovations to nZEB are not possible to all house typology through repayment scheme fully focused on savings on energy bills.

Therefore resulting in the following recommendations. First of all, for what concerns policy makers, so far the already offered funds to stimulate energy efficiency renovation in residential buildings were limiting a wide range of homeowner, leaving the possibility to renovate a dwelling only for higher income class of homeowners. Therefore the financial credibility check should be done in a different way. It can be advised to evaluate achieved energy savings and history of bills payments when homeowners are requesting for a loan, in order to make it more accessible to all.
From the survey it was shown that homeowners would rather have a renovation as-a-service then a mortgage or loan. Therefore more collaboration should be made between Governmental entities and companies offering energy efficiency renovations to enable companies to request for funding on behalf of homeowners.
Moreover, it can be advised to increase steering policies towards energy efficiency renovations, for instance increasing taxes for gas and decreasing electricity taxes, would allow for offering a wider range of technologies with the concept of repayments linked to the achieved savings on the energy bills. To further stimulate a market for energy efficiency government should have stronger regulations on energy efficiency in houses, for instance to force dwellings to have a certain energy label before they are sold or generate a market using schemes similar to the white certificates, a permits systems that stimulates a market for energy efficiency[46].

Secondly, as proposed in the Klimaat akkoord [54], the current size of the Heat Fund will not significantly contribute in meeting the National targets of residential renovations, therefore private financial entities should contribute also. By having a

higher fund, and enabling companies in requesting for it on behalf of homeowner, a market for energy efficiency renovation will be stimulated. In this case renovations repayments should last for no longer then 30 years.

To conclude, this project aim was to depict how companies offering energy efficiency renovations could innovate their BM in order to enable energy efficiency in the Dutch residential buildings.
From this research have emerged the most important innovations to include between companies BM, and the main limitations.
Beside recommending in forming a collaborative structure with possible stakeholders the research pointed out that renovating on a neighborhood level could follow the Government plannings [54] and engage more homeowners, moreover it could decrease the costs of installations.
There are no procedure analysing how to arrange a neighborhood level renovation, my recommendation would be to follow an approach similar of the one that the Vve follows when wanting to bring changes to the dwelling complex. Therefore the company should organize a plan for the energy efficiency neighborhood and present few options to the homeowners, in these way each household would still be able to have the renovation of their desire.
Moreover, resulting in lower costs if collective solutions are chosen.
Once homeowner are convinced and ready to sign the long term contract, the financial credibility check should be made using available software to control a dwelling energy consumption in every day life, hence enabling to calculate the decrease of energy consumption due to different energy efficiency upgrade applied, in this way a relatively precise prediction of future energy saving can be issued to the financial authorities which aim is to issue the loan to homeowners [65]. The fund could then be released to the company, that would be able to design and manage the energy efficiency renovations for the dwelling. Resulting in a more efficient way and able to engage more customers, speeding up the process of renovation.
The repayments will be predicted upfront in order to be similar to the predicted savings on energy bills, making sure that the contract is shorter then 30 years. Figure 6.6 summarises this procedure.

For cases in which energy renovation repayments would be more costly, this procedure cannot be applied yet, indeed it would be possible if technology prices and electricity taxes will decrease while gas taxes increase. At the moment the most indicate recommendation would be to still offer the renovation as-a-service although at a higher monthly price, stressing the achieved comfort, the inclusion of maintenance and the positive impact on the environment.

