Non-technical variables that stimulate retrofitting uptake within the bioenergy and fuels sector in Europe

MSc thesis

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Abstract

This research focusses on non-technical variables that stimulate retrofitting uptake within the bioenergy and fuels sector in Europe. Retrofitting means switching from traditional fossil fuel to renewable bio-based energy sources or integrating the production of (advanced) biofuels. This can be done by adding or replacing features of installations to match current or new technologies. The decision to retrofit by companies is studied using innovation adoption literature. Using innovation adoption literature, several variables were identified that were stimulating innovation adoption in general, and within the bioenergy sector specifically. To test whether these variables were influencing the uptake of retrofitting within the bioenergy sector in Europe, seven companies were selected as case studies. The case studies were analysed through surveys, interviews, and secondary data. In conclusion, it was found that access to financial resources, policy instruments, policies in related industries, the interconnectedness or network participation, the information exchange within networks, top management support, and corporate image were variables that influenced the retrofit decision of these companies.

Key words: innovation adoption, bioenergy, retrofitting, biomass, non-technical variables, business environment, networks, adopter characteristics

Preface and acknowledgements

This report is the result of my master thesis in order to complete my master's programme Management, Urban Environmental Management at the Wageningen University.

When I started this master thesis project, I had a broad interest in sustainable entrepreneurship. I got the opportunity to work with the BIOFIT team on a large European project which aim is to facilitate the introduction of bioenergy retrofitting. I saw the option to directly ask company representatives why they invested in retrofitting. Investigating these decisions, which involved large investments, and which would have significant environmental impact, motivated me from the beginning to the end of this project.

First, I would like to thank Emiel Wubben for introducing me to the BIOFIT team. Thank you for all the constructive feedback, your practical knowledge on doing research, and above all, for challenging me to deliver better work all the way through this project.

Thank you Gohar Nuhoff-Isakhanyan, for giving me the opportunity to work with the BIOFIT team. It was a good learning opportunity to be part of a research team. Thanks to Jos Verstegen, Paul van Leeuwen, Hans Dagevos, and Dominique van Wonderen.

I would also like to thank my dear friends, my family, and all the people that gave me advise, tips, and who kept me motivated during this project.

Finally, I would like to thank all the company representatives that gave insights in their decision to retrofit and who made this research possible.

Wageningen, 8 September 2019,

Loes Mellink

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1. Introduction

This chapter first provides an introduction of the context and the position of this thesis within broader academic research in paragraph 1.1. The conceptual research design is presented in paragraph 1.2, which answers the question what, why, and how much was researched in this thesis. The technical research design is discussed in paragraph 1.3, which highlights which research material was used to answer the research questions and how this material was accessed. Finally, in paragraph 1.4, a short outline of the chapters in this thesis is presented. The order of this chapter follows the book of Verschuren and Doorewaard (2005).

1.1 Research context

1.1.1 Background of the research

Bioenergy has become an increasingly important topic for the European Union. Bioenergy is a form of renewable energy derived from the conversion of biological sources, better known as biomass. Within the Renewable Energy Directive ll, several European institutions decided to make the share of renewable energy 32 percent of the final energy consumption in 2030. Within the last Renewable Energy Directive of 2009, Member States of the EU were obligated to submit national targets. However, in the second edition Member States are only obligated to submit National Energy and Climate Plans to the European Commission (Council Directive 2015/1513/EU, 2018).

Currently, bioenergy covers 60 percent of the renewable energy sources that are consumed within the EU. Although the share of wind and solar power is increasing, the EU expects that bioenergy will remain the most important renewable energy source for the coming decades (Bioenergy Europe, 2018). The EU emphasizes that the transition towards an economy with low emissions requires fossil fuels to be phased out and that renewable energy is in some sectors one of the few decarbonized alternatives. Aside this, the EU emphasizes that bioenergy is applicable to various industries and is therefore the best option to achieve fast decarbonisation (Bioenergy Europe, 2018).

Bioenergy can be used for various purposes such as heating, cooling, electricity, and fuels. Currently, bioenergy is largely used for heating, which represents around 75 percent of the gross final bioenergy consumption. The transport sector represents around 12 percent of the gross final bioenergy consumption and bioelectricity represents around 13 percent of this gross final bioenergy consumption. Bioenergy can be a solution for sectors that are now still largely using fossil energy sources. For example, the heating and cooling (H&C) sector represents 50 percent of the final energy consumption in the EU and is still largely fossil based (80 percent). Bioenergy can be a solution for this sector by, for example, using biomass to heat buildings (Bioenergy Europe, 2018).

Aside the versatility of bioenergy, the EU has also emphasized that promoting bioenergy decreases the dependency on fossil resources from foreign countries. Bioenergy is locally produced which can decrease Europe's dependency on fossil energy that has to be imported. The energy dependency (net energy imports divided by gross inland consumption) on fossil fuels is 90 percent compared to only 4.1 percent for bioenergy. By promoting bioenergy, the import of fossil energy has already started to decrease.

Aside from lowering the import of fossil energy, the EU can create direct and indirect employment by promoting bioenergy. Bioenergy is considered more labour intensive compared to other energy sources such as nuclear energy. Bioenergy relies on feedstock from agricultural and forests and therefore can create employment within rural areas (Bioenergy Europe, 2018).

As stated before, bioenergy is applicable to various industries. In this thesis the focus will be on the following five industries: first-generation biofuels, pulp and paper, fossil refineries, fossil firing power and combined heat and power (CHP) plants or systems. Within these industries, bioenergy is applicable in different ways which can be better explained using examples. Within the biofuels sector, the production of first-generation biofuels is developing towards a second generation of biofuels. First-generation biofuels concern fuels

made from for example sugars and vegetable oils found in food crops. Second-generation biofuels concern fuels made from non-food biomass such as waste materials from plants and animals or used cooking oils. Within the pulp and paper industry, bioenergy can be produced on site through CHP systems or by converting waste materials such as pulp mill sludge into biodiesel. Fossil refineries can produce biodiesel from vegetable oils or used cooking oils on site. Fossil fired power can develop from solely coal firing to co-firing biomass. Currently there is a steady increase in the demand for wood pellets which are replacing the firing of coal. CHP systems that are fossil-fuel fired can be developed to fire biomass which means that biofuels are replacing fossil fuels.

Although promoting bioenergy seems to be a logical step following the trends mentioned above, there are also some issues related to bioenergy. Several NGOs and environmental organizations have written a report about the risks of bioenergy when it is not regulated in a sustainable way (ActionAid, BirdLife International, Brot, Dogwood Alliance, Fern, Greenpeace, NRDC, Oxfam, Southern Environmental Law Centre, Transport and Environment, Wetlands International, 2016). According to this report several issues play a role, especially with the sourcing of biomass.

Bioenergy sources consist for the greater part of wood. When bioenergy sourcing is not regulated well and sourcing wood for biomass is promoted by EU subsidies, this could result in (excessive) deforestation, sourcing wood from non-sustainable sources, and decreased biodiversity. Furthermore, it is claimed that some categories of carbon emissions are not considered by companies. When some emissions are not considered the transition to bioenergy could show a more positive effect on the lowering of emissions than is the case. For example, the burning of wood could result in additional or more emissions, but if these are not considered the actual effect on the lowering of the total emissions is not clear. Other issues with the sourcing of biomass are land ownership and human rights issues when there is no prior and informed consent about which forests or land is used for the sourcing of biomass.

The report claims that the EU is not paying enough attention to the 'waste hierarchy' (Council Directive 2008/98/EC, 2008). The idea behind the waste hierarchy is that resource and energy consumption has most favourable and least favourable actions. The most favourable action of reducing waste is to prevent waste. The least favourable option is disposal of waste. According to the waste hierarchy, reusing resources should be promoted over recycling. Within the bioenergy sector this means that wood should first be used to build houses rather than being burned as a raw material. According to the NGOs and environmental organizations, the focus of the EU should be on bioenergy production from waste first, before promoting bioenergy production from alternative raw materials. When there is no prioritization between high and low risk biomass, this could result in companies sourcing mostly high-risk biomass. Aside from the sourcing of biomass, another issue related to bioenergy is using farmland to grow 'energy crops' that will be used for energy production. Fuels made from food crops were criticized by researchers because they emphasized that farmland should be used to produce food and not to produce edible crops that are used for biofuels production.

1.1.2 Introduction to the research and problem statement

Although there are issues related to bioenergy, it still represents a large part of the renewable energy production of Europe and is therefore an interesting object of study. Although EU policy and sustainability issues are increasingly important, it is also interesting to look at how companies operate within this context. Aside from technical factors such as the compatibility of bioenergy production systems, there are socio-economic factors that drive companies to produce bioenergy and fuels. A combination of social and technical perspectives on the implementation of bioenergy systems is often lacking (Frambach and Schillewaert, 2002). For example, life cycle assessments are done to see whether the bioenergy technology fits current industries, but there are little studies that address the adoption of bioenergy systems from a social-economic perspective.

As said before, companies are increasingly influenced by social-economic factors. For example, bioenergy markets, the competition within these markets, national and local policy, and the perception of the public about bioenergy determine the success of bioenergy production. There are also other factors that determine successful bioenergy production such as investment grants, favourable policy, developing knowledge and institutional capacity, enabling companies to be an example for other potential adopters, and creating networks between energy companies (McCormick and Kåberger, 2007). How companies deal with these social-economic factors can determine how the energy transition is developing. This calls for a research that studies non-technical variables that stimulate the uptake of bioenergy systems within the bioenergy and fuels sector in Europe.

This thesis focusses on retrofitting, which means adding or replacing features of current installations to match current technologies. Through retrofitting, companies can increase bioenergy production and lower CO2 emissions. When companies implement retrofitting, alternative sources of energy can be explored, and environmental pollution reduced. For example, retrofitting is supposed to lower capital expenditure (CAPEX), increase efficiency, adapt the industry to new inputs, and reduce maintenance costs (Khairi, Jaapar, and Yahya, 2017). It is important to understand the variables that influence the adoption of retrofitting to stimulate the energy sector to become more efficient and more sustainable. Also, by studying these variables, more businesses can be stimulated to retrofit in the future.

Retrofitting can take on many different forms within the 5 industries. An example of retrofitting is replacing or adding installations that produce heat by wood combustion instead of or complementing coal combustion. Another example is the conversion of first-generation biofuels plants into second generation biofuels, which means developing cellulosic ethanol production or biodiesel production. There are also recent types of innovative retrofitting cases such as creating second generation biofuels by gasification of black liquor which is a waste product of the pulp and paper industry. Another example is the production of bioenergy from the conversion of algae.

This thesis uses innovation adoption theories to explain why companies have decided to retrofit. In this thesis literature will be compared to empirical evidence from the bioenergy and fuels sector. This thesis consists of a literature study on the variables that explain innovation adoption and an analysis of surveys and interviews with company representatives from the bioenergy and fuels sector in Europe. The companies have already retrofitted in the past and will be asked about their main motivations for doing so. Eventually, this thesis will present the main variables that stimulate the uptake of retrofitting within the bioenergy sector in Europe. Aside from these variables, recommendations will be suggested for (EU) policymakers concerning the facilitation of retrofitting via policy development. These recommendations will inform policymakers about the context in which companies decide to retrofit by studying previous retrofitting experiences. The recommendations will also be useful for companies and industries that have not retrofitting yet, are considering retrofitting, or are in the process of retrofitting.

The main concepts used in this thesis are “bioenergy”, “retrofitting”, and “innovation adoption”. “Bioenergy” means converting biological sources, biomass, to create energy. “Retrofitting” is defined as adding or replacing features of current installations to match current technologies. In this thesis, “retrofitting” is considered an “innovation” which is an idea that is considered ‘new’ according to the definition of Rogers (2010). “Innovation adoption” means the decision of an organization or an individual to use an innovation (Rogers, 2010). In this thesis the decision to retrofit is from now on described as the adoption of an innovation. Furthermore, the bioenergy and fuels sector are hereafter referred to as bioenergy sector.

1.2 Conceptual research design

1.2.1 Research objective

The goal of this thesis is to research the variables that stimulate the uptake of retrofitting within the bioenergy and fuels sector in Europe and from that, establish recommendations for policymakers on facilitating the uptake of retrofitting.

1.2.2 Research process

To achieve the research objective, this thesis was divided into four phases which are displayed in Figure 1.

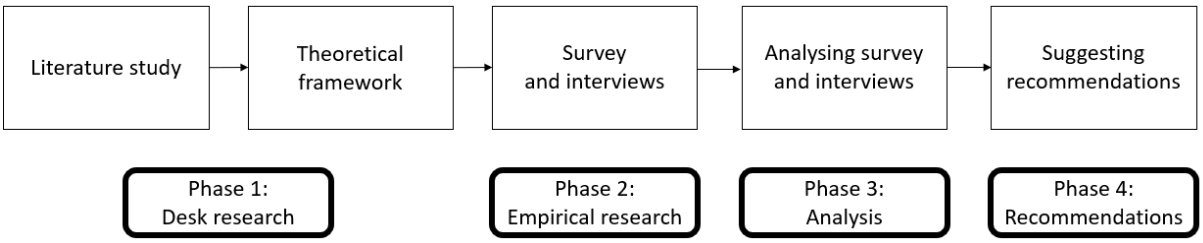

Figure 1: Four phases of the research process

1.2.3 Research questions

The central research question is:

What variables of innovation adoption determine the uptake of retrofitting within the bioenergy sector in Europe?

The four research questions that will contribute to answering the central research question are described in the following segment.

1. According to the literature, how is the phenomenon of innovation adoption described and defined, and what are the main variables that stimulate innovation adoption?

2. How can variables that stimulate innovation adoption within the bioenergy sector be analysed?

3. Which variables stimulate innovation adoption within the bioenergy sector?

4. What recommendations can be made for policy development based on innovation adoption literature and previous retrofitting experiences?

1.3 Technical research design

1.3.1 Research material

Following Figure 1, different research materials are studied within the four phases.

In phase 1, “innovation adoption” is studied in general as well as within the bioenergy sector specifically. In this phase literature is studied.

In phase 2, the methods for analysing retrofitting within the bioenergy sector are defined. For this question several books on research methods are studied.

In phase 3, variables that stimulate innovation adoption in general and specifically in the bioenergy sector will be studied. To do this, the results of the literature study, survey, and interviews will be analysed. Aside this, a web search will be done to describe noticeable developments within the bioenergy sector in Europe.

In phase 4, recommendations are formulated. The analysis of phase 3 will be used to suggest practical recommendations that will inform (EU) policymakers and companies within the sector that deal with retrofitting or did not retrofit yet.

1.3.2 Research strategy

This thesis has both a qualitative and quantitative approach. An important note is that this thesis was part of a larger project called BIOFIT. This project has received funding from the European Union's Horizon 2020 research and innovation programme. The overall aim of the BIOFIT project is to facilitate the introduction of bioenergy retrofitting in the five industry sectors: first-generation biofuels, pulp and paper, fossil refineries, fossil firing power and combined heat and power plants. The BIOFIT project contains several work packages of which one was assigned to several researchers from Wageningen Economic Research which is one of the research institutes of Wageningen University and Research Centre. These researchers are hereafter referred to as the BIOFIT team.

For the BIOFIT project a survey was developed that was partly based on the literature that was studied for this thesis. The interviews were done solely for the purpose of answering the research questions of this thesis. However, with consent of the respondents their data was also shared with the BIOFIT team. Both the data from the survey and the interviews were analysed for this thesis. Several companies that are part of the BIOFIT database were interviewed to gain additional detailed information about their motivation to do retrofitting projects. By using both qualitative and quantitative approaches, a holistic understanding on retrofit projects can be formed. Further explanation about the BIOFIT project and how this thesis relates to this project is explained in Chapter 4 Methodology.

1.4 Outline of the report

In this paragraph the outline of the report is presented. Chapter 1 introduced the research topic and its context. After this, the research objective, research questions, and the pathway to answer these research questions to reach the objective of this research was described. In Chapter 2 a literature study is presented that shows empirical evidence on variables that stimulate innovation adoption in general and within the bioenergy sector specifically. In Chapter 3 the literature review is used to create a theoretical framework. In Chapter 4 the methodology that is used for this research is described which is both quantitate (survey) and qualitative (case study interviews). Chapter 5 shows the results of the desk research, survey, and interviews. In Chapter 6 recommendations are given to facilitate and stimulate retrofitting. In Chapter 7 the results of this research are discussed, and conclusions are made.