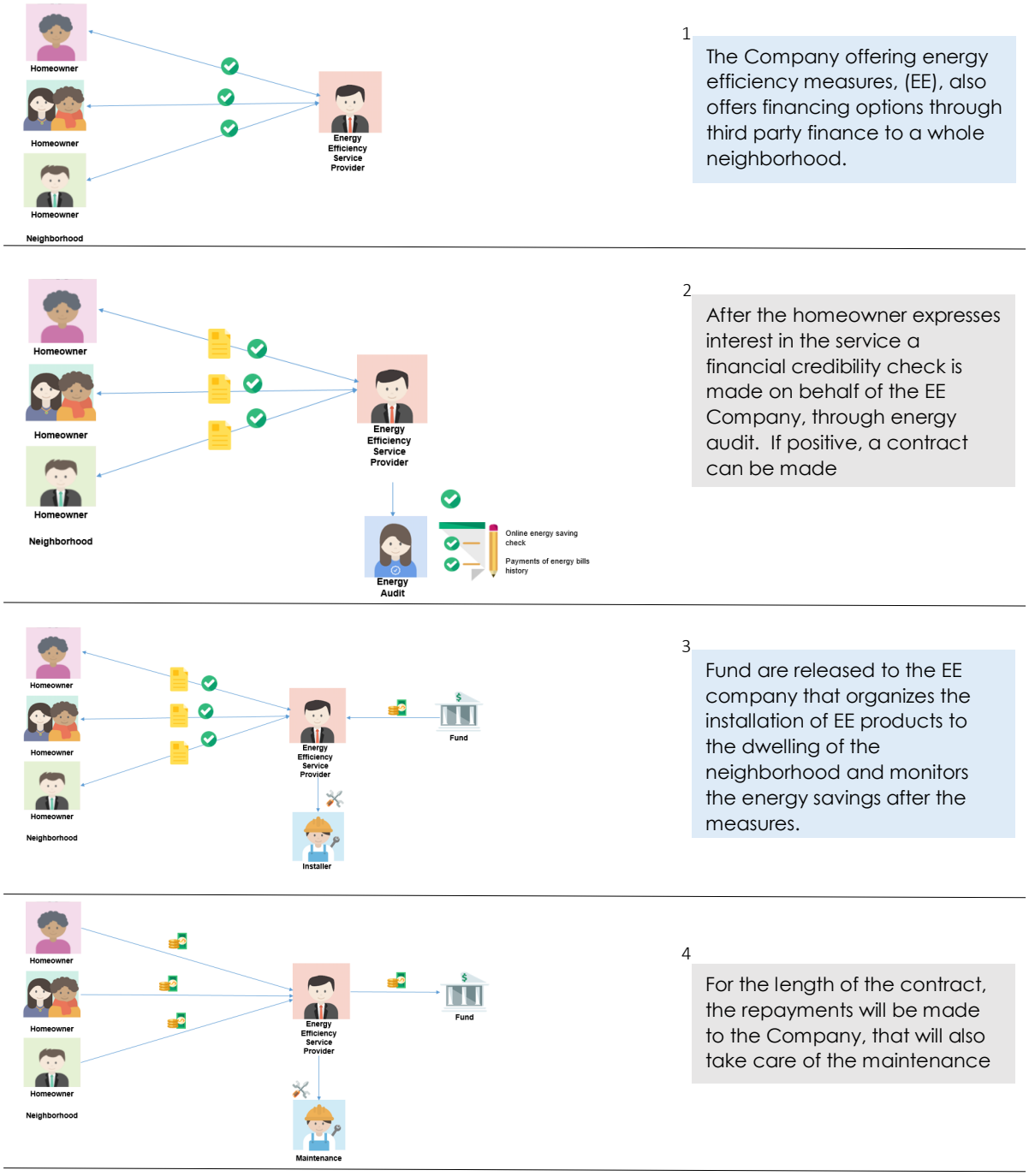

Figure 6.6: Recommendation on BMI for Dutch companies offering energy efficiency renovation

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A APPENDIX A: SURVEY QUESTIONS AND ANSWERS

Descriptive statistics, characteristic of respondents

After two weeks of data collection, there were 100 respondents, although 24 had to be removed since they did not own a house, or the questionnaire was left before the ending. In this section the descriptive characteristic of the respondents will be presented.

AGE

The largest group of respondents is between 30 and 40 years old, and between 50 and 60. only a small percentage represent people younger then 30. Figure A.1.

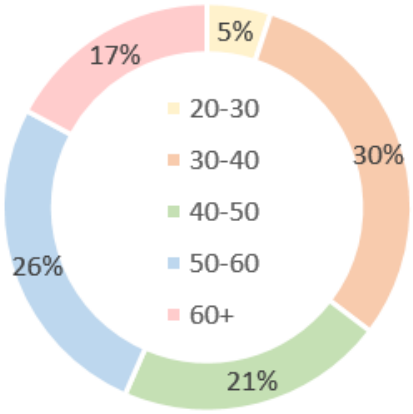


Figure A.1: Age of respondents

INCOME

It is shown in figure A.2 the distribution of the income of the respondents, only 6% of the respondents did not want to share its salary.

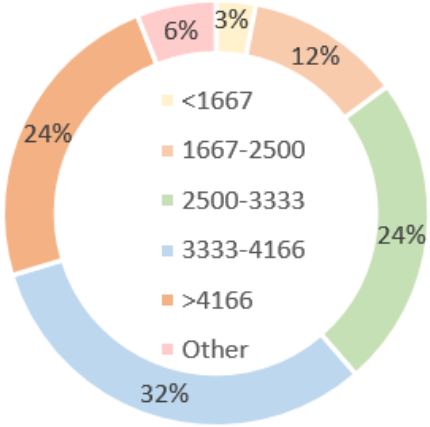


Figure A.2: Income of respondents

GEOGRAPHIC LOCATION

The respondents location is quite divers and spread throughout the Netherlands, as can be seen in figureA.3. the red dots indicate the location in which the respondents live.Although there is a higher density of respondents in the areas surrounding Utrecht, Amsterdam, Rotterdam and The Hague.

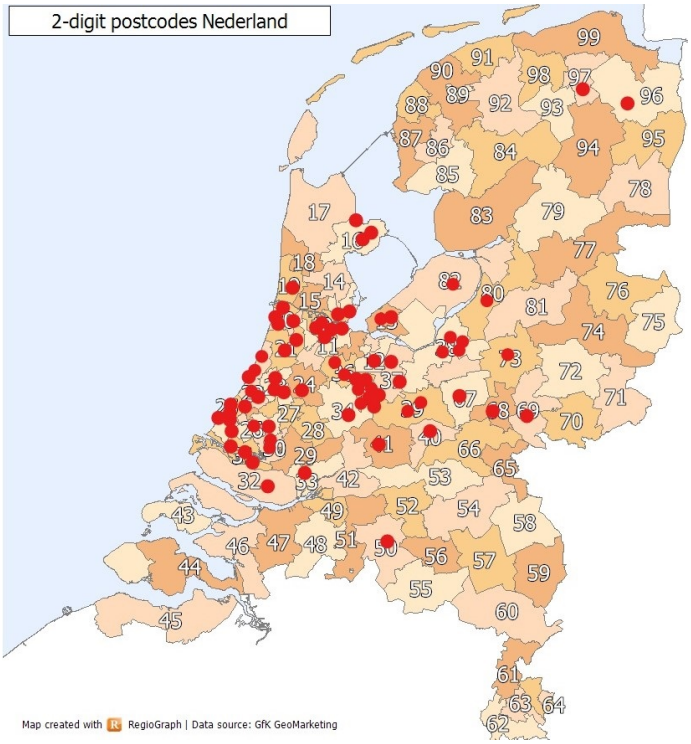


Figure A.3: Location of respondents

HOUSEHOLD COMPOSITION

The majority of respondents lives with theirs partner, while 21% leaves alone, and 18% and 19% of respondents share their house with their partner and kid(s).

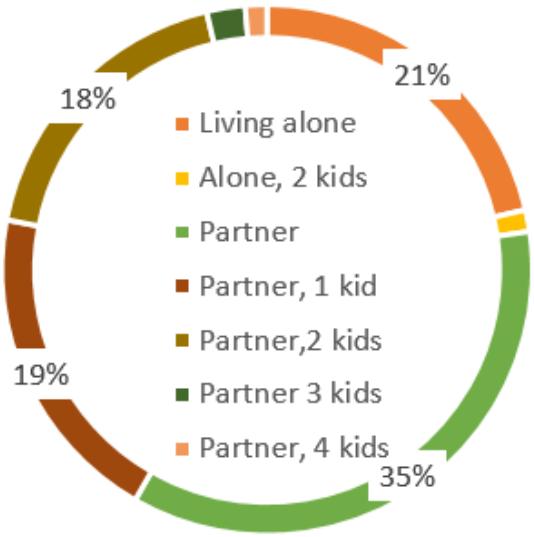


Figure A.4: Household composition of respondents

AWARENESS OF FINANCING OPTIONS

Due to the fact that, as depicted from the Woon survey [109], the main form of finance of home renovation is with own homeowner savings, a question was assessed to all respondents in order to know their level of knowledge about the possible options for financing house energy efficiency renovations.
Only 33% of the respondents gave a low score to this question, therefore the majority is aware of the financing options.

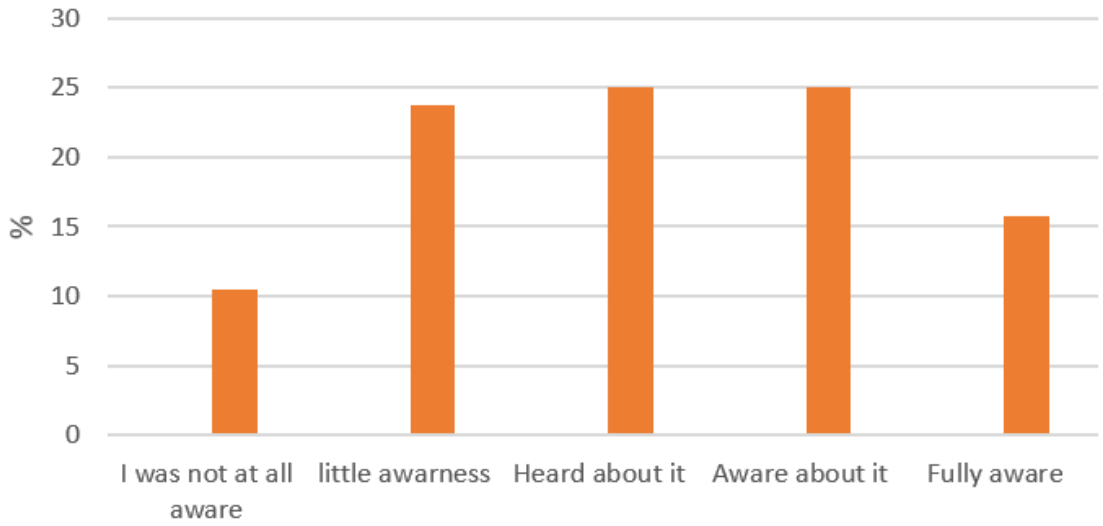


Figure A.5: Awareness to respondents to financing options for energy efficiency renovations

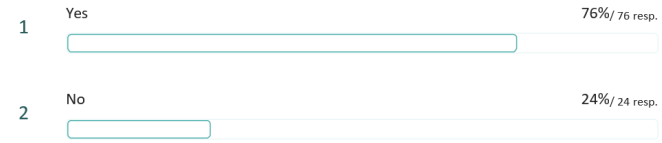
B | APPENDIX B: SURVEY SCRIPT

Hoe Duurzaam wonen makkelijker kan zijn

100 responses

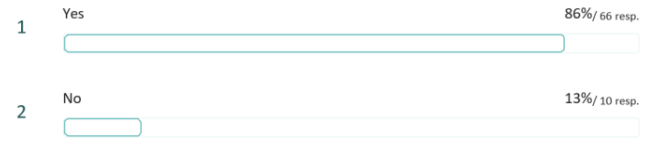
Bent u de eigenaar van uw huidige woning?