2. Theoretical background

This chapter is aimed to answer research question 1: "According to the literature, how is the phenomenon of innovation adoption described and defined, and what are the main variables that stimulate innovation adoption?". Within this chapter a literature study on the phenomenon of innovation adoption is presented. The prominent ideas about the levels on which innovation adoption occurs are presented in paragraph 2.1. The process and different phases of innovation adoption are explained in paragraph 2.2. Several variables that influence innovation adoption will be explained and displayed in an overview in paragraph 2.3. Conclusions made from the literature study are presented in paragraph 2.4. The literature is focussed on what is known about innovation in general and how this related to studies about innovation adoption in the context of the European bioenergy sector. Finally, a theoretical framework will be presented in the following chapter to explain which variables of the literature study are going to be researched through surveys and interviews.

2.1 Innovation adoption on different levels

2.1.1 The individual and organizational level

Most of the innovation adoption research started with the adoption of information systems and other IT innovations around the end of the twentieth century. Within the IT sector a dominant paradigm emerged that when companies would have enough innovation-related needs and abilities, this would stimulate innovation adoption (Jeyaraj, Rottman, and Lacity, 2006). Within companies there is a difference between the needs and abilities of individuals, between individuals or groups and of the entire organization. Therefore, research focussed on either organization innovation adoption or individual innovation adoption.

Most of the research of individual innovation adoption is focused on specific characteristics of people such as gender, personal innovativeness, experience, age, and education. The research objects are mostly the behavioural intention to adopt an innovation and the actual behaviour of adopting innovations by individuals (Jeyaraj et al., 2006). Organizational adoption research focuses on the decision to adopt, the intention to adopt, the intention to use, the adoption, and the diffusion of innovation adoption within organizations as a whole (Jeyaraj et al., 2006). Organizational adoption research does not focus on specific characteristics of people, but on collective characteristics of groups of people. On the organizational level, there are other needs and abilities than on the individual level. On the organizational level, variables such as relative advantage of the innovation, the complexity of the innovation, top management support, championship, and organizational structure influence innovation adoption (Jeyaraj et al., 2006).

Innovation adoption can also occur within a workgroup or a department within a company. This specific context cannot be placed within the individual or organizational paradigm of innovation adoption. Research shows that innovation adoption can also occur within a specific context (Fichman, 1992).

2.1.2 The system, network, and agent level

In this paragraph the origin of variables that influence innovation adoption is discussed. In the previous paragraph it was discussed that there exists individual and organizational innovation adoption. Aside this, it was discussed that innovation adoption can occur in specific contexts such as workgroups. In this paragraph the focus will be on where variables that influence innovation adoption originate from.

On the societal level there are variables that make individuals, groups of people, and organizations decide to innovate. These variables or 'external factors', such as a natural disaster or economic crises could force a company to adopt an innovation. Public opinion is another example of an external factor that can stimulate innovation adoption (Radics, Dasmohapatra, and Kelley, 2016. Aside from what is happening within companies, there are variables beyond their influence that affect innovation adoption. Thus, innovation adoption is influenced by different variables on different levels. To show how this works the Sectoral Diffusion Analysis Framework (Van der Veen and Kasmire, 2015) is used. In this framework three

different levels are identified that influence company decision making. These levels are the system, network, and agent level which is displayed in Appendix 1.

On the system level 'drastic' events could occur that influence companies to radically decide to alter their business strategy. An example of such an event is a natural disaster or economic reform by a national government. Due to climate change, new and more ambitious climate goals are set by national and international institutions and governments. The Renewable Energy Directive ll is an example of such ambitious climate strategy. The polices formed in this Directive are causing several companies within the bioenergy sector to alter their business strategy to be able to comply with the new regulations. Although some companies are involved in creating these policies, for most companies it is a variable that influences them from the outside.

On the network level, companies can be influenced by different 'domains' and networks with other actors. Domains can be defined as fields that concern different developments that influence agents (or actors) (Van der Veen and Kasmire, 2015). For a company, not all these domains are equally important, and they influence company decision making in different ways. IT companies can for example be concerned with keeping up with technology developments and therefore they follow closely what is happening within the technology domain. Within the bioenergy sector, companies are concerned with new sustainability goals and thus follow what is happening in the policy domain. Examples of other domains are displayed in Appendix 1. Aside from these domains, companies are interacting through networks with other actors. A company could be part of an association, union, or bond with other companies, NGOs, public institutions, or other organizations. These networks also influence company decision making (Van der Veen and Kasmire, 2015).

On the agent (or actor) level, the system level with its 'drastic' events, and the network level with its domains and networks are forming the 'context' in which a company operates. Aside from this context, other variables *within* a company determine decision-making. A company has certain 'capabilities' and a 'bounded rationality' (Van der Veen and Kasmire, 2015). Capabilities are for example the companies' human resources and financial assets. The bounded rationality of a company can consists of the norms and values of the company or its strategic objectives.

What can be learned from these studies is that innovation adoption occurs on different levels, the individual and organizational level, or in a specific context such as workgroup. Aside this, there are variables that influence innovation adoption. These can originate from various levels, namely the system, network, and agent level. It is important to understand exactly which variables are influencing the innovation adoption process the most and from which levels these variables originate. Once it is understood which variables affect the adoption decision the most, innovation adoption can be better understood and stimulated.

2.2. Phases of innovation adoption

In this paragraph the prominent ideas on the process of innovation adoption and the different phases that this process contains are presented.

Many authors refer to the diffusion of innovations for the definition and process of innovation adoption and diffusion (Rogers, 2010). According to this work, an innovation is "an idea, practice, or object perceived as new by an individual or other unit of adoption" (Rogers, 2010). An innovation can refer to the physical object of a technology which is called 'hardware', or to the knowledge on using this technology which is called 'software'.

The process of innovation adoption starts with gathering knowledge about an innovation, forming an opinion about this innovation, make the decision to adopt the innovation, implement the innovation, and then confirm this decision after implementation. Confirming this decision means that the adopters are certain that they made the right decision to adopt the innovation (Rogers, 2010).

An important note is that there is a difference between the decision to adopt an innovation and the diffusion of an innovation. The adoption decision refers to the decision to adopt or reject the innovation whereas diffusion of innovation refers to the number of users of an innovation (Rogers, 2010). An "innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2010). This definition insinuates that even though it can be decided to adopt an innovation, this decision is not necessarily also accepted by its users.

Going back to the process of innovation adoption, a prominent idea is that there are mainly two phases of innovation adoption; the initiation phase at the beginning, and the implementation phase at the end of the innovation adoption process. What happens between the initiation phase and the implementation phase is perceived differently by various authors. For example, between these two phases there can be just an adoption decision as displayed in Figure 2 (Pierce and Delbecq, 1977). However, there are authors that define more phases before the initiation phase, between the initiation and implementation phase, as well as after the implementation phase. An overview of phases that are determined by various authors can be found in Appendix 2.

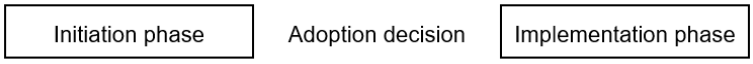

Figure 2: The initiation phase and the implementation phase of the innovation adoption process

In this overview in Appendix 2, several other prominent ideas come to the fore such as how innovation adoption moves through an organisation. Kamal (2006) links different stages from well-known authors to the Lewin's social change model (Lewin, 1952, as cited in Nettler, 1949). The different phases are linked to the three steps of Lewin's model: unfreeze, change, and refreezing. According to this theory there is a status quo, which is changed through an innovation, and then there is a situation that becomes the new status quo within companies. This process is explained through the organizational innovation process of Pierce and Delbecq (1977) and Cooper and Zmud (1990): initiation, adoption, and implementation. Initiation (unfreeze) is interpreted as the pressure to change and searching and assessing information about the innovation. Adoption (change) means the commitment and effort towards the innovation. Finally, implementation (refreezing) means embedding the innovation within the organization and making sure that it matches previous expectations.

There are other, more complex, ideas about the process of innovation adoption. Innovation adoption can be described as first getting aware of an innovation within an organization, after which the innovation is considered, then there is an intention to adopt the innovation, the adoption decision is made, there is a continuous use of the innovation, and only in the end of the process the innovation is accepted by its users (Frambach and Schillewaert, 2002). In this process description we see the diffusion more clearly; an individual or group of individuals get to know about an innovation, which is then adopted by a group of individuals, and must be accepted by even a larger group of users. During this process, different individuals and groups are involved. This means that individual and organizational innovation adoption is not statically defined. First, an individual or group of people decide to adopt an innovation, after which it trickles down to all the users of this innovation. In this case, individual innovation adoption moves into organizational adoption. As mentioned above, innovation adoption can thus occur in multiple contexts.

Even after the adoption decision, the innovation might not be accepted by its users. Therefore, the Technology Acceptance Model focusses more on how (potential) users of an innovation perceive the benefits of an innovation before using it (Davis, Bagozzi, and Warshaw, 1989). In this model, perceived usefulness and perceived ease of use determine the attitude towards using an innovation. Furthermore, its shows how this attitude influences the behavioural intention to using an innovation as well as the actual usage of the innovation. The usage of an innovation is defined as the extent to which the innovation is

accepted within the system. This model also shows that only when an innovation fits the 'system' of the organization and is really used by the people that it was mentioned for, the innovation is accepted.

The second version of the Technology Acceptance model describes how the subjective norm, image, job relevance, output quality, and result demonstrability influence the perceived usefulness of an innovation and its perceived ease of use (Venkatesh and Davis, 2000). This model combines the perceived positive characteristics of the innovation (usefulness and ease of use) with the social factors that influence employees to use an innovation. For example, when an employee considers the innovation will increase his/her image within the company, it is more likely that he/she accepts the innovation (Venkatesh and Davis, 2000).

What can be learned from these authors is that innovation adoption is a *process* that consists of different *phases*. Usually the process of innovation adoption consists of two main phases: the initiation phase and the implementation phase. Before, in between, and after these two phases several other variables can influence the innovation decision. This innovation decision usually occurs between the initiation phase and the implementation phase. Another point from the literature is that adopting an innovation does not necessarily mean that the innovation is accepted by its users. In the following paragraph the variables that stimulate innovation adoption are discussed in more detail.

2.3 Variables that stimulate innovation adoption

In the previous paragraphs it was described how innovation adoption occurs on different levels. Furthermore, the process of innovation adoption consisting of different phases was described. In this paragraph the variables that stimulate innovation adoption are described in more detail. In this paragraph empirical evidence of variables that stimulate innovation adoption will be presented in general and for the bioenergy sector specifically. In the next chapter several variables will be chosen to be tested using the survey and interviews. The variables are divided in three main themes that are found in the literature; business environment, perceived innovation characteristics, and adopter characteristics. An overview of all the variables that were found to influence innovation adoption are presented in Table 1.

2.3.1 Business environment

In paragraph 2.1.2 it was discussed that there are 'external factors' that influence innovation adoption decisions. These 'external factors' were discussed to be drastic events such as natural disasters or an economic crisis. Aside this, domains with different themes and networks of actors influence corporate decision-making (Van der Veen & Kasmire, 2015). In the following paragraph, these factors are all included under the theme 'business environment'.

The business environment of the bioenergy sector is facing several barriers that hamper innovation adoption. These barriers are mostly economic and institutional variables. Within the bioenergy sector there is an issue concerning the **access to financial resources** (Rösch and Kaltschmitt, 1999). The investment that is required for innovations can be very capital intensive. The costs of energy production of fossil fuels are low compared to bioenergy production. The costs of bioenergy production are higher due to the diverse characteristics of biomass which makes production more difficult. Aside this, fossil fuel technology is widely available on the market at modest prices. Private funding within the bioenergy sector is available through banks and financing institutions. However, there are many uncertainties within the bioenergy sector which make investors hesitant.

Public funding is established to resolve this problem because national governments and the EU are aware of the environmental benefits of bioenergy. The emissions related to bioenergy production are significantly lower compared to the energy production from fossil fuels. The social and environmental benefits of bioenergy are reflected in for example fixed prices, taxes, and subsidies. These kind of policy instruments are established to financially support bioenergy companies and develop the bioenergy market.

There are various types of **policy instruments** that promote bioenergy and create financial opportunities for companies (Thornley and Cooper, 2008). However, the effect of these different policy instruments can be different per country and context. Sometimes only a specific combination of policy instruments seems to stimulate the bioenergy sector. In the following paragraph the effects of various policy instruments on the bioenergy in Europe are described.

Fixed prices can be a solution for the bioenergy to initiate growth in the sector. However, fixed prices are subject to numerous other economic variables to succeed. Investing in the bioenergy sector is risky now since the market is still developing. For example, customers need to see the fixed price of bioenergy as more beneficial than fossil fuels. Aside this, when the prices are not fixed for several years, investors might still be hesitant to invest in the bioenergy sector. Aside fixed prices, investors seem motivated to invest in bioenergy when **subsidies** are set for several years. Aside this, investors seem willing to invest in bioenergy more when a (national) **program** is dedicated to developing the sector. **Taxation** has shown to be successful in Sweden, but this taxation must be considerably high to make people switch to bioenergy. Taxation stimulates capital intensive investments because of lower investment risks. However, these taxes must increase substantially over a period of several years. What is notable is that **investment subsidies** did not seem to develop the bioenergy industry in some countries. Only in Italy where subsidies were combined with fixed prices it seemed to stimulate the development of the bioenergy sector. However, the amount of years that these policy instruments were effective were too little to fully stimulate the development of the bioenergy sector. Finally, the experience with **green certificates** is not enough to draw conclusions or has only proven to be effective in combination with for example fixed prices or subsidies in some countries such as the UK and Italy (Thornley and Cooper, 2008).

So, although these policy instruments seem to have mixed effects in various countries and contexts, they are perceived as necessary for the development of the bioenergy sector. It seems that public funding plays an important role in establishing the bioenergy market as well as facilitating growth in the sector.

Another example of how **policy instruments** affect innovation adoption can be found in the case of the diffusion of CHP systems within the Dutch greenhouse sector (Van der Veen and Kasmire, 2015). Through the opening of the energy market, greenhouse companies could sell their excess heat in the form of electricity. At the same time the energy market opened, there was a large difference between the price of electricity and natural gas. This price difference made CHP systems an affordable and profitable investment because it became cheaper to generate electricity on site than buying it from the grid. Aside producing electricity on site, it became interesting to sell electricity because there was enough demand for it. Through heat storage, it was relatively easy for greenhouse companies to store gas for their own use as well as for the demand of others. Aside from the opening of the energy market, there were other policy instruments that were influencing potential adopters of CHP systems. The Dutch government provided subsidies in the form of **feed-in tariffs** for CHP systems, **investment subsidies** for CHP systems, and companies could deduct CHP gas from their **energy tax**.

Aside from policy instruments, **networks** stimulated the diffusion of CHP systems within the Dutch greenhouse sector. This sector is perceived as cooperative as well as competitive by greenhouse companies. This means that companies were open to talk about CHP technologies. At the same time, companies were competitive and discrete towards each other about creating a business structure for CHP technologies (Van der Veen & Kasmire, 2015).

Policies in related industries of bioenergy, such as waste management and agriculture, influence the bioenergy sector indirectly (Huttunen, Kivimaa, and Virkamäki, 2014). To produce biogas, bio-waste, industrial wastes, or waste sludge can be used. Biogas and the digestate that result from these waste materials and by-products connect various sectors such as waste management, energy production, the food industry, and transport systems when the bio-waste is refined as biodiesel. For this reason, the regulations in related industries of bioenergy should be aligned. For example, strict policies concerning using digestate

from biogas as fertilizer, or using animal waste as a bio-waste, could hamper the production of bioenergy. Therefore, Huttunen et al., (2014) state that policies in related industries of bioenergy should be aligned to facilitate bioenergy producers.