100 out of 100 answered



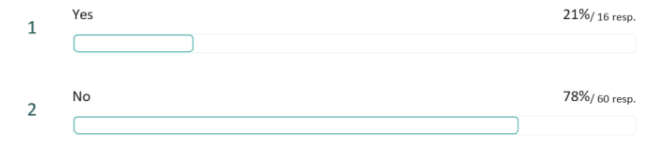
Blijf u naar verwachting in ieder geval in de aankomende 2-5 jaar in dit huis wonen?

76 out of 100answered



Woont u alleen ?

76 out of 100 answered



Woont u samen met uw partner?

60 out of 100 answered

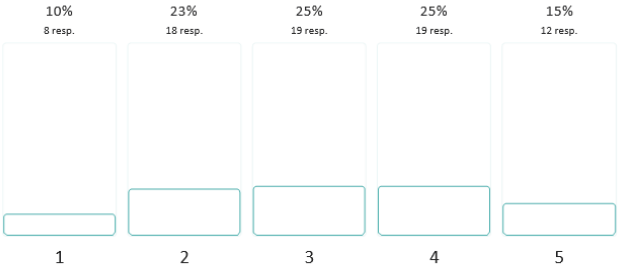
Hoeveel thuiswonende kinderen heeh u?

60 out of 100 answered

Op een schaal van 1 tot 5, in hoeverre bent u op de hoogte van de **mogelijkheid** om **naast eigen geld**, **leningen** en/of **subsidies** aan te vragen om **energiebesparende oplossingen te laten installeren** in uw huis?

76 out of 100 answered

3.1 Average rating

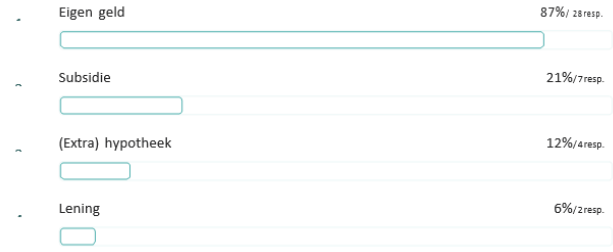


Heeh u ooit al energiebesparende oplossingen (bv. zonnepanelen, warmtepompen en elektrische boilers, verbetering van de isolatie) in uw huis laten installeren?

76 out of 100 answered

Hoe heeh u het gefinancierd?

32 out of 100 answered



Waarom hebt u de beschikbare financiële mogelijkheden (lening / subsidie / hypotheek) niet gebruikt?

32 out of 100answered

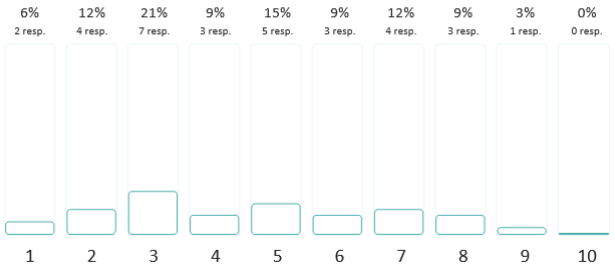
Hoe heeh u het uitzoeken en laten uitvoeren van energiebesparende oplossingen georganiseerd?