When policies in related industries are not aligned, this could cause **administrative challenges** for the bioenergy sector (Rösch and Kaltschmitt, 1990). Companies already require permits for the use of biomass, the emissions that the plant causes, the construction of new projects and machines, and any other by-product or waste the plant produces. Applying for the permits for the implementation of new innovations is difficult because there are various parties and regulations involved, on different levels and within different fields (Rösch and Kaltschmitt, 1990).

An example of how companies can be influenced by other businesses that operate within their business environment are **supplier marketing efforts** (Frambach and Schillewaert, 2002). Supplier marketing efforts are coming from the suppliers of the innovations. These efforts are for example clear communication about the innovation to (potential) adopters or risk reducing mechanisms such as testing possibilities for the innovation. Through these efforts an innovation can be perceived as more attractive by its (potential) adopters. The importance of supplier marketing efforts and their effects on innovation adoption are shown in the case of farm biogas adopters in Tuscany, Italy (Gava, Favilli, Bartolini, and Brunori, 2017). These farmers are mainly influenced by the upstream industry which are companies that sell biogas plants and deliver training, service, and R&D. The upstream industry stimulates knowledge diffusion across (potential) adopters.

Aside suppliers of innovation, farmers also gained information through self-accessible resources such as books, information on the internet, and conferences. It seems that farmers gather information by themselves before they make the decision to adopt farm biogas. After this decision they gain more information though the upstream industry. This is an important finding about the process of innovation adoption and how farmers can be facilitated in receiving information (Gava et al., 2017).

The influence of **social networks** is dependent on the **interaction frequency** and **richness** of the contact between a company and other actors (Frambach and Schillewaert, 2002). Informal networks can facilitate companies to adopt innovations when the information about this innovation is positive. Also, when companies share more information amongst each other within these informal networks, they are more likely to know about new innovations. So, when the frequency and richness of the interaction between companies is high, this results in a faster adoption rate of innovations (Frambach and Schillewaert, 2002).

Aside the interaction frequency and richness of the contact between companies, the kind information that is exchanged is also important.

Aside from companies and policy institutions, there are also other actors involved in the bioenergy sector such as consumers and the general public. There are several variables that influence the public opinion on bioenergy. This **public opinion** can negatively influence innovation adoption in the bioenergy sector (Rösch and Kaltschmitt, 1999). One of the reasons for this is a lack of knowledge about bioenergy, access to knowledge, and unfamiliarity with bioenergy. The bioenergy sector is still developing and therefore a relatively new concept for the public as well as local authorities (Radics et al., 2016). Because bioenergy is a relatively new concept, organizational and legislative support are often lacking. Furthermore, the public worries about the possible negative effects of bioenergy such as smells within neighbourhoods and safety measures (Rösch and Kaltschmitt, 1999). The public also worries about the effects of bioenergy on their community, the support of the government, and especially the price of bioenergy. Moreover, the discussions about edible food crops that are used for energy production and the conditional use of for example trees are issues that consumers are worried about (Radics et al., 2016).

2.3.2 Perceived innovation characteristics

Through its business environment, a company gets in touch with new innovations. The **perceived innovation characteristics** refers to how potential adopters perceive new innovations (Frambach and Schillewaert, 2002). The "*degree to which the innovation is perceived as better than the idea it supersedes*" determines whether an organization adopts an innovation (Rogers, 2010). Perceived innovation characteristics consist of the relative advantage, compatibility, complexity, triability, observability, and uncertainty of an innovation (Frambach and Schillewaert, 2002).

The compatibility is the degree to which an innovation fits within the 'system' of an organization. For example, it should be in line with the corporate strategy. Within the Dutch greenhouse sector, CHP systems were considered compatible with existing business strategies and technologies already present in the greenhouse sector such as heat storage systems. Because the technology was compatible, innovation adoption was stimulated (Van der Veen & Kasmire, 2015). Triability is the extent to which an innovation can be tested within an organization. Observability refers to the extent to which adopters can see the effects of the innovation adoption.

2.3.3 Adopter characteristics

Aside from what occurs *outside* companies, variables *within* companies also influence innovation adoption. In paragraph 2.1.2 of the literature study several adopter characteristics were discussed as bounded rationality and capabilities of companies (Van der Veen and Kasmire, 2015). Aside these variables, there are other adopter characteristics that influence innovation adoption. In this paragraph these variables are explained under the theme 'adopter characteristics' (Frambach and Schillewaert, 2002). Adopter characteristics are organizational features that influence adoption decisions.

The **size** of an organization influences innovation adoption. However, there is mixed empirical evidence about whether a large or small organization is more likely to adopt innovations. Some researchers found a positive relationship between organizational size and IT innovation adoption (Lee and Xia, 2006). When firms are growing, this usually goes hand in hand with the expansion of (human) resources and increased financial assets which stimulate innovation adoption. When large organizations are more specialized, they are more likely to adopt disruptive innovations, if they are in line with their expertise, to stay ahead within the sector. Aside this, if an organization is well integrated, which means that there exist communication channels across different functions, actors, and levels of the organization, it is more likely to adopt innovations (Germain, 1996). Large organizations are more likely to adopt innovations to stay up to date and increase their performance. However, small organizations have been debated to be more flexible and are structurally more capable to innovate fast and on a continuous basis (Frambach and Schillewaert, 2002). Thus, both small and large companies have characteristics that stimulate innovation adoption.

Aside from the size of a companies, other adopter characteristics influence innovation adoption. Within the IT sector, predictors of organizational innovation adoption are found to be the **support of top management**, external pressures, professionalism of the innovation, and external information sources (Jeyaraj et al., 2006). **External pressures** are for example competitive pressures and trading partners that influence the organization to innovate. **Professionalism** refers to the capabilities or capacity of the innovation. **External information sources** are used by organizations to gather more information about innovations. The best predictors of *individual* innovation adoption are **perceived usefulness**, **top management support**, **computer experience**, **behavioural intention**, and **user support**.

There is a relation between innovation adoption and corporate culture within the machinery and metal works industry (Kitchell, 1995). Companies with a **focus on international markets**, a **proactive attitude towards information searching**, **long term goals**, a **flexible corporate culture**, and a **future orientation** are more likely to innovate. Companies adapt their organizational structure to their markets. Making innovation a key strategy has a positive effect on innovation adoption.

Although these researches were done in different industries, it shows the variables that influence innovation adoption in general. Now, looking at the bioenergy industry, there is evidence for adopter characteristics that influence innovation adoption. Within the pulp and paper industry, several innovations can be adopted to produce more sustainable. For example, black liquors can be combusted to create heat and wastewater can be treated on site. The most important reason for adopting these 'Clean Technologies' for some companies is a **better corporate image**, followed by **complying with regulatory requirements**, and **personal commitment of managers** (Del Río González, 2005).

Aside size and structure, organizational **innovativeness or strategic posture** is defined as an adopter characteristic. Organizational innovativeness or strategic posture refers to whether companies are receptive for innovations and whether innovation is part of the key strategy of companies (Frambach and Schillewaert, 2002).

Variables that stimulate innovation adoption	**Subject**	**Author**
- Access to financial resources - Capital intensiveness of new technologies - Costs of and; - administrative and organizational difficulties - Lack of knowledge within the energy sector as well as too little information exchange - Perception and acceptance of the public and local authorities	Variables that *negatively* influence innovation adoption within the bioenergy sector	Rösch and Kaltschmitt, 1999
- Policy instruments; fixed prices, subsidies, national programs, taxation	The effectiveness of policy instruments in promoting bioenergy	Thornley and Cooper, 2008
- Compatibility of technology - Price influencing policy measures - Cooperative and competitive nature of sector	Motivations for CHP adoption within Dutch greenhouse sector	Van der Veen and Kasmire, 2015
- Consistent regulations in related industries of bioenergy	The need for policy coherence to trigger a transition to biogas production	Huttunen et al., 2014
- Supplier marketing efforts; targeting, communication, risk reduction - Social network; interconnectedness/network participation - Environmental influences; network externalities, competitive pressures (varies) - Perceived innovation characteristics; relative advantage, compatibility, complexity (negative), Triability, observability, uncertainty (negative) - Adopter characteristics; size, structure (varies), organizational innovativeness or strategic posture	Relationships between probability of organizational innovation adoption and determinants	Frambach and Schillewaert, 2002
- Knowledge diffusion from upstream industry - Self-accessible information resources	Farm biogas adopters	Gava et al, 2017
- Price and vehicle compatibility of biofuels - Extent of knowledge - Available information about energy source	Variables that influence public opinion	Radics et al., 2016

- Size; large organizations are more likely to adopt innovations	Organizational size and IT innovation adoption	Lee and Xia, 2006
- Size and environmental uncertainty predict high-cost, radical innovation. - Specialization predicts expensive, radical innovation as well as low-cost, incremental innovation - Integration predicts high-cost, radical innovation	The role of context and structure in radical and incremental logistics innovation adoption	Germain, 1996
Best predictors of *organizational* adoption: - Top Management Support - External Pressure - Professionalism of the innovation - External Information Sources Best predictors of *individual* adoption: - Perceived Usefulness - Top Management Support - Computer Experience - Behavioural Intention - User Support	Predictors, linkages, and biases in IT innovation adoption research	Jeyaraj et al, 2006
- Focus on international markets - Proactive attitude towards information searching - Long term goals - Flexible corporate culture - Future orientation	Corporate Culture, Environmental Adaption, and Innovation Adoption	Kitchell, 1996
- The improvement of corporate image - Complying to regulatory requirements, and - Personal commitment of managers - Pulp and paper industries which are small are less likely to adopt disruptive sustainable innovations	Clean Technology Adoption in Spanish Pulp and Paper Industry	Del Río González, 2005

Table 1: Variables that influence innovation adoption in general and within the bioenergy sector specifically

2.4 Conclusion

The aim of this chapter was to answer research question 1; "According to the literature, how is the phenomenon of innovation adoption described and defined, and what are the main variables that stimulate innovation adoption?". Within the literature the phenomenon of innovation adoption is described as a process that consists of several phases. Furthermore, innovation adoption is influenced by different variables on various levels.

Innovation adoption is influenced by various variables that can be categorized in themes. According to the literature, these themes are the business environment and networks, perceived innovation characteristics, and adopter characteristics.

Within the business environment and networks innovation adoption is influenced by access to financial resources, policies, policies in related industries of the bioenergy sector, supplier marketing efforts, the frequency and richness of social networks, and the public opinion.

Perceived innovation characteristics are features of an innovation that determine whether companies find an innovation worthy to adopt. These perceived innovation characteristics are found to be the relative advantage, compatibility, complexity, triability, observability, and uncertainty of an innovation.

Adopter characteristics are features within a company that influence innovation adoption. In the literature, adopter characteristics that influence innovation adoption are size, top management support, external pressures, external information sources, corporate culture, corporate image, complying to regulations, personal commitment of managers, and the innovativeness or strategic poster of a company.

In the following chapter the main variables that are going to be researched in this project are discussed in further detail.

3. Theoretical framework

In the last chapter it was discussed how innovation adoption is influenced by the business environment and networks, the perceived innovation characteristics, and adopter characteristics. In this chapter the theoretical framework is formed using the literature from the previous chapter. First, the concepts are defined, after which they are connected to each other in a theoretical framework. The levels on which innovation adoption will be studied are explained in paragraph 3.1. The phases of innovation adoption that will be researched are described in paragraph 3.2. in paragraph 3.3 the concepts that are used in this thesis are defined and explained. In paragraph 3.4 the theoretical framework is presented. In paragraph 3.5 the hypotheses that were formed for this thesis are described.

3.1 Levels of innovation adoption

In paragraph 2.1.1 of the literature study, the difference between organizational and individual innovation adoption was described. Aside this, in paragraph 2.1.2, literature showed that corporate decision-making can be influenced by variables on the system, network, and agent level.

In this thesis, organizational innovation adoption will be researched. Bioenergy companies can be very large and have over thousands of employees. Aside this, international bioenergy companies can have departments in several countries. Because of the size of these bioenergy companies, it is difficult to assess which individuals are involved in the innovation adoption process. Furthermore, the business environment and networks seem to be important factors that influence innovation adoption. For these reasons, this thesis researches organizational innovation adoption.

In this thesis the Sectoral Diffusion Analysis Framework of Van der Veen and Kasmire (2015) is used to define categories of variables that influence innovation adoption within the bioenergy sector. In Figure 3 an overview of these variables on the different levels is given.

On the system level climate change can be defined as a ‘drastic event’ that formed an incentive for national and international governments and institutions to set more ambitious sustainability goals. Amongst other things, this led to the Renewable Energy Directive ll. These events affected bioenergy companies in Europe and made several companies had to change their business strategy or business models.

On the network level a distinction is made between the business environment and networks. The literature showed that variables within these themes have a big influence on innovation adoption and therefore each of the themes will be researched separately.

On the agent level several variables influence innovation adoption. Aside ‘capabilities’ and ‘bounded rationality’ that are mentioned in the Sectoral Diffusion Analysis Framework, there are other variables that will be researched in this thesis. To include more variables a more general term ‘adopter characteristics’ will be used.

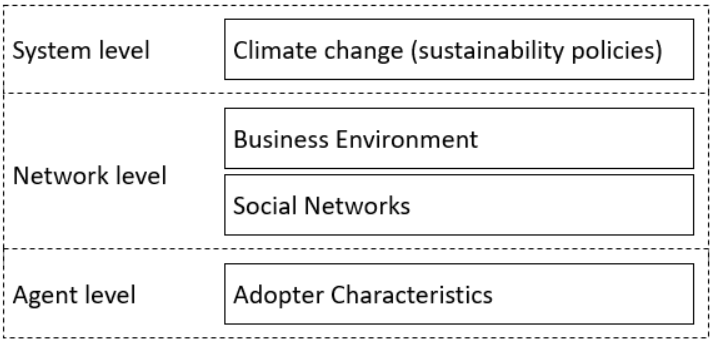

Figure 3: Three levels on which variables influence organizational innovation adoption.

The variables that influence innovation adoption will be discussed in more detail in the following paragraphs of this chapter.

3.2 Phases of innovation adoption

In paragraph 2.2 of the literature study, several important studies on the process of innovation adoption were presented. In this research the focus will be on the adoption decision within the innovation adoption process. The research object of this thesis are companies that have retrofitted in the past which means they have already been through the whole process of innovation adoption and made the adoption decision. This thesis focusses on what influenced these companies to make this adoption decision.

3.3 Categories of variables of the theoretical framework

In this paragraph the theoretical framework of this thesis is presented. In this thesis the Organizational Innovation Adoption Framework from Frambach and Schillewaert (2002) is used as a basis. The Framework is displayed in Appendix 3. The adapted framework that is used for this thesis is displayed in Figure 4. Frambach and Schillewaert (2002) describe the phases of the process of innovation adoption as follows: Awareness, Consideration, Intention, Adoption Decision, Continuous Use, and User Acceptance. They highlight the importance of indirect factors that influence organizational innovation adoption. By doing a literature study, some factors within this framework were not found to influence innovation adoption within the bioenergy sector. In the next paragraph it is described which parts of the framework from Frambach and Schillewaert (2002) are used, which parts are not used, and which parts are extended to apply specifically the bioenergy sector. The variables that are bold will be researched and are thus remained as in the model of Frambach and Schillewaert (2002). The variables marked with *(+)* are added to the model. Variables that are crossed are not studied in this thesis.