32 out of 100 answered

Het vinden van de juiste duurzame oplossingen / producten voor uw huis

32 out of 100answered

4.6 Average rating

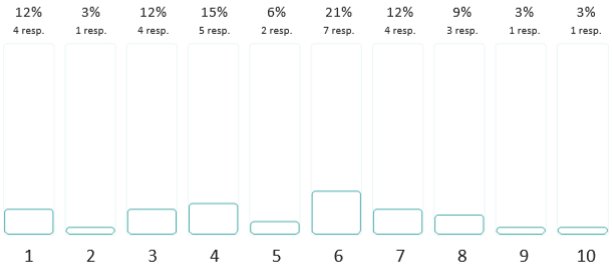


Heel makkelijk Heel moeilijk

Het vinden van een betrouwbare installateur

32 out of 100 answered

5.0 Average rating

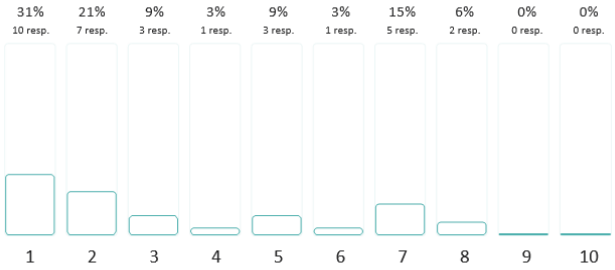


Heel makkelijk Heel moeilijk

Het organiseren van de financiën

32 out of 100 answered

3.4 Average rating

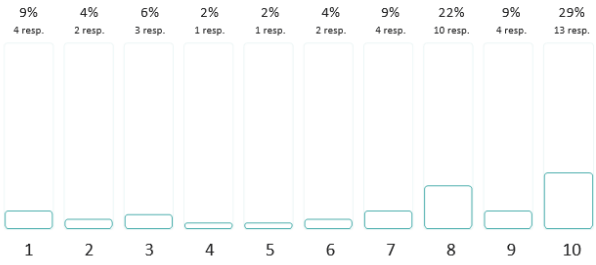


Heel makkelijk Heel moeilijk

Ik wil geen schuld in de vorm van een lening of hypotheek

44 out of 100answered

7.1 Average rating

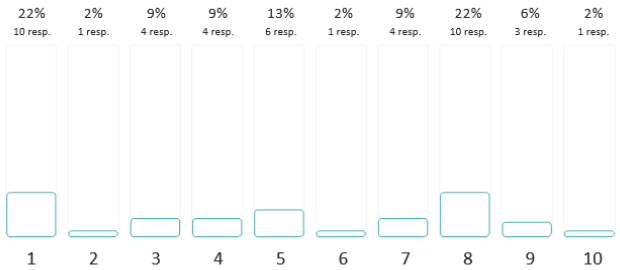


helemaal mee oneens helemaal mee eens

Op dit moment ben ik te druk, en ik heb geen tijd om het uitvoeren van werkzaamheden te organiseren

44 out of 100answered

5.0 Average rating

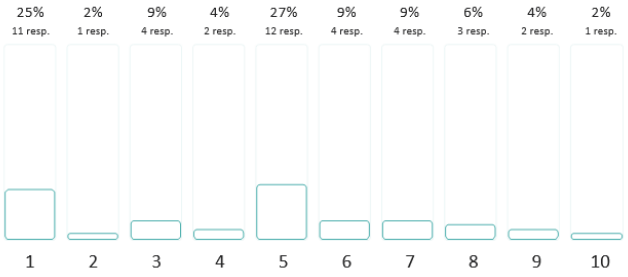


helemaal mee oneens helemaal mee eens

Ik denk niet in aanmerking te komen voor de financieringsopties

44 out of 100answered

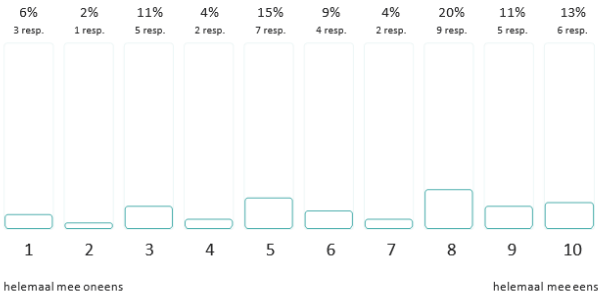
4.5 Average rating



Ik ben tevreden met mijn huidige woning, dus ik onderneem geen actie om mijn woning te verduurzamen

44 out of 100answered

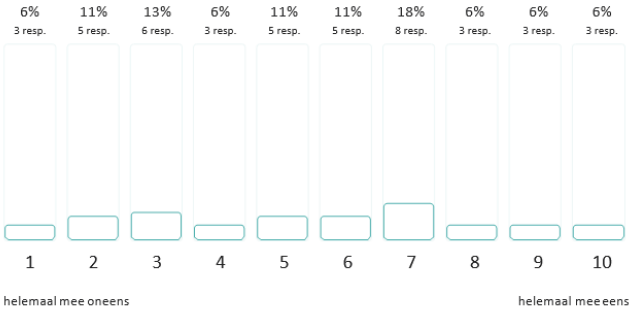
6.3 Average rating



Ik vertrouw bedrijven die financieringsopties aanbieden voor energiebesparende oplossingen niet