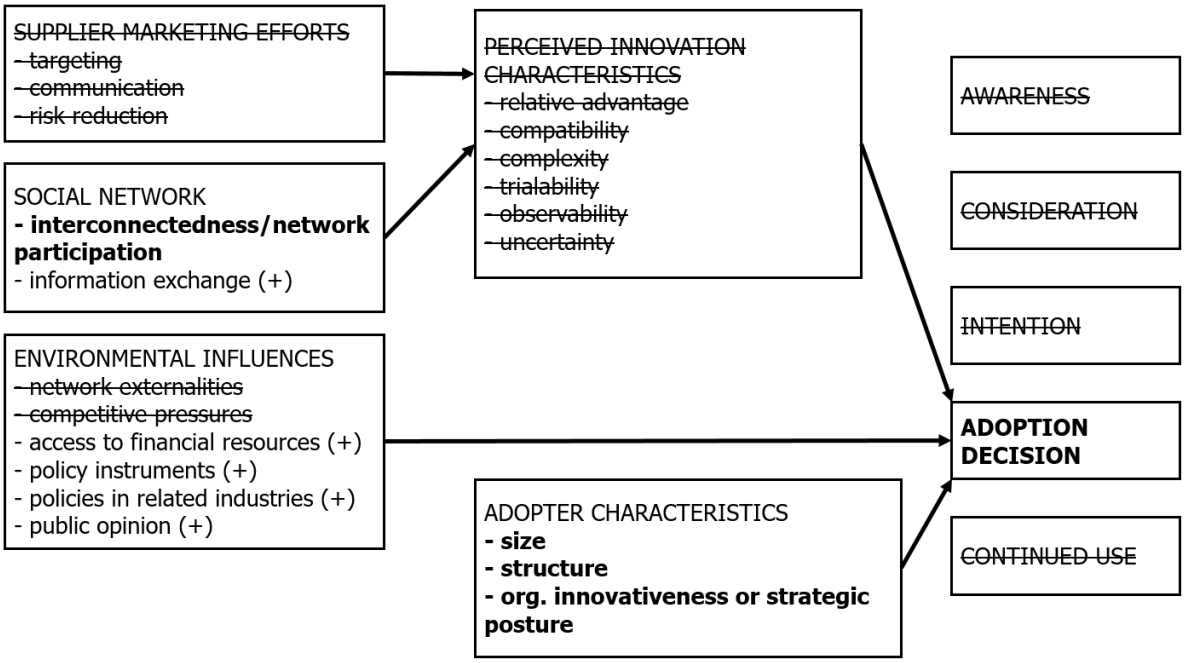

Figure 4: Organizational innovation adoption

Social network

It is empirically proven that social networks influence innovation adoption (Frambach and Schillewaert, 2002). Formal and informal networks within industries or amongst companies can support the diffusion of information about new innovations. The impact of social networks depends on the extent to which companies are interconnected with others and participate in networks. Frambach and Schillewaert define interconnectedness as “the degree to which organizations share information with others (Rogers, 1995 as

cited in Frambach and Schillewaert, 2002). When companies participate in (informal) social networks the spread of information about innovations is stimulated. The interaction between companies can be defined by the frequency and richness of the interaction (Zaltman et al., 1973, Lind and Zmud, 1991, as cited by Frambach and Schillewaert, 2002). To get a better understanding on what is discussed between companies this research will also focus on the type of information is exchanged between companies.

Environmental influences

Environmental influences are defined as the business environment of companies in this thesis. Frambach and Schillewaert (2002) define environmental influences as network externalities and competitive pressures. Network externalities refer to the "theory that the value of an innovation and, hence, its adoption probability, is determined by the number of other users" (Markus, 1990, Rogers, 1991, Katz and Shapiro, 1994, Kraut et al., 1998, as cited by Frambach and Schillewaert, 2002). In the literature no specific evidence was found that companies within the bioenergy sector are influenced by these variables. Therefore, the variables from the framework of Frambach and Schillewaert (2002) are not researched in this thesis. The term 'business climate' was not used on purpose to incorporate more variables that occur on the system level without the influence of governments, lending institutions, businesses themselves, labour unions and such.

Financing capital intensive innovations and accessing financial resources is an issue within the bioenergy sector (Rösch and Kaltschmitt, 1999), In this thesis it is researched whether the access to financial resources is affecting companies to decide to retrofit. Policy instruments have mixed effects on the bioenergy sector in Europe and differs per country and context (Thornley and Cooper, 2008; Van der Veen and Kasmire, 2015). Therefore, the type as well as the effect of policy instruments that stimulated companies to retrofit are researched in this thesis.

Policies in related industries also affect bioenergy companies (Huttunen, et al., 2014). In this thesis the type as well as the effect of these policies in related industries on the bioenergy sector is researched.

Finally, the influence of the public opinion is researched. The public opinion can have a negative influence on innovation adoption in the bioenergy sector when local authorities have a lack of knowledge about it. This can cause a lack of organisational and legislative support for bioenergy companies (Rösch and Kaltschmitt, 1999). Aside this, the public is concerned with several issues related to bioenergy such as safety, price, and support of the government (Radics et al., 2016). Both the influence of the public and consumers of bioenergy are researched in this thesis.

Perceived innovation characteristics

Perceived innovation characteristics are factors that are taken in consideration before adopting an innovation (Frambach and Schillewaert, 2002). The benefits of innovations should be higher than for example the costs, time, or effort to adopt the innovation. Within the framework of Frambach and Schillewaert (2002), networks have an influence on perceived innovation characteristics. Though interaction with other actors, the perceived benefits of an innovation can influenced. These perceived innovation characteristics in turn influence the innovation adoption decision. In this thesis the perceived innovation characteristics are not considered because they deal with the technical characteristics of the innovation such as compatibility. In this thesis, non-technical variables that influence innovation adoption are studied. Furthermore, this thesis does not focus on how retrofitting is perceived, but on how networks influence innovation adoption directly. For this reason, the direct influence of networks and information exchange is researched.

Adopter characteristics

Adopter characteristics are the features of organizations that influence innovation adoption (Frambach and Schillewaert, 2002). These adopter characteristics determine how and in what pace an innovation is

adopted. In this research several adopter characteristics are researched to determine exactly which characteristics are stimulating retrofitting uptake.

Size seems to have mixed effects on innovation adoption (Lee and Xia 2006; Germain 1996; Frambach and Schillewaert, 2002). There is evidence that large companies are more likely to adopt innovations because they have more resources and financial assets compared to small companies (Lee and Xia, 2006). However, small companies can innovate faster and on a continuous basis due to their flexible organizational structure (Frambach and Schillewaert, 2002). Large organizations that are specialized and companies that are well integrated are more likely to innovate (Germain, 1995). These studies show that the size and structure of companies are related to each other and affect innovation adoption. In this thesis both the effect of size and structure on innovation adoption is researched.

Aside size and structure, there are other adopter characteristics that influence innovation adoption. Organizational innovativeness or the strategic posture of companies refers to whether companies are receptive for innovations and if innovating is part of their key strategy (Frambach and Schillewaert, 2002). In this thesis several other variables are added to this definition of organizational innovativeness or strategic posture.

In the literature a relation between innovation adoption and corporate culture is found (Kitchell, 1995). In this study, Kitchell (1995) states that companies should maximize their assimilative capacity for new innovations to increase production versatility and market responsiveness in a turbulent and competitive environment. This can be done through encouraging cultural norms that "emphasize flexibility to change, openness in communication, and a future orientation that focuses on staff development and strategic planning". Because of climate change, companies are now forced to look beyond short-term profits. In this thesis the effects of having long term goals as well as a future orientation on innovation adoption are investigated. The term corporate culture is not used since it focusses more on the employees within companies and their shared values, attitudes, and beliefs. In this thesis a corporate perspective is chosen and thus the strategy of the whole company rather than shared values, attitudes, and beliefs of employees is researched. Aside this, strategic posture refers to the extent to which companies pursue a strong innovation-oriented marketing strategy (Frambach and Schillewaert, 2002). Therefore, the researchers suggest that long term goals and future orientation are more in line with the definition of strategic posture than corporate culture.

The study of Del Río González (2005) showed that personal commitment of managers are important variables that stimulate innovation adoption. Aside this, the study of Jeyaraj et al. (2006) showed that top management support stimulated innovation adoption. In this thesis the support of top management is also added to the definition of organizational innovativeness or strategic posture.

Supplier marketing efforts

Supplier marketing efforts are not researched in this report since retrofitting has been implemented already in the cases that are investigated. Furthermore, retrofit projects can be proposed internally from the R&D department of companies which excludes marketing efforts from external parties.

3.4 Theoretical framework

The model from Frambach and Schillewaert (2002) is adapted to what was found in the literature concerning innovation adoption within the bioenergy sector specifically. This research framework is displayed in Figure 5. The hypotheses that are referred to in the figure as H1, H2, H3, and H4 are explained in the next paragraph 3.5.

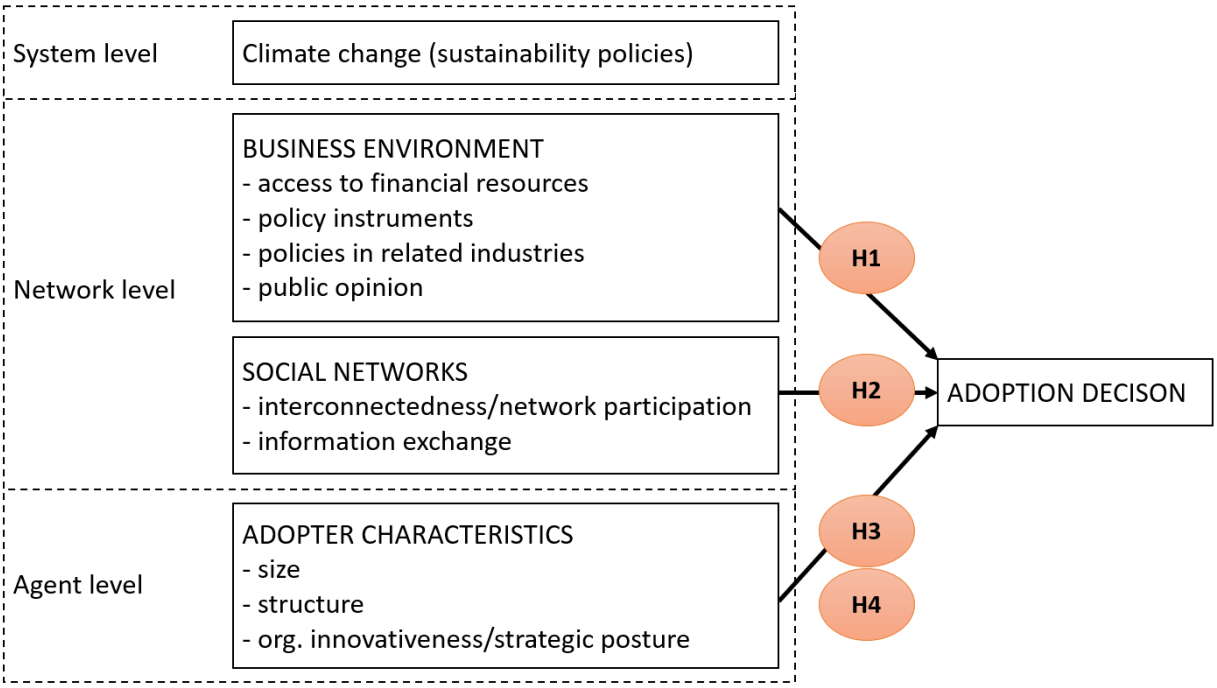

Figure 5: Research framework

3.5 Hypotheses

In this paragraph the expected outcomes of the empirical research are explained through several hypotheses. Several variables will be studied for each hypothesis. Based on the outcomes of the researched variables, the hypotheses will be rejected or accepted. The method for the empirical research is explained in the next chapter of this thesis.

3.3.1 Hypotheses concerning the business environment

In paragraph 2.3.1 of the literature study it comes to the fore that the business environment is influencing innovation adoption in several ways. The business environment contains variables that influence innovation adoption from the system as well as the network level (Van der Veen and Kasmire, 2015). Networks play an important role in the decision of companies. For this reason, networks will be further discussed in their own paragraph in the next paragraph 3.3.2.

Aside from networks, financing innovations and accessing the financial resources to be able to do this seems to be a big issue within the bioenergy sector (Rösch and Kaltschmitt, 1999). The investment required for innovations can be capital intensive and investors are hesitant because the bioenergy sector is still developing.

Since financing innovation is such an issue within the bioenergy sector, complying with regulations seems to be the most important incentive to adopt innovations for energy producers (Del Río González, 2005). Policy is a way to stimulate innovation adoption aside private investments (Thornley and Cooper, 2008; Van der Veen and Kasmire, 2015). Several policy instruments such as fixed prices, subsidies, national programs, and taxation have mixed effects on the bioenergy sector in Europe (Thornley and Cooper, 2008; Van der Veen and Kasmire, 2015).

The bioenergy sector is not only influenced by policies within its own sector, but also policies in related sectors are affecting bioenergy producers (Huttunen et al., 2014). Moreover, administrative difficulties and the accompanying costs can hamper innovation within the bioenergy sector (Rösch and Kaltschmitt, 1990).

The public opinion can negatively influence innovation adoption within the bioenergy sector (Rösch and Kaltschmitt, 1999). Since the sector is still developing, the public as well as local authorities often lack

information about the sector. Therefore, legislation is often not in place or support for the development of the sector is lacking. Aside this, the public worries about the effects of bioenergy on their community such as smells and the safety of the technologies that are used. Aside this, the consumers of bioenergy are concerned with the price and compatibility of bioenergy (Rösch and Kaltschmitt, 1999; Radics et al. 2016).

So, access to financial resources, policy instruments, policies in related industries, and the public opinion are variables that influence innovation adoption. Related to these variables within the business environment, the following hypothesis was formed:

Hypothesis 1: The uptake of retrofitting will be higher in geographical areas (e.g. countries or provinces) with a more benign business environment (R&D subsidies, investment subsidies, securities/pledges).

For this hypothesis this thesis will take a closer look at the following variables within the overall theme of business environment:

BUSINESS ENVIRONMENT
- access to financial resources
- policy instruments
- policies in related industries
- public opinion

Figure 6: Operationalization of the concept 'business environment'

3.3.2 Networks

The influence of networks on innovation adoption is dependent on whether companies are receptive to innovation and whether innovation is part of companies' key strategy (Frambach and Schillewaert, 2002). Information from upstream industries have proven to stimulate bioenergy adopters (Gava et al., 2017). The kind of relationship that companies have with other companies in their sector influences their innovativeness. The cooperative and competitive nature of the contact between companies can stimulate innovation adoption (Van der Veen and Kasmire, 2015). This means that aside from the frequency of interaction, the richness of the interaction is a point of attention in this research. Participating in (informal) networks can increase the spread of information about new innovations (Frambach and Schillewaert, 2002).

Aside from the frequency and richness of the contact between companies, the kind of information that is exchanged also influences innovation adoption. Business that have a proactive attitude towards information searching are more likely to innovate (Kitchell, 1996). Also, external information sources are important for organizational innovation adoption (Jeyaraj et al., 2006). What companies share and what companies do not share with each other influences the richness of their interaction. This is what Frambach and Schillewaert (2002) refer to as interconnectedness.

The interconnectedness/network participation and information that is exchanged between companies are variables that influence innovation adoption. Related to networks the following hypotheses was formed:

Hypothesis 2: Strong links with other energy companies or consultants with retrofitting experience in your network has a positive effect on the uptake of retrofitting.

For this hypothesis this thesis will take a closer look at the following variables within the overall theme of networks:

SOCIAL NETWORKS
- interconnectedness/network participation
- information exchange

Figure 7: Operationalization of the concept 'networks'

3.3.3 Adopter characteristics

Adopter characteristics are the internal features of companies that influence innovation adoption (Frambach and Schillewaert, 2002).

The size of a company seems to have mixed effects on innovation adoption. Large companies are more likely to innovate because they have more financial resources and skilled personnel (Lee and Xia, 2006; Germain, 1996). However, small companies can have a more flexible organizational structure which makes them more receptive to innovations than bigger, rigid structured companies (Lee and Xia, 2006; Kitchell, 1995; Del Río González, 2005).

Aside from the size and the skills of the personnel of companies, the degree to which innovation is central within a business strategy of a company also determines the innovativeness of a company. When a company is growing, this usually goes hand in hand with increased financial assets and (human) resources. Aside from the growth stage of a company, its strategy to be specialized or integrated also influences their need for innovations (Germain, 1996).

Another variable that influences innovation adoption is the strategic posture of companies. Whether companies are receptive to innovations and whether innovation is part of their key strategy determines their innovativeness (Frambach and Schillewaert, 2002). Aside this, companies with long term goals and a future orientation are more likely to innovate (Kitchell, 2006).