44 out of 100answered

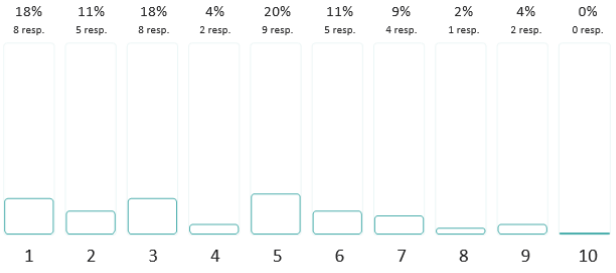
5.3 Average rating



Het is te moeilijk om installateurs te vinden

44 out of 100 answered

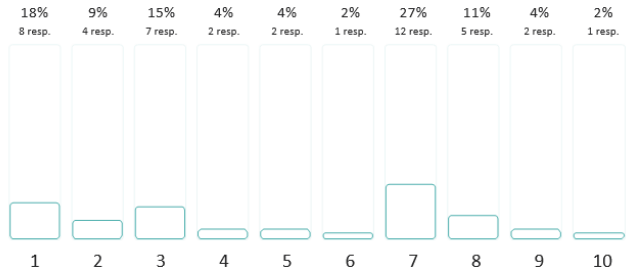
4.1 Average rating



Het is te moeilijk om de juiste oplossingen voor mijn huis te vinden

44 out of 100answered

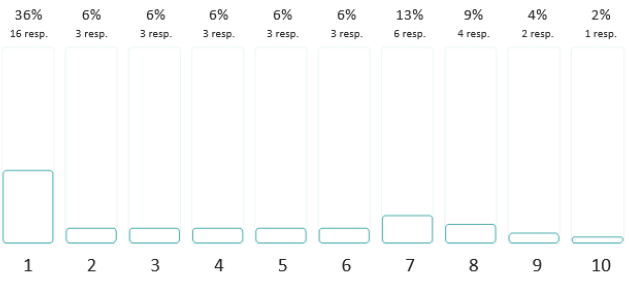
4.8 Average rating



Ik was niet op de hoogte van het bestaan van subsidies en (groene) leningen

44 out of 100answered

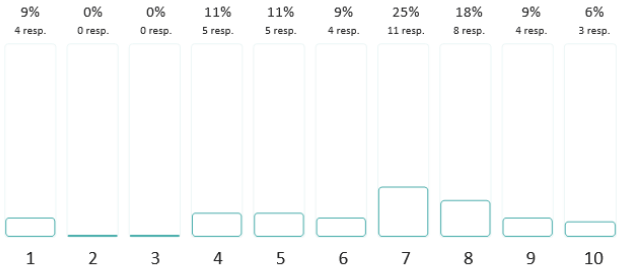
4.0 Average rating



Als er in mijn buurt een collectief plan voor renovaties zou komen, zou ik hieraan meedoen

44 out of 100answered

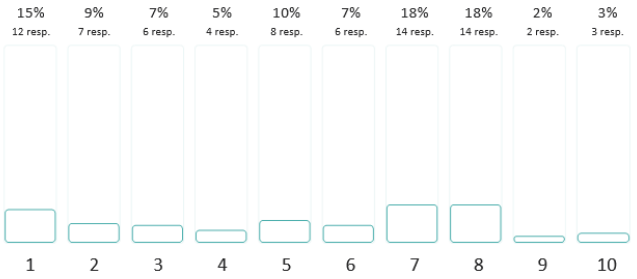
6.4 Average rating



Het geld om te renoveren wordt verstrekt door een bedrijf dat de **installatie en het onderhoud** van de energiebesparende oplossingen **voor u organiseert**?

76 out of 100 answered

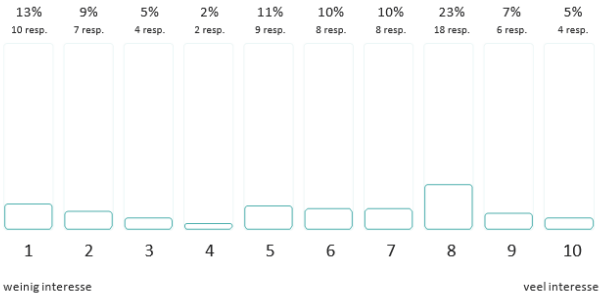
5.2 Average rating



Zie de afbeelding hieronder. De lening plus de betaling voor het Bespaarabonnement is **lager** dan uw huidige energierekening.

76 out of 100 answered

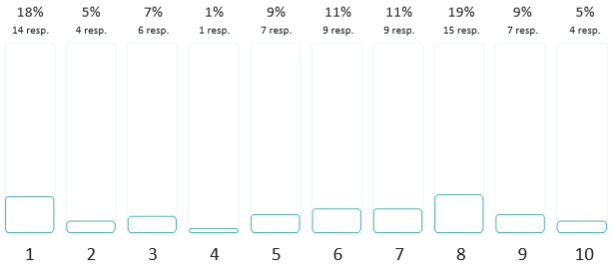
5.7 Average rating



De financiering om duurzaam te wonen - komt **niet op uw naam** te staan - *maar* wordt gekoppeld aan uw woning (dus **gebouwgebonden**).

76 out of 100 answered

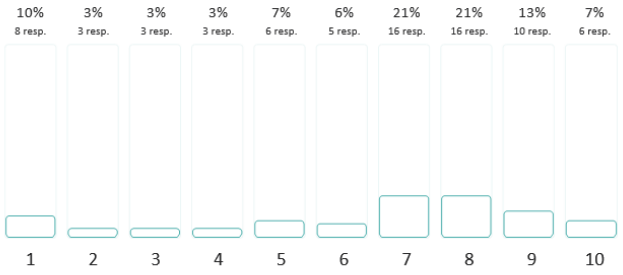
5.5 Average rating



Uw maandelijkse energierekeningen en de kosten van het Bespaarabonnement worden **samen in rekening gebracht**.

76 out of 100 answered

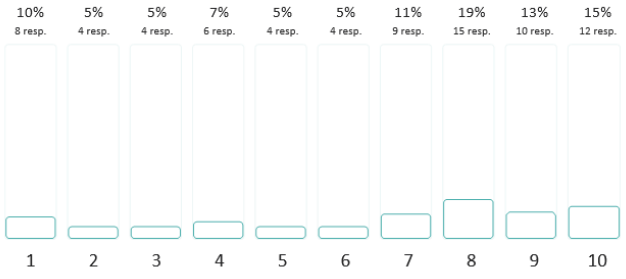
6.4 Average rating



U krijgt het **Bespaarabonnement** met **buurt-voordeel** (à 10-15% korting) als uw buren ook meedoen.

76 out of 100answered

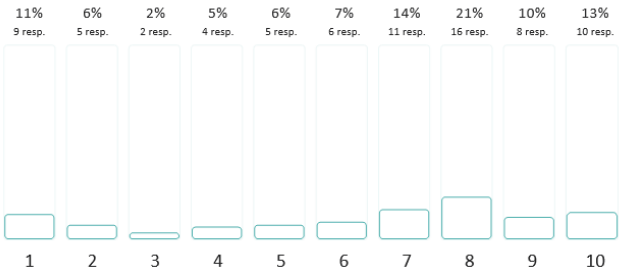
6.4 Average rating



Hoe belangrijk is het voor u om **zelf te kiezen hoeveel u elke maand betaalt**?