The support of top management is also critical for the stimulation of innovation adoption (Jeyaraj et al., 2006; Del Río González, 2005).

The size, the expertise of employees within companies, the innovativeness or strategic posture of companies, and the support of top management influence innovation adoption. Related to adopter characteristics the following hypotheses were formed:

Hypothesis 3: Companies with an integral sustainability orientation and strategy, and companies with a customer base of sustainable companies are more inclined to uptake retrofitting.

Hypothesis 4: Companies with high turnover and equipped personnel that are familiar with retrofitting are more likely to uptake retrofitting.

For these hypotheses this thesis will take a closer look at the following variables within the overall theme of adopter characteristics:

ADOPTER CHARACTERISTICS
- size
- structure
- org. innovativeness/strategic posture

Figure 8: Operationalization of the concept ‘adopter characteristics

4. Methodology

This chapter is aimed to answer research question 2: "How can variables that stimulate innovation adoption within the bioenergy sector be analysed?". In this chapter the research strategy will be described in paragraph 4.1. Furthermore, the data sources and methods to collect data will be explained in paragraph 4.2. Then, the research framework will be operationalized, and interview questions will be presented in paragraph 4.3. After this, the validity and reliability of the methodology will be discussed in paragraph 4.4. Finally, the method for analysis will be described in paragraph 4.5.

4.1 Research strategy

As stated in paragraph 1.3.2, this thesis contributed to a larger project called BIOFIT. The goal of this project is to analyse the motivation, experiences, and perceptions on retrofitting within the bioenergy and fuels sector. The goal of this thesis is to research the variables that stimulate the uptake of retrofitting within the bioenergy and fuels sector in Europe and from that, establish recommendations for policymakers on facilitating the uptake of retrofitting. This thesis aims to test whether variables that influence innovation adoption, that are found in literature, can be applied to the bioenergy sector in Europe. Aside this, this thesis aims to expand the theoretical framework on innovation adoption when it is found that additional variables influence innovation adoption within the bioenergy sector in Europe which are not mentioned in literature.

During the BIOFIT project several hypotheses were established. To test these hypotheses, the BIOFIT team established a survey that addressed companies within five industries: the biofuels sector, pulp and paper industry, fossil refineries, fossil fired power, and combined heat and power (CHP) systems. The survey was supposed to give insight in the motivations of companies that had retrofitted in the past. This thesis became part of the project to provide more in-depth information by doing interviews. When this thesis became part of the project, several hypotheses were changed or added to make them more scientifically grounded. The reason for doing this was that after doing the literature study, it was found that not all hypotheses were grounded and consistent with the evidence that were found in the literature concerning the bioenergy sector. Two hypotheses that were established by the BIOFIT team were not examined in this research. The reason for this was that one of these hypotheses concerned comparing geographical areas. Doing interviews with only a small group of company representatives, empirical evidence could not represent all geographical areas in Europe. The other hypothesis concerned a technical factor, the depreciation rate of energy installations, which are not researched for this thesis.

The following hypotheses were researched in this thesis:

Hypothesis 1: The uptake of retrofitting will be higher in geographical areas (e.g. countries or provinces) with a more benign business environment (R&D subsidies, investment subsidies, securities/pledges).

Hypothesis 2: Strong links with other energy companies or consultants with retrofitting experience in your network has a positive effect on the uptake of retrofitting.

Hypothesis 3: Companies with an integral sustainability orientation and strategy, and companies with a customer base of sustainable companies are more inclined to uptake retrofitting.

Hypothesis 4: Companies with high turnover and equipped personnel that are familiar with retrofitting are more likely to uptake retrofitting.

After establishing the hypotheses, the BIOFIT team continued with forming a survey. Aside from existing knowledge, the BIOFIT team partially used the findings from the literature of this thesis to finalize the survey. Aside from this quantitative approach, a qualitative approach was needed to understand the decision to retrofit by companies in more detail. Through a qualitative approach, this thesis could provide the BIOFIT team with a detailed description of the decision process of companies that did retrofit projects.

The research object of this thesis were companies that have retrofitted in the past. Companies were selected from the database of the BIOFIT project. The survey from the BIOFIT team was send to these companies. Furthermore, additional information about the company was studied before conducting interviews. The results of the surveys, interviews, and the additional documents of the companies were analysed. Through this analysis recommendations for policy makers were established.

4.2 Methods for data gathering

4.2.1 Case study approach

This thesis used a multiple case study approach. The reason for choosing this approach was to understand the process of deciding to retrofit in detail using a qualitative approach. The hypotheses of this thesis were focussed on complex contextual variables that explain innovation adoption. To understand these contextual conditions and their influence on the process of retrofitting, a case study seemed to be a suitable method. The BIOFIT team was studying a limited number of variables using surveys whereas this thesis focussed on performing an in-depth study of the context of innovation adoption from a company perspective.

The purpose of a case study can be intrinsic, instrumental, evaluative, explanatory, and exploratory (Thomas, 2015). This research focusses on how the retrofit decision came about, connecting several variables that played a role in the decision and the possible barriers and benefits of implementing retrofitting from a company perspective. The purpose of this research was both explanatory and exploratory. It explains the process and context of the retrofit decision made by companies and explores the variables that influenced this process.

There are several approaches of a case study; testing a theory, building a theory, drawing a picture, experimental, and interpretative (Thomas, 2015). This research was testing and building innovation adoption theory. This thesis was testing whether variables from innovation adoption literature were applicable to innovation adoption within the bioenergy sector in Europe. The variables that were found through the empirical study which were not mentioned in the literature were added to the theoretical framework in order to build a theory.

Within this research multiple case studies were included. Multiple case studies provide an in-depth and broad study of a research object (Yin, 2003). The reason for using multiple case studies was that retrofitting was studied in different industries. Moreover, the retrofit cases could differ substantially from each other because the industries, type of retrofit, context, and companies could be very different from each other. Even when retrofitting was studied in the same industry, retrofitting could take on many different forms. For example, some companies only added an installation that is biobased while others replaced fossil-based installations with biobased installations. For these two examples, the variables that the companies would consider when deciding to retrofit could be completely different.

Although the multiple case studies provided specific information about retrofitting within these industries, they were part of a larger unit of analysis; the bioenergy and fuels sector. Studies can be 'nested' within a larger unit of analysis (Thomas, 2015). The focus was not on comparing different industries, but on showing which challenges and opportunities these companies faced when deciding to retrofit. The focus of this research was to understand how bioenergy and fuels production can be stimulated and facilitated in general, without looking explicitly into the differences and similarities between the five industries.

When the data was being collected, it was decided to alter the standards for the case study method. Normally, a case study is characterized by a selective, strategic sample (Verschuren and Doorewaard, 2005). For this sample, standards should be created to make a well-grounded choice between optional cases.

Reaching companies to conduct both the interview and survey proved to be very difficult. Over 80 companies were contacted through e-mail to do the survey and around 50 companies were called to fill in the survey and/or do the interview. After two months, only 11 companies filled in the survey and 7 interviews were conducted with company representatives. Consequently, standards for case studies were

no longer applicable to the available cases. Due to the low number of responses, a snow-ball sampling was used to conduct interviews.

4.2.2 Selected companies

Within Table X an overview of the selected companies is provided. In this overview the companies are categorized per industry.

	Company	**Industry**	**Project description**
1	Electric utility company	Fossil fired power	Retrofit installations to co-fire coal and biomass and aside this retrofit installations to fire a 100% biomass in the form of wood pellets.
2	Second generation biodiesel company	Biofuels	Retrofit biodiesel plant to use a 100% waste product instead of partially using waste and non-waste products.
3	First generation biofuel company	Biofuels	Retrofit biofuel plant that runs on rapeseed oil to produce bio kerosene that can be blended with conventional kerosene.
4	Biogas producing company	Pulp and paper	Biogas producing company leads a project that concerned installing a wastewater treatment unit to a pulp and paper mill. On the site of the mill a biogas plant was built by a third company.
5	Waste processing company	CHP	Retrofit a boiler at a biomass plant that was producing electricity to also produce heat in order to supply water from low pressure steam to the existing systems of the company.
6	Power (electricity and heat) company	CHP	Retrofit a CHP plant from running on a 100% coal to run on a 100% biomass in the form or wood pellets.
7	Petrol producing company	Fossil refinery	Retrofitting refinery to co-process used cooking oil along with conventional light gas oil, a mixture of various crude oil fractions.

Table 2: Overview of selected companies for case studies

4.2.3 Interview design

The interviews within this thesis were hold with representatives of 7 companies that had retrofitted in the past. These respondents were R&D managers, project managers, and energy managers. The interview was focussed not only on which variables played a role in the retrofit decision, but also which variables were important, and which were less important when this decision was made. The interviews were focussed on the three themes of variables: business environment, networks, and adopter characteristics. However, when the representative stated that additional variables were important during the decision, these variables were added to the empirical evidence. The interviews consisted of 17 questions that where directed to explore which variables played a role during the retrofit decision. These questions are further discussed in paragraph 4.3 operationalization of variables. The interview followed a protocol which is presented in Appendix 4.

4.2.4 Method for literature study

To answer research question 1: “According to the literature, how is the phenomenon of innovation adoption described and defined, and what are the main variables that stimulate innovation adoption?” a literature study was done. The literature in this research was accessed through Google Scholar, WebOfScience, and the (online) library of Wageningen University and Research. In these search engines the search terms that were used were “innovation adoption”, “innovation acceptance”, and “innovation diffusion”. The concepts “individual” and “organizational” were added before “innovation”. After “innovation” the concept “bioenergy” and/or “biofuels” were added. Furthermore, some scholars describe

"innovation" as a "technology" which is also considered an innovation in this research and therefore added to the search terms.

In this literature study, the most important inclusion criterion was that the studies are supported by empirical evidence. The literature concerns articles from the IT sector and the (bio)energy sector. The processes were thus studied within the context of the bioenergy sector specifically and in general. More inclusion and exclusion criteria for the literature can be found in Appendix 5.

During the desk research several other documents were studied such as reports, company files, and annual reports are addressed as well as secondary data such as reports from research institutes. The variables that were found in the literature were listed in an overview that categorizes the author, subject of the research, and the variables that stimulate innovation adoption in general and within the bioenergy sector specifically. Once the literature study was completed, the variables that influence innovation adoption were constructed in a research framework. The variables were then used to create hypotheses.

4.3 Operationalization of variables

In this paragraph the variables that were described in the theoretical framework are operationalized. This means that the exogenous variables that stimulate innovation adoption will be given value. By doing this, operational variables will be created that can be measured. In Figure 9 an overview of the operational variables, the exogenous variables, and the categories of variables (business environment, networks, and adopter characteristics) can be found. First the concept business environment will be discussed, after which the concept of networks and adopter characteristics will be discussed.

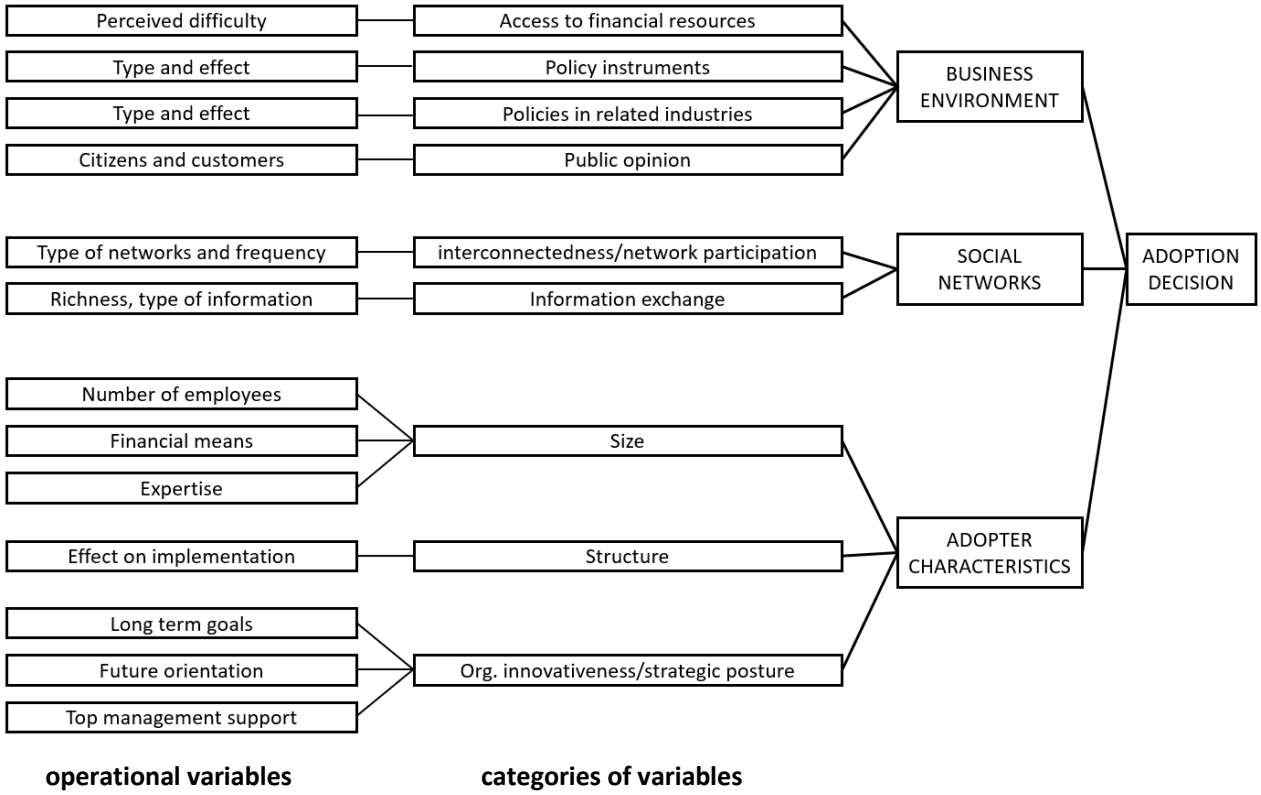

Figure 9: Exogenous variables and operational variables that influence innovation adoption

4.3.1 Operationalizing the concept Business Environment

Several variables within the business environment of the bioenergy sector are influencing companies with their decision to adopt retrofitting. In the literature study it was described how access to financial resources and the capital intensiveness of bioenergy technologies are issues that companies are facing (Rösch and

Kaltschmitt, 1999). Therefore, the perceived difficulty of ascertaining financial resources for the retrofit project was measured.

Policy instruments showed mixed effects on the bioenergy sector in Europe (Thornley and Cooper, 2008; Van der Veen and Kasmire, 2015). Policy instruments can be R&D support, subsidies, tax systems, and local/national programs (Thornley and Cooper, 2008; Van der Veen and Kasmire, 2015) Therefore, it is important to distinguish which policy instruments are affecting companies the most concerning financing and supporting their retrofitting projects. The policy instruments were measured through type and effect on the company.

Policy in related sectors, such as the waste and agricultural sector, influence the bioenergy sector (Huttunen et al., 2014). Therefore, the type and effect of these policies were also measured.

The public opinion influences the bioenergy sector (Rösch and Kaltschmitt, 1999; Radics et al., 2016). Therefore, influence of the public opinion on the decision to retrofit was measured. In this thesis a distinction was made between the influence of consumers and citizens.

Interview question	**Measurement**
6. Was it difficult or easy to ascertain financial resources for your retrofit project?	Perceived difficulty
1. Did you consider the political climate benign when it was decided to retrofit? What were key influencer(s) in the retrofit decision?	Type and effect
7. What stakeholders were critical during the retrofit decision? For example, in other industries (waste/agriculture/nature conservation), customers (with sustainability orientation), or citizens living close to bioenergy installation?	Content analysis

Table 3: Interview questions 'business environment'

4.3.2 Operationalizing the concept Networks

As mentioned in paragraph 3.3.2, interconnectedness/network participation refers to whether companies are receptive to innovations and whether innovation is part of their core strategy (Frambach and Schillewaert, 2002). Interconnectedness/network participation focusses on the participation of companies in networks and the interconnectedness they share with these networks.

Participating in (informal) networks can stimulate the spread of information about new innovations (Frambach and Schillewaert, 2002). To discover which networks are most important to retrofit companies, and in which domain these networks operate, the companies were asked to describe their most important network during the retrofit process. Aside this, the frequency of interaction with their most important networks was measured.

The interconnectedness of companies refers to what kind of information they share amongst their networks, and what they do not share. The kind of relationship that companies have with actors in their networks influences their innovativeness (Van der Veen and Kasmire, 2015). The interconnectedness of companies is thus measured in the richness of interaction. Therefore, the type of information that was shared amongst companies and their networks was measured in this thesis.

Interview question	**Measurement**
2. If any, how did your network influence the retrofit decision?	Type of networks
3. Who in your network was most influential in the decision to retrofit?	Type of networks
4. How frequent did you interact with this network before retrofitting and during the retrofit implementation? (and via which platform?)	Frequency

5. What type of information about retrofitting did you gain from your network before retrofitting? And reversely, what type of information does your company share about retrofitting?	Richness, type of information

Table 4: Interview questions 'networks'

4.3.3 Operationalizing the concept Adopter characteristics

The adopter characteristics are features of companies that influence innovation adoption (Frambach and Schillewaert, 2002). These adopter characteristics are size, structure, and organizational innovativeness or strategic posture (Frambach and Schillewaert, 2002).

The size of a firm determines if an organization has the financial means or equipped personnel to implement an innovation (Lee and Xia, 2006; Germain, 1996; Frambach and Schillewaert, 2002). Therefore, the influence of the size of the company on their innovation decision was measured in the number of employees, the financial reserves of the company, and the internal expertise that the company had when it decided to retrofit.

The structure of a company determines if retrofitting can be easily implemented considering the flexibility of the company. Therefore, the influence of the organizational structure on how the retrofit was implemented and the speed of the implementation process was measured.

Organizational innovativeness or strategic posture refers to whether the company has an innovation-oriented marketing strategy. The companies were asked about their latest innovations to analyse whether these innovations were consistent with a sustainable and innovative strategy. Aside this, the companies were asked to choose a corporate strategy that was important when making the decision to retrofit.

As explained in paragraph 3.3, the variables long term goals and future orientation were added to the definition of organizational innovativeness or strategic posture of Frambach and Schillewaert (2002). The effect of these variables was measured in their ambition to retrofit further in the future.

As explained in paragraph 3.3, the variable top management support was also added to the definition of organizational innovativeness or strategic posture of Frambach and Schillewaert (2002). The support of top management was measured in this thesis through the extent of personal support and the exerted influence during the decision-making process.

The variables of the business environment consider variables that are influencing innovation adoption from outside the company. The adopter characteristics consider variables that are happening inside companies that influence innovation adoption.

Interview question	**Measurement**
8. When it was decided to retrofit, what was the influence of the company size and/or financial reserves?	Content analysis
9. How many full-time employees did your company have when it was decided to retrofit? How many employees worked on the retrofit transition?	Likert scale 1=fewer than 50, 2=50-99, 3=100-249, 4=250-499, 5=500-749, 6=750-999, 7=1000 or more (Damanpour and Schneider, 2008). For retrofit team; number

10. Did your company have enough internal expertise when it was decided to retrofit?	Content analysis
11. Was the complexity of your organizational structure influencing your retrofit decision concerning the speed and difficulty of implementing the retrofit?	Effect on implementation
12. How was your top management involved in the retrofit decision in terms of personal support and exerted influence during the decision-making process?	1) Extent of personal support 2) Exerted influence during decision-making process (Hurley and Hult, 1998)
13. From the following 4 options can you choose a corporate strategy that was important when making the decision to retrofit: a) Long-term market growth b) Technology leadership c) Short-term profitability d) Financial returns for owners	4-point scale (Kitchell, 1995)
14. Can you shortly describe three of the more important innovations that have been implemented in your company in recent years, say in approximately the last 5 years?	Content analysis
15. Ultimately, what percentage of your plant is going to be retrofitted and when is this going to be realized?	Percentage. For realization; number of years
16. Are there relevant non-technical reasons for or against retrofitting that were not mentioned yet in this questionnaire?	Content analysis
17a. If you intent to retrofit in the future, do you experience a shift in non-technical reasons for retrofitting?	Content analysis
17b. If you do not intent to retrofit in the future, what is the most important reason for this?	Content analysis

Table 5: Interview questions 'adopter characteristics'

4.4 Validity and reliability

The validity of this research is defined as four types of validity; construct validity, internal validity, external validity, and reliability.

Construct validity deals with "identifying correct operational measures for the concepts being studied" (Yin, 2009). The operational measures for the concept are partially based on previous studies from Damanpour and Schneider (2008), Hurley and Hult (1998), and Kitchell (1995). Aside this, the categories of variables are all based on previous literature on innovation adoption in general as well as for the bioenergy sector specifically. The hypotheses are based on literature as well. This is explained in paragraph 3.3. To improve construct validity, this thesis also used multiple sources of evidence such as surveys, interviews, corporate documents, news articles and literature. By basing operational variables and categories of variables on literature, the risk of the researcher knowing or guessing a desired outcome is reduced. Aside this, companies were also asked if any additional variables, that were not mentioned in the survey, influenced

their retrofit decision. This way, the risk of creating a biased method that would stimulate companies to answer a certain way was considered.

The internal validity of a research concerns justifying causal relationships. According to Yin (2003), internal validity can be improved using *triangulation*. This term refers to using several research methods to study the same object or phenomenon. In this thesis several research methods were used, a literature study, interviews, surveys, and a desk research, to study innovation adoption. By using several research methods, different empirical evidence from these methods can confirm conclusions about innovation adoption. Aside this, the empirical research was based on methods described in Thomas (2015), Verschuren and Doorewaard (2010), and Yin (2009). One method that was used in this thesis and comes from these works is the hierarchical method. This method states that first, the individual cases are studies on their own before, in the end, compare them. Aside using these logic methods, instructions for the survey were standardized in an interview protocol which can be found in Appendix 4.

External validity is the extent to which this research can be generalized (Yin, 2003). The case studies in this research represents different industries. Interviews were done with companies from all five different industries which makes the results generalizable to some extent for the whole bioenergy sector.

The reliability of a research lies in the data collection procedures (Yin, 2003). If the research is going to be repeated using the same methods and measures, it should provide the same outcome. In this thesis an interview protocol was used which can be found in Appendix 4.

To conclude, when discussing validity and reliability this research explicitly tried to deal with maximizing the quality of the empirical research. The limitations are described in paragraph 7.3 which reflects on constraints that were experienced during the research concerning reliability and construct validity.

4.5 Method of analysis

The interviews have been fully transcribed and were coded using Atlas.ti. The codes were the operational variables as mentioned in overview of paragraph 4.3. The code families were the categories of variables mentioned in the overview of paragraph 4.3. The purpose for coding the interviews was to see if there were any variables influencing the retrofit decision, that were not mentioned in literature, which could then be included in the theoretical framework.

When analysing the interviews, quotes that matched the variables within the themes were highlighted. Sometimes quotes concerned multiple variables and categories of variables. In this case, the quotes were marked with multiple codes and families. Quotes that corresponded to new variables, which were not known before and did not result from previous literature, were given a new code.

The case studies were first individually described and analysed. After each individual case, several notable findings were described. After all the case studies were individually analysed, the cases were compared to make cross-case conclusions. This cross-case analysis was done by looking at which variables were influencing multiple companies. By doing this, a comparison can be made between companies and sectors and similarities that overlap all companies and industries can be found. These variables that were found in the case studies were compared to previous empirical evidence that was found in the literature.

The empirical evidence that was found in the case studies was analysed to see whether hypotheses could be supported or rejected. Furthermore, the theoretical framework was extended with new variables that were found through empirical evidence of the cases studies.

During the analysis possible policy recommendations were formed which were described after supporting and rejecting the hypotheses. These recommendations were given to provide policymakers with tools to stimulate innovation adoption within the bioenergy sector.

5. Empirical results

In this chapter the empirical results of the case studies are presented. In total, seven case studies were analysed. First, the cases are individually analysed. Second, notable findings are described at the end of each individual case description. Finally, a cross-case analysis is done in Chapter 6, and the empirical findings are discussed. In paragraph 5.1 the individual case description of an electric utility company is presented, followed by the case descriptions of a second generation biodiesel company in paragraph 5.2, a first generation biofuel company in paragraph 5.3, a biogas producing company in paragraph 5.4, a waste processing company in paragraph 5.5, a power company in paragraph 5.6, and a petrol producing company in paragraph 5.7.

5.1 Individual case description: Electric utility company

Case description

The thermal power plant of this company generates electricity through thermal and hydro power plants. The company pursues a strategy whereby the thermal power plants are going to be transformed to meet future environmental standards in line with EU regulations. The transformation, or retrofit, concerns the transition of the power plant(s) from producing electricity from coal-firing to (co-)firing wood pellets. The lifespan of the plants also required the company to invest in improvements. Investments first went into creating case study examples of co-firing biomass and coal. The goal was to eventually phase out coal entirely to produce electricity. One business case study was aimed at full conversion to biomass while another concerned co-firing with 30 percent biomass. So far, in April 2019, the investments are related to R&D projects and trial runs in the power plant. The company has also created new business plans to pursue its strategy, together with another bioenergy company as well as university partners.

5.1.1 Business environment

The size of the company influenced its access to financial resources. Subsidies did not cover larger power plants above 10 Megawatt which means that the company had to find other financial means to cover the costs of the retrofit. A bank is willing ready to finance the project once feasibility of the business model is achieved. This bank already financed the larger part (80 percent) of the feasibility studies. The rest of the project was financed with equity (20 percent). The perceived difficulty of the access to financial resources had to deal with the large size of the company. This is not confirming with the statement of Rösch and Kaltschmitt (1999) that difficulty with finding financial resources exists because of capital intensiveness of retrofit technologies which makes combustion of biomass not competitive in current markets.

Two issues within the business environment were raised by the company that affected their retrofit decision. These issues are the CO2 tax procedures and subsidies for the use of biomass. The country in which this power plant is located is not yet a member of the EU and therefore the RED II do not apply (yet). The RED II is crucial for this company because after feasibility studies it was found that the new business plan would not be feasible without the CO2 tax.

Sourcing of biomass seemed to be a problem for the company. It mainly faced problems with regulations of the forestry sector and wood industry. These problems mainly had to do with the supply of biomass. "*They need to improve and be able to deliver more quantities of waste wood on the market or directly to us as a potential big biomass user. It is a very diversified problem. We have a very developed wood industry but most of waste wood goes to factories of pellets that then goes outside the country".* So, even though the country's wood industry is developed and there can be a stable supply, it is rather exported on the market. The company was influenced by policies in related industries, namely the forestry and wood sectors. This is in line with (Huttunen et al., 2014) which stated that policies in related industries of the bioenergy sector need to be coherence to trigger a transition in the bioenergy sector.

The company emphasizes that focussing on environmental technology influences its corporate image. "*When environmental technology is considered, this is a good point for the image of the company".* Aside their customers, local citizens were also aware of the developments within the company. "*When we held trials in the power plant with biomass local citizens knew about it and were very happy about the development".*

Corporate image is a variable that, until now, has not been taken considered. Still, it seems to affect the company positively, because its customers and local citizens were reacting positively on the retrofit project. In this case, the public reacted positively and did not influence the retrofit decision in a negative way as was found earlier by Rösch and Kaltschmitt (1999).

5.1.2 Networks

This company stated that the most important network that influenced their retrofit decision was the academic society. The idea of using biomass was formed through the familiarity with regulations and strategies concerning CO2 policies within the EU. Conferences and lectures were visited on this matter. There was continuous communication with the academic institutions and especially with a faculty of mechanical engineering. The connection with these institutions was very rich since these institutions and the company started the retrofit project together. Aside the retrofit project, the company and university also share other projects and the university is part of the R&D department of the company. This company also interacts with other power plants all over Europe. Several co-firing projects were visited in Poland, the Netherlands, Germany, Denmark, and Finland. The company shares its experiences with other power plants in Europe: "*We are exchanging experiences. We have good industry connections along with these academic connections".* So, the company mostly interacts with academic networks which are partly incorporated within the company. The effect of this network is that it contributes expertise to the companies R&D department.

The company cooperates mainly with operational managers from other companies. "*They always like to share any information with us on the operational level. It was good to compare these situations with our own operation".* Aside operational managers, information is also shared through other platforms outside of the company. "*We presented the discoveries on our power plant. The information is spread through conferences, energy journals and so on".* It seems this company is interconnected with its networks because it is willing to share its experiences and knowledge about retrofitting projects to other companies, the academic community, and the public.

5.1.3 Adopter characteristics

The company is large and therefore should have a benefit concerning expertise and financial means (Lee and Xia (2006). However, the company did require external expertise to train its staff and to cooperate in the retrofit project to make it a success. From the total number of 4.349 employees, around 30 people were involved in the retrofit and trial run projects. Concerning internal expertise, the company had a series of presentations and preparations to get the operational staff and managers informed about the retrofit project. Concerning external expertise, the company was supported by the mechanical engineering faculty of a university.

The complexity of the structure of the company did not influence the implementation of the project which does not confirm the link between organizational structure and innovation adoption of Frambach and Schillewaert (2002). By involving the operational and manager staff in the retrofit project, the process of implementing the trial runs was easier. The company has a R&D department that is working closely with the operational staff and managers.

The project did not require substantial funding and therefore the company did not face many problems with implementing it. However, when a project would involve substantial costs it would be more difficult to convince the board of directors to invest in it. "*We did not face too many problems because the project*

required only small financial means. However, when we want to convert coal installations or implement larger co-firing rate, this will be more difficult financially. This would then affect the time of implementation because the decision is then more difficult". The costs of the retrofit project can influence how it is implemented and the speed of the implementation process.

In this company the management team was supporting the retrofit project. Still, there were several directors that were involved in making the decision whether a retrofit project was going to be executed. When projects show financial viability and feasibility, it's more likely to be adopted by the top management. The top management of this company was involved from time to time, being aware of the project. Still, there were no members from the top management personally involved which is supposed to stimulate innovation adoption (Jeyaraj et al., 2006; Del Río González, 2005).

The future orientation of the company concerns complete conversion for the thermal power plant from coal to biomass. Within the coming years the company will do more feasibility studies and gather all obligations necessary to make this conversion possible. The conversion should be ready in 2022 or 2023. Now it is using 7 to 10 percent biomass without making large changes within the installation which require large costs. "*In the future we want to convert every plant or at least partially convert the plants. Environmental issues are going to play a big role in this".*

In the future, the company emphasizes that environmental and economic benefits are the most important to consider. Still, on the multiple-choice question which corporate strategy was important when making the decision to retrofit, the company chose financial returns to owners.

Aside this, the innovations that the company implemented in the last five years mainly concern the modernization of the construction of their thermal power plants. Aside this, there were some innovation in the field of electro-mobile and distribution. It seems that the innovative behaviour of this company is not in line with its emphasis on future environmental benefits.

Notable findings

- The company faced difficulty with accessing financial resources because its size exceeded the norm to receive subsidies
- Feasibility of the new business model, including the retrofit, was not possible without the European CO2 tax system
- The company was influenced by the forestry and wood sector that is exporting most of the wood pellets to other European countries.
- The company stated that focussing on environmental technology influenced its corporate image in a positive way
- The company interacts mostly with networks from the academic society and a university that is part of the R&D department of this company
- The company is open about sharing experiences and knowledge about its retrofit project
- Although the company is large, external expertise was required to do the retrofit project
- Because the costs of the retrofit project were small, the board of directors quickly gave permission to execute the plans
- The key strategy of the company did not concern adopting many sustainable innovations
- Top management was occasionally involved and seemed mostly concerned with the financial viability and feasibility of the retrofit project.