76 out of 100answered

6.3 Average rating

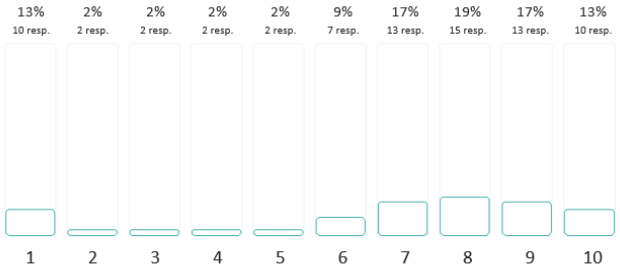


heel onbelangrijk heel belangrijk

U kunt het Bespaarabonnement **overdragen bij de verkoop** van uw woning aan de nieuwe bewoners. Hoe interessant vindt u dit?

76 out of 100 answered

6.7 Average rating

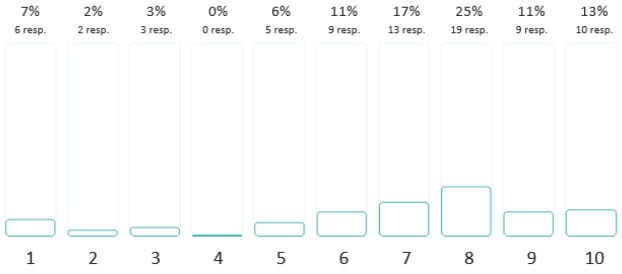


heel onbelangrijk heel belangrijk

Hoe belangrijk is het voor u om de lengte van het abonnement (**periode in maanden**) te kunnen selecteren?

76 out of 100answered

6.9 Average rating

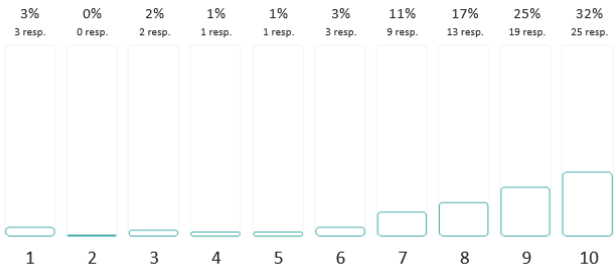


heel onbelangrijk heel belangrijk

Hoe belangrijk vindt u het om **zelf** te kunnen **beslissen** over de energiebesparende producten die in uw huis worden geïnstalleerd?

76 out of 100 answered

8.2 Average rating

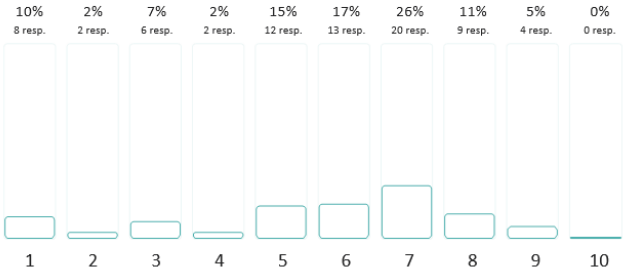


heel onbelangrijk heel belangrijk

Hoeveel vertrouwen heeh u in een bedrijf dat **zowel** de **installatie en onderhoud** van energiebesparende producten organiseert, **alsook de aanbieder van dit abonnement** is?

76 out of 100 answered

5.6 Average rating

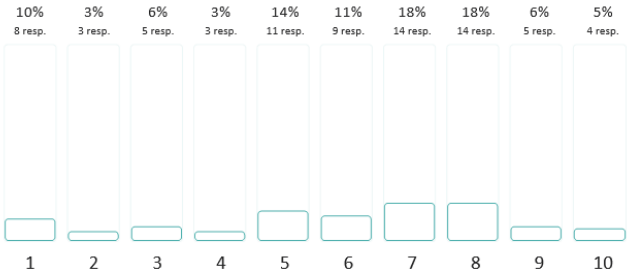


geen vertouwen volledig vertrouwen

De betaling en financiering van het Bespaarabonnement lopen **via een bank.**

76 out of 100 answered

5.9 Average rating

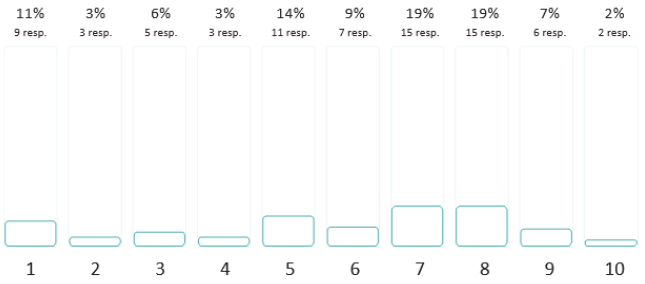


geen vertrouwen volledig vertrouwen

De betalingen worden geïnd via belastingen van **de Gemeente** waar u woont.