5.2 Individual case description: Second generation biodiesel company

Case description

Before the retrofit project this company's biodiesel plant was already running since 2011/2012. The retrofit project concerned producing biodiesel from 100 percent waste products instead of partially using waste

products. At the time the facility was build it could only handle a small percentage of waste and was mainly running on used oils. To produce biodiesel from 100 percent waste products, the company retrofitted a previous installation and invested in two new installations. One of these new units was going to be a biogas plant to convert by-products and wastes into energy. Due to several factors, including the European economic crisis, the investment for the two new units was withdrawn. The company only converted its existing biodiesel installation.

5.2.1 Business environment

When it was decided to retrofit, the national government of the company decided to impose taxes on the plant. At this stage, the company was already two years into the retrofit project. Since these taxes were not considered when the new business model was created. The company had to deal with a new variable within its institutional environment. Aside this, when the investment was made around 2012/2013, it was the high point of the economic crisis in Europe. Banks in this country were hesitant to give out new loans since they were already struggling with the collection of the rent of former loans. The company faced difficulties collecting investments from these banks. Even though these variables were creating problems for the company, it perceives its business environment as relatively good now. "*It was hard to convince a bank to finance our project. However, thanks to the fact that it was a good business case we could proceed with the activities. In general, the business climate has been better now compared to that time".* Aside having a good business case and good economic performance, the company also experienced support through RED ll. Within RED ll, special attention is given to waste-to-energy activities and the promotion of biofuels is mostly focussed on second generation biofuels.

Even though the government imposed a tax on biofuels plants, the government also imposed an investment law as stated above to create investments for retrofit projects. This investment law was initiated to give incentives to industries to invest in companies that are producing new products or improving existing facilities.

The company financed 30 percent of the retrofit project through an investment law which consisted partly of tax returns and direct investment. The company did not have a separate R&D budget for the retrofit project meaning they had to apply for budgets within the company. The application of these budgets will follow in using equity or an application for a bank loan by the company. The remaining 70 percent of the retrofit project was financed through a bank loan.

Aside from these issues, the company also had to deal with unused capacity. They have the capacity to scale up, but the company cannot find the markets to sell the extra product. Also, the margin on the products is not high due to the increased price of waste. "*The price of raw materials (waste) have increased, because it is promoted by the EU and more people are now buying this waste. This means that the margin in to so high as you might expect."* It seems that this company is facing issues related to the sourcing of biomass as well as selling products on full capacity.

When the company first operated on waste as well as non-waste products, it was already clear that the company would go into using only waste products. *"The company wanted to have a good corporate image which was turning waste into energy, aside from making money from this business".* This was decided by the owners of the company at the start of their business. Again, corporate image is playing a role in the retrofit decision.

The company invited several clients that were using their end-product when it was decided to do the retrofit investment. The company claims that its clients admit that the quality of the product is very high and superior to other products. However, the company is not seeing this in terms of margins because the prise is the same as other products on the market. "*Unofficially when we talk to each other, our clients admit that our product is of very high quality, it is very clean due to our distillation process. Our product is superior compared to other products on the market, but we are not experiencing higher margins on our product".*

Although the company did not interact with citizens close to its installation, it stated the public reacts positively on their developments. "*We did not have any interaction with the public or citizens close to the installation. However, in general the public reacts very positively on the fact that waste is transformed into biodiesel. Even some people are not aware that we are using a waste product to produce bio oil".*

5.2.2 Networks

The most important network for this company was the EU because it promoted biofuels and therefor created the basis for the business. "*You know your investment and products will be valued in the coming years. This was a good basis for our business".* The company is part of the European Biodiesel Board (EBB) which represents almost all biodiesel producers in the EU. Because most of these biodiesel producers make diesel from fresh oils, the decision to retrofit was not influenced by this network.

The richness of the contact between this company and the EBB is strong, they have two representatives on this board. The head of R&D is a member of the technical board within EBB, another employee is a representative in the general assembly. This means that the company on the one hand advises the board on technical knowledge related to biodiesel specifications, and on the other hand advices the board on general ideas and developments within the biodiesel sector. Aside EBB, the company is active within the European Waste-to-Advanced-Biofuels Association (EWABA). This association represents biofuels producers that produce biofuels from waste materials. Concerning the richness of the interaction with this board the company stated the following: "*within this institution we are quite active about what we believe and sharing our opinion on what would be best for our business. This is sometimes presented to the EU if necessary".*

Aside these boards of biodiesel producers, the company also has partners at the beginning of the supply chain. When the company decided to retrofit it already had an established network of partners that collected used cooking oils. The supply of biomass was stable, since these partners collect around half of the oils that are available in the country.

The company does not share information about retrofitting or innovations to industry members. The only information that is exchanged concern technical issues and general developments of the biodiesel sector. "*We only share information on technical aspects, and we interact within discussions about for example the market developments".* So, although the company interacts in European platforms on biodiesel, it is not keen on sharing information making its interconnectedness with industry members rather weak. Frambach and Schillewaert (2002) state that interconnectedness or network participation can enhance innovation diffusion. However, in this case, innovation is part of the company's key strategy. Therefore, it seems this company adopts innovations because of its own strategy instead of being influenced by others.

5.2.3 Adopter characteristics

The company is connected to a larger mother company which owns 37 percent of the company. The banks knew these companies were related and well established within the sector. For this reason, the company received some credits from the banks. "*We have similar names and up to this year we had a similar trademark. This created a positive image for our company. Although our mother company is not directly connected with us, it was beneficial for our profile".* Aside its image, the company stated it was also healthy at the time it applied for funding which made their application more successful. The image and size of the company was influencing their access to funding, which confirms that size positively influences innovation adoption (Lee and Xia, 2006).

The company claimed it had enough expertise implement the retrofit. The company was involved in the bioenergy sector for several years and was familiar with using waste materials and the production process of biodiesel. Nevertheless, some experience was lacking on this new process. This knowledge was gained through experiments and research within the company's own laboratory. So, even though the company is large, it had to gain additional expertise through experiments.

To the question whether the complexity of the organizational structure influenced the retrofit decision concerning the speed and difficulty of the implementation process, the company stated the following: "*In ten months after preparation we already started implementing so the plans were implemented very fast".* The decision to retrofit was not influenced by the organizational structure although this is suggested by Frambach and Schillewaert (2002).

The retrofit project of this company was in line with its core strategy. "*The idea was to produce biodiesel from waste. This was the idea from the start; the owners of the company envisioned that the company would produce biodiesel from waste".* Even though the head management is not located in the same city as the company, once per month they have a meeting with the company that constructed the plant and discuss the way the company is proceeding. Sometimes the management was pressuring the company to speed up the process to meet deadlines. "*The management is then also involved in viewing if we proceed according to the timesheet. Sometimes we had some pressure to move faster and to follow the plan".* Even though Jeyaraj et al. (2006) and Del Río González (2005) suggested that top management stimulates innovation adoption, this company had its own strategy to innovate and pursued this strategy, without much support from its top management.

On the multiple-choice question, which corporate strategy was important when making the decision to retrofit, the company chose long-term market growth as well as technology leadership: "*The first and the second I would say, however, technology leadership is on top. When the company was established, the vision for the company was to produce high quality biodiesel from waste materials. This vision became reality when the retrofit took place".*

The future orientation of the company focusses on the developments within the transportation sector. Since this sector is slowly developing towards electric mobility, this might affect the company. However, the company stated that for the coming 10 years, till 2029, it will be able to deliver a high-quality product based on waste. The company also has a vision of going into producing biofuels for the aviation sector. "*Aside from retrofitting, we have a dream/vision of producing biofuels for aviation. It is a very big investment and now we are just following what is happening concerning research. If in one point in the future, we find partners for this we might move into bio jet fuel but in the coming years we are sure that biodiesel will still be very relevant".*

In this case, a future orientation and long-term goals to create products from waste materials were important variables that influenced the retrofit decision of this company. The innovations that the company implemented in the last five years concern expanding oil collection activities. The company is for example trying to expand collection to the household level. Aside this, the company wants to expand beyond biofuels by producing products for the chemical sector using its existing plant. In this case, the organizational innovativeness confirms that the company is adopting innovation according to its core strategy. This confirms the positive link between long term goals and a future orientation, and innovation adoption (Kitchell, 1996).

Notable findings

- Due to the promotion of the EU to use waste to produce bioenergy, rising waste prices are negatively affecting the company
- Creating a good corporate image through turning waste into energy was the key strategy and the main motivation of the company to retrofit
- The company perceived the RED II as a supportive policy because it values their products in the coming years
- The company does not share information about retrofitting or innovations to industry members unless it concerns technical issues and general developments within the biodiesel sector
- Instead of hiring external expertise, the company gained lacking expertise on the retrofit project by doing experiments in its own laboratory

5.3 Individual case description: First generation biofuel company

Case description

This company was established around 2009. It started by exploiting the results from research and developments on biofuels of the 10 years prior to establishing the company. The company saw interesting results concerning the replacement of gasoline with biobased fuels. The company is family-owned and had a vision to improve air quality. The goal was to reduce emissions of carbon dioxide by replacing fossil fuel with renewable fuels. At the same time the company was concerned with particulate matter[1], which it wanted to reduce by altering the burning process of materials. For these reasons, the company began to focus more on burning biofuels instead of fossil fuels. Aside improving air quality, the company noticed that people were concerned with oil running out and therefore looked at alternative fuels. The company produces fossil free diesel fuel, gasoline, and jet fuel from food crops. The retrofit project concerns exploring whether an existing biofuel plant that runs on rapeseed oil can be retrofitted to producing bio kerosene which can be blended with 50 percent conventional kerosene. This means the retrofit project is not executed yet but focusses on exploring possibilities to retrofit the biofuel plant.

5.3.1 Business environment

The company required investment to redesign several first-generation biofuel plants to use more sustainable raw materials. Aside this, the company investigated the production of a wider range of biofuels. Besides alternative fuels for ground transportation, alternative fuels for aviation were explored. For this project the company used a 100 percent equity.

The company mentions several opportunities and challenges within its business environment. At first, the company claimed that "*nothing was helpful at the time"* since their product would only be sold when it had competitive prices compared to fossil fuels. The company did a project with a big farmer's cooperative to improve the blending of its rapeseed methyl ester. By increasing the amount of bio component in the standard diesel, the company was able to sell more biofuel. This project shows that the company had to collaborate with other sectors that relate to the bioenergy sector. Policies in related sectors such as the agricultural sector affect the bioenergy sector (Huttunen et al., 2014). Although the business environment was perceived as not helpful, the company did receive support from various national and international programs that focus on the development of alternative aviation fuels.

5.3.2 Networks

The founder of the company is a member of numerous committees. Among others, the company is participating with FlightPath (EU Advanced Biofuels) which stimulates the development of the market for Sustainable Aviation Fuels. Aside this, the company is connected to ARTfuels forum, the EU subcommission on advanced biofuels. The company stated that it is well presented in Brussels through these networks. "*When it comes to being represented in Brussels, I think we are doing a lot of work and we are well represented. When it comes to trading associations, we have a lot of bilateral relation with people in the supply chain such as suppliers and clients".* The type of networks that this company participates in are mostly industry related. More interestingly, most networks are committed to sustainability.

Even though the company states that it has a voice within the EU, it stated that creating these kinds of connections is a time-consuming activity: *these kinds of relations take a lot of time. These meetings, committee meetings, forum meetings, group meetings require a high level of commitment and take a lot of time.*

5.3.3 Adopter characteristics

The company consists of only 25 people, which makes it the smallest of selected companies for case studies. Concerning expertise, the company stated that it did not use any external consultation. "*We have extensive*

[1] Particulate matter is the sum of all solid and liquid particles that are suspended in the air

internal expertise and so did not need to use external consultants". Although Lee and Xia (2006) stat that large organizations are more likely to adopt innovations because they have more financial means and equipped personnel, this does not seem to be the case for this company.

Since the company is relatively small and family owned, the company's top management was involved in the retrofit project. Involvement of top management can stimulate innovation adoption (Jeyaraj et al., 2006; Del Río González, 2005).

Concerning the future of biofuels, the company emphasizes that the industry requires stable long-term policy as well as enough biomass. "*Industry and investors need dependable long-term policy and the future of biofuels depends on securing sufficient raw materials".* Long-term goals and a future orientation stimulate innovation adoption within companies (Kitchell, 1996). In this case, the company states that policy should also create long-term goals and a future orientation.

Notable findings

- Through collaborating with a big farmer's cooperative, the company was able to increase the bio component in the standard diesel
- The company states that participating in networks takes a high level of commitment and a lot of time
- the company suggests that the industry and investors are depended on long-term policy and a secure amount of raw materials

5.4 Individual case description: Biogas producing company

Case description

This company's retrofit project concerns upgrading the technical solution for wastewater treatment of a pulp and paper mill while maintaining its current treatment capacity. Aside from the company and the mill, a biogas plant was built on the site of the mill. The company saw an opportunity to combine two activities of treating water and producing biogas through the breakdown of the pulp mill sludge. The project is still ongoing for evaluation, but the biogas plant is already in operation.

5.4.1 Business environment

The company expressed that ascertaining financial resources for the retrofit project was not difficult. The project was part of a larger investment and was included in an overall ongoing project. The retrofit project was also supported by the EU LIFE program that funds environmental and climate action. The share of the contribution from the LIFE program was significantly larger than the own contribution of the company which financed only around 10 to 20 percent of the total investment. The company financed the pilot case through its own R&D while the LIFE program financed the full-scale project through supporting operational costs, time cover during the demonstration period, and covering costs that were involved with analysing and monitoring of the project. Moreover, the program financed some differentiation costs of the equipment installed. Especially support for the analysis was appreciated by the company in order to create a reference case as well as being able to show the benefits of such a project.

The company was looking into the roadmap of 2050 for biogas in Europe during the execution of this project. There are different perspectives on the project from the three parties that are involved. The company mentions that the pulp and paper mill was very cautious to change its wastewater treatment system because the new technology was relatively new in the sector: "b*ecause they do not have any reference case with similar conditions this raises a lot of question marks".* However, the technology itself was already used for municipal wastewater treatment.

The technology was supposed to be implemented in other plants, but these plants were also not keen on making the transition. The company stated that it had to show the economic and environmental benefits of the project to eventually convince the mill to make the transition. "*What really made the project fly was*

showing the economic and environmental benefits of the project. The main motivation was lowering operational costs that are associated with chemical and electricity usage".

This company did not have difficulty accessing financial funding since their share of the investment was relatively low compared to the share of subsidies by the EU LIFE program. Furthermore, the investment was part of a larger ongoing project. Other mills had to be convinced to do the project, which indicates they were hesitant to invest. In this case, the policy instrument of subsidies was crucial. Not only did it finance the project, but it also significantly lowered investment risks since there was no reference case of a similar project available.

5.4.2 Networks

The company stated that there was no specific network that was influencing the retrofit decision since it was decided upon internally in the company. The company did bring in a member-funded gas association into the project. Aside this, the company was supported by an investment aid program for local and regional projects that reduce emissions. These organizations support in terms of funding, facilitating a better tax system, or direct investment. So, even though Frambach and Schillewaert (2002) state that network participation stimulates innovation adoption, in this case the company made the decision internally.

The company shares information on different levels. The company promotes retrofit concepts to mills or other industries. The information that the company shares comes from an internal reference project team that evaluates all their projects. This team consists of both industry experts and academia. The company states that it is active in terms of information exchange: "*we are quite active in national and international workshops and seminars and so on. This is how we meet the other mills or industries that apply the same concept. We always try to show them the benefit of doing something with that".* In terms of information sharing, the interconnectedness, this company is relatively open about its findings and is active in promoting their concept.

5.4.3 Adopter characteristics

The company counts around 50 employees. The retrofit project team consists of four people of which two work full time on the project. Aside from the employees of the company, some operators from the mill are also involved in the retrofit project. The company did not involve any external expertise and the project came from their own R&D. A large external consultancy firm did not want to be involved due to the lack of a reference case. It seems that, although the company is relatively small, it had enough internal expertise which contradicts findings of Lee and Xia (2006).