76 out of 100answered

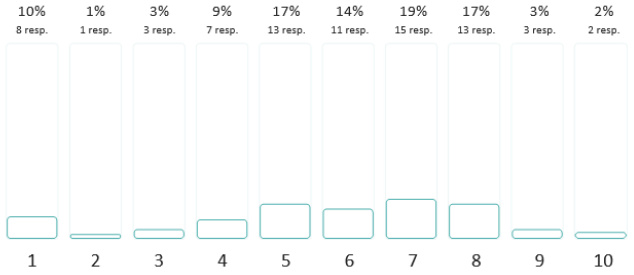
5.8 Average rating



De betalingen worden geïnd door een **energiebedrijf** (bv. Essent, Nuon, Eneco).

76 out of 100answered

5.7 Average rating



In hoeverre wilt u in het Bespaarabonnement zelf betrokken zijn bij het realiseren van een duurzamere woning?

73 out of 100 answered

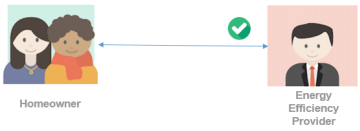
1	Ik wil het liefst dat 1 coördinerende partij voor mij alle installaties kiest en inplant met de onderaannemers	43% / 32 resp.
2	Ik verwacht dat ik zelf onderzoek doe naar verschillende technieken en zelf kies welke ik wil	42% / 31 resp.
3	Ik heb zelf contact met onderaannemers en plan zelf de afspraken in met de installatiepartij	17% / 13 resp.
4	Other	8% / 6 resp.

Wat is uw maandelijks inkomen, na belastingen?

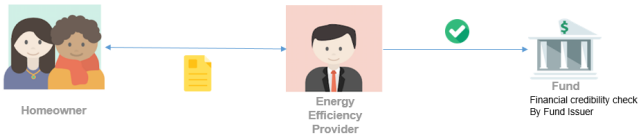
76 out of 100 answered

1	3333- 4166 euro	31% / 24 resp.
2	2500- 3333 euro	23% / 18 resp.
3	>4166 euro	21% / 16 resp.
4	1667- 2500 euro	11% / 9 resp.
5	<1667 euro	2% / 2 resp.
6	Other	9% / 7 resp.

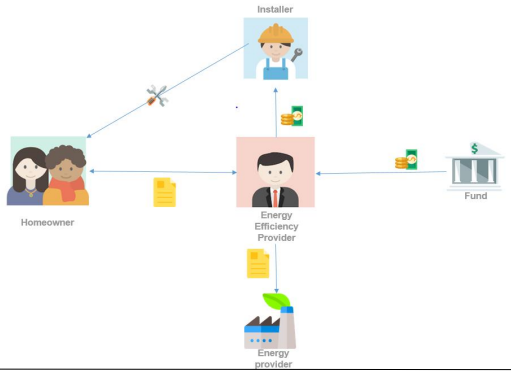
C APPENDIX C: IMPLEMENTATION OF BMI FOR DUTCH COMPANIES, ON-BILL FINANCING



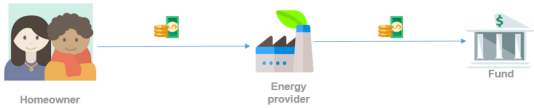
1 The Company offering energy efficiency measures, (EE), also offers financing options through third party finance.



2 After the homeowner expresses interest in the service a financial credibility check is made by the fund issuing body. If positive, a contract can be made

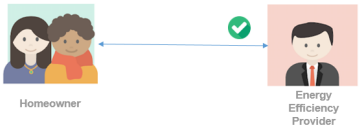


3 Fund are released to the EE company that organizes the installation of EE products to the dwelling and monitors the energy savings after the measures. Moreover, a contract is stipulated with the energy provider of the dwelling in order to organize the repayments to the fund.

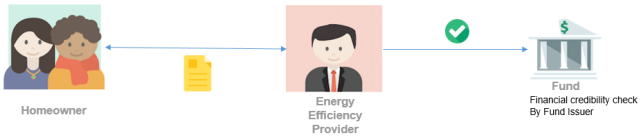


4 For the length of the contract, the repayments will be part of the utility bills to the dwelling, that the energy provider will send to the revolving fund for EE

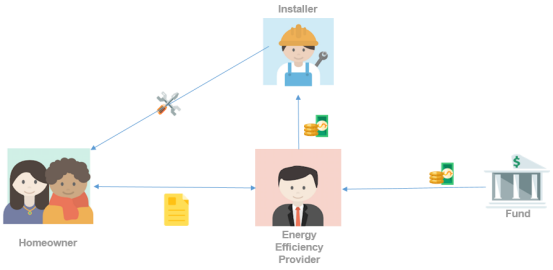
D APPENDIX D: IMPLEMENTATION OF BMI FOR DUTCH COMPANIES



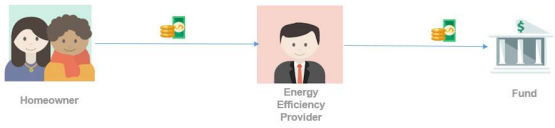
1 The Company offering energy efficiency measures, (EE), also offers financing options through third party finance.



2 After the homeowner expresses interest in the service a financial credibility check is made by the Fund provider. If positive, a contract can be made



3 Fund are released to the EE company that organizes the installation of EE products to the dwelling and monitors the energy savings after the measures.



4 For the length of the contract, the repayments will be collected by the EE company, that will further more perform maintenance on the dwelling