Since there were three different parties involved in this retrofit project, this influences the implementation of the retrofit project. "*To have these three actors involved in a project has been, and still is the challenge. We all have different driving forces and different targets to achieve within the same project".* The company had an operational group that was working on the project management of the retrofit. The company also did the research and development side of the retrofit and the analytical work. For this company, the most important aspect of the project was creating a demonstration of a full-scale wastewater treatment system. The pulp and paper mill is responsible for the operation of the wastewater treatment plant. This mill's goal is to gain as much economic savings as soon as possible. The biogas plant feeds on the affiliate of the mill and has the goal of making an efficient integration with the mill to keep costs down.

Concerning the richness of the interaction between the three parties, the company has an interesting view on how the parties interact and perceive the project:

"*The main barrier is the different expectations of the parties involved; the mill, biogas plant, and us. It's like a step-by-step approach to reach the finals. Not everybody starts from the same step. We move from the bottom to the top. The other actors are looking at it from the top, they want to reach targets as soon as possible. In this process, they forget the time that is needed to achieve the project. Especially when, in this*

case, we are talking about biological processes. It's not like something technical where you move a switch and it is working. There is a lot of tuning time needed before we are reaching full operation".

The company states that it is constantly looking out for a common ground between the parties and functions as an intermediary. After this description of the process of the implementation of the retrofit project, the company was asked which party had the larger share of the joint investment of the project: "*I think it is us, (…) our affiliate we own 54 percent of it. From the pulp and paper perspective they are not the one putting money on it. They are more part of the project and take the environmental and economic benefits from it. Everything is linked to the biogas plant; the small part of the retrofitting retains on our budget".*

These descriptions show that various parties look at the retrofit project in a different way. Moreover, it has different meaning within their corporate strategies. According to Frambach and Schillewaert (2002), small companies have a flexible structure that makes them more receptive to innovations compared to large companies. However, in this case, the organizational structure for the company was complex because multiple parties were involved.

The top management of the company is involved through steering group meetings that occur on a quarterly basis. Aside this, the project attracts external parties and the top management is aware of this matter which is a reason for them to be involved in the project. *"(…) these kinds of projects, it draws some external attention towards the companies due to the communication around the project and because it is part of this EU Life program. It draws attention to the development of the project overall. Therefore, the top management is supporting it all".* It seems that also in this company, corporate image is an important factor for top management to be involved.

The company stated that technology leadership was their most important corporate strategy since the project should show a demonstration of R&D concepts. Aside their own corporate strategy, the company also answered the question from the perspective of the mill and the biogas plant: "*for the pulp and paper mill it is short-term profitability because they are the ones that will receive economic and environmental benefits as soon as the project is operational. For the biogas plant it is long-term market growth or financial returns for owners. If we think about the small size of the project of retrofitting it is probably long-term market growth".* The innovations at the mill implemented in the last five years concern general projects by the mill on its operations and reducing costs. Sometimes the mill also uses recycled paper that goes back into the mill. However, this depends on the quality that is demanded by its customers (more recycled paper means more colour in the paper). The company states that the mill is not investing much on these kinds of innovative projects.

So, the company is willing to invest in sustainable innovations and has long-term goals. However, these goals are not in line with the strategy of the partners that they are working with to implement the retrofit project. In this case, having long term goals and a future orientation did not influence the innovation adoption decision that much. What was more important were the economic and environmental benefits.

Notable findings

- Investors for this retrofit were hesitant due to a lack of reference cases.
- The decision to retrofit was made internally without specific influence of any network.
- The company actively shares information about its concepts via workshops and seminars to industry members.
- Although the company is relatively small, no external consultancy firm was involved in the retrofit project.
- Because three parties were involved with the project, creating shared objectives for the retrofit project was difficult.

- The top management of the company was aware of the external attention that the company was given for the retrofit project and participating in an EU LIFE program, which was a reason for them to be involved.
- Having long-term goals and a future orientation that concerns sustainability, did not directly influence the retrofit decision since economic and environmental benefits were more important for crucial partners that were involved.

5.5 Individual case description: Waste processing company

Case description

This waste processing company did a retrofit project on its biomass plant which processes wood waste. The retrofit project concerned a specific boiler (CHP) within this biomass plant. The goal was to improve the boiler so it would be able to operate again for the coming 12 years, till 2029. The incentive for this retrofit project came from a subsidy application. The boiler would be eligible for this subsidy if it would produce electricity and heat. Before the retrofit, the boiler was only able to produce electricity and was therefore not eligible for the subsidy.

5.5.1 Business environment

The incentive for this project was an application to extend a subsidy. The biomass plant was eligible for a subsidy that concerned the supply of sustainable heating in the form of electricity if it could be transformed to also producing heat. Without the subsidy, the company would have closed the whole installation and put it out of use.

Concerning the ascertaining of financial resources, the company claims this is not as easy as it used to be even though it is a big waste processing company. "*The banks are reasonably risk averse. This means that we still have to find some other ways to finance these types of projects. It is not easy to get money out of banks and they have many demands. This goes quite far in my view. We are a fairly large company with a good reputation, but they demand a lot of progress reports and what you have done with the money that you have received. Independent reports must also be created. This is a sustainable project, and you would expect them to be a bit more flexible, but that is not the case".* In this case, the access to financial resources is not difficult because of the technology, rather because it is perceived as a risky investment by banks.

The company was supported by its national government in the form of subsidies. These subsidies were given out to create continuity for sustainable heat and energy to meet national sustainability targets. The company perceives the help of its national government as positive: "i*t is a positive aspect that our government is doing it this way, also in the context of sustainability because it does have a major effect. Although not 100 percent, but it does help".*

The company mentions that related to the BREFs document (EU Best Available Techniques), companies should retrofit more. "*Certainly, in our industry things continue to develop which is also important for the environment with NOX deposition. The related legislation means that you often have to retrofit or adjust something".* Even though it seems that these documents and regulations facilitate innovation in the sector, the company mentions an issue with the BREF. "*The BREF is a very difficult and difficult document and that should be simpler. This is sometimes a book of 700 pages. Companies say that they adhere to this document, but sometimes they do not know what it is about when I mention the BREF. It should be slightly more known among producers of this type of installation. They should also have more influence in this document".* Aside having documents on technical innovations, the company emphasizes that legislation is also important to push the industry. "*Reducing emissions can also be facilitated by legislation, despite the fact that we are often already working on it ourselves".*

So, policy instruments are perceived by this company as being crucial in order to innovate. Furthermore, there is information available about new technologies and innovations in a large document. however, this document is too complex and large that the company finds it difficult to read.

5.5.2 Networks

The company is part of a branch association for waste companies. All the waste incinerators are part of this association. Within this association there are several platforms for certain subjects. For example, there is a platform for incineration technology and residual material. The company also communicates through this association to its government because it feels it has a stronger voice in that way. "*Individually, as a company, you can also lobby but as an association we can bring in something to our government in a collective way".*

Because retrofit projects can be capital intensive, it is important to find the right parties for the job. Aside from parties that do the operational work, the company also looks out for companies that can assess the work that has been done as a verification. The company therefore communicates with the supplier of the installation, as well as parties that helped with the tender. This project was tendered on European level. Several companies were involved in this tender, and one company won. However, communication did not stop after the tender. Together with these and other third parties, the company looked at the retrofit project. This is in line with previous findings that biogas adopters gain information through upstream industry (Gava et al., 2017).

The most important network for this company were parties that were involved in the tender as well as companies that were hired to monitor the installations. These monitor activities can only be done when the installation is off, which it is during maintenance stops every eight months. After monitoring, the company decides what to do next in order to keep the installation operational.

Information about the results of the project is shared through broader platforms. "*This retrofit was a fairly successful, technically as well as financially. We also communicate this to others, but not too much because it costs me too much time. However, sometimes when we are asked for symposia and the like I tell about it".* During meetings with other parties the subject of the conversation is mainly of a technical nature. Less is discussed about the way of doing business. Since the liberalization of the waste sector, the company is experiencing more competition between industry members. "*We used to be competitive colleagues but now we are more competitors, resulting in fewer cases being discussed than in the past.* Depending on the amount of waste materials available on the market, the companies are in competition with each other. *If everyone has something it is good. It has been a fairly competitive market and therefore not much is shared in financial terms (business case)".* So, even though technical issues are discussed, companies are more cautious in sharing information about investments and financial aspects of their projects. Although the company participates in various platforms and associations, the richness or interconnectedness with these actors is less strong since only specific technical information is shared.

Due to the retrofit, the company could extend contracts with its waste timber suppliers. The amount of waste timber available depends on the market: "r*egarding the supply of waste timber, this is fairly stable. Although it works according to market mechanism, we currently have a bit more waste timber available but sometimes this may be a little less. We are also bound to other countries with regard to the supply of biomass".* This statement shows that the company is dependent on other sectors for the supply of biomass.

5.5.3 Adopter characteristics

The company consists of 240 people. The retrofit project team consisted of 10 to 15 people that did not all work full-time on the project. The company hired engineering companies to help them write the project plan. Concerning internal and external expertise, the company was supported by several consulting and engineering companies. The company states it had to hire external expertise since the retrofit project was not part of its core business. "*We are actually a production organization and these types of projects we do 'aside' our business. We do them with a fairly limited number of people internally and therefore require some people from outside depending on what we tender for".* Still, the company states its internal expertise is often underestimated and that companies should encourage the search for internal expertise.

There were several organizations involved in the retrofit project. From the line organization only several people were involved, and from that group not every person worked full-time. Furthermore, the team responsible for maintenance stops was involved. Aside having internal expertise, the company hired external experts as well. Concerning the influence of this organizational structure on the retrofit decision and the implementation of the retrofit, the company states that preparation is essential.

Large companies can have more financial means and expertise to execute innovation projects (Frambach and Schillewaert, 2002). However, even though the company has a substantial number of employees and has a good financial reputation, it still needed to hire external expertise.

The innovations that the company implemented in the last five years concern the upgrading of by-products or waste materials in order to let them flow back into the company. Two examples are given by the company. The first project was the capture of CO2 that is converted into a product that captures acid parts. The company states this innovation is quite unique and that they have won a European innovation prize for it last year. The second project was the working up of ground ashes from the installation. Although these innovations have been set up internally, the company also involves other parties for innovation projects. The company is working on cleaning ground ashes which must be line with sustainability regulations from the national government. For this project the company set up and innovative partner tender. Via this tender companies can come into test innovations and in return receive compensation. The company does this to exchange knowledge that is already present in the country and in Europe. "*We try to show and prove the knowledge that is in the country, or Europe actually".*

On the multiple-choice question which corporate strategy was important when making the decision to retrofit, the company chose financial returns for owners. The shareholders of this company are mainly municipalities aside of some other parties. Although the company stated the financial returns are the most important, it stated that the continuity of the company is the first goal. As said before, when the installation was not retrofitted, this would have had consequences for the company in terms of lost jobs. The company states that the retrofit is a financial as well as a sustainability project. "*It is financially a motivator and it is a motivator to be an initiator in the field of sustainability. This type of business is the "backbone" of our organization and therefore also important in the revenue model".* The company states that retrofit projects are very important for the continuity of the company. "*Ensuring continuity in the company and thereby eliminating certain business risks is important. As far as licenses and contracts are concerned, everything is interconnected, so it is good to sometimes take a larger approach to matters besides regular maintenance".*

The future orientation of the company concerns two incineration plants that were building the 90s with the best techniques from that time. The company is looking into converting a large smoke box cleaning installation. This will be a capital intense project since the company states that in terms of investment the boiler was 1/3 part and the installation 2/3. The company states it has retrofit around 30 percent of its operations through the boiler project, if they continue with all the boilers they will be on 40 percent. The company also aspires to do more with the working up of residues. "*In the context of the circular economy, we are also looking at what we can still do with certain residues; whether we could still make products from this".*

So, the innovations are part of the company's key strategy to maintain continuity of the company. Sustainability and financial returns are important drivers and the innovations show that the company is actively adopting innovations. This is consistent with earlier findings of Kitchell (1995) and Frambach and Schillewaert (2002) that a future orientation and having innovations as a key strategy within the company stimulates innovation adoption.

The top management of this company "*quite closely involved (…) this project was quite an important project for our company.* One board member is always part of a steering group that is then part of the project organization team. Through this steering group the retrofit team and board members have meetings on regularly basis.

Notable findings

- Even though the company is large, it perceived accessing financial resources as difficult since banks were hesitant to invest without various progress reports.
- Legislation is perceived by this company as a driver for the industry to reduce emissions.
- Information about new innovations and technologies is available through BREF (EU Best Available Techniques) but this document is perceived by this company as too complex and too big which makes it difficult to read.
- Through joining associations and platforms with industry members, the company feels it has a bigger voice towards its government.
- The company only shares technical aspects of the retrofit with others, the business side of the retrofit is not discussed.
- Even though the company has a substantial number of employees and has a good financial reputation, it still needed to hire external expertise because the retrofit was not part of its core business.
- Innovation and a future orientation are key strategies within this company and top management is personally involved and part of the project team and steering groups.

5.6 Individual case description: Power company

Case description

The scope of this project was to convert a coal fired CHP plant to use wood pellets. The retrofit project concerned a modification of logistics and a mill installation.

5.6.1 Business environment

The company partnered with the municipal district heating distributor and split the investment as well as the revenue of the retrofit. Revenue was mainly coming from a tax reduction which is mentioned in the following paragraph. The company could still use its existing installation and only change its logistics and the burners of the firing system. Consequently, the investment was low compared to other options such as building a new plant. For the project no banks or other financial resources were used. The company states that the significant size of the company had a positive impact on accessing financial resources: "b*ecause of the size of the company and because it was a split investment it was easy. Of course, we had to show a certain revenue but the amount for the investment was available within the company".* This is in line with earlier findings of Lee and Xia (2006) and Frambach and Schillewaert (2002).

The company states that its political climate was in favour for this project. "*There was political support to phase out coal and demand for green energy solutions. The support was shown through a lower tax on CO2 of biofuel (wood pellets or wood chips) compared to that of coal".* Through this lower tax the company was able to create a business model with its customers and the municipal district heating distributor.

The company is seeing the development of the (internationally) standardization of wood pellets. The company emphasizes that the purchasing and quality assurance of wood pellets is crucial. Still, the market is young, and the quality standards are under development. The company itself is also involved in the standardization of wood pellets, to assure they are CO2 neutral. They do this by making sure that they have certified suppliers and that replanting of harvest wood is happening. To get wood pellets standardizes, the sector must work with wood suppliers, which means working with another sector.

Consumers seemed to play a big role in the decision to retrofit for this company. It even stated that it was one of the main motivators for the conversion. "*One of the main motivators for converting is that the end user of district heat, the customer, they want greener products. To be sure that we can deliver greener products we have to convert our power plants".* This shows that the opinion of the customers had the most impact on the company's decision to retrofit.

5.6.2 Networks

The company did not have a strong relation with other parties, only a few. The retrofit project was perceived as a frontrunner and therefore the company could not share technical knowledge with other parties. The company did consider explosion experts an important stakeholder since using biofuel, and especially wood pellets, results in higher explosion risks.

The most important network for this company were its stakeholders which are also its customers, the municipal district heating distributors. Aside this, the technical consultants within the company were crucial to make technical solutions possible. The company had intense interaction with the municipal district heating distributors: "*there was intense negotiation for half a year before the final investment decision, so it was often.* Aside this, the company had intense contact with its consultants because of negotiates about the contracts that were set up with them: "w*ith them we did the technical development of the project so on weekly basis we had meetings and exchanged ideas and concepts".* It seems that for this company, the richness of the interaction with its networks did not go beyond technical and financial issues.

Information about the conversion came from case examples or pilot plants of other companies in Europe. Also, the company gained most of its information from its own consultants and developments. Due to the standardization of wood pellets, the company got to know the different consumers of biomass and through that, the different users of biomass. Through this development the company gained information about other retrofit cases. The main introduction to retrofitting came from visiting retrofitting cases or conversions at other plants.

The company did not engage with a platform to exchange ideas since it owns most of the power plants in the country. Aside gaining information, the company is also willing to share information. This occurs through contractors that sell their conversion expertise that they gained by the retrofitting project. The company is selling this knowledge to retrofit other power plants and shares information on its website to potentially help other plant owners that are looking into retrofitting.

5.6.3 Adopter characteristics

At the time of the retrofit the company counted between the 4000 and 5000 employees. From this number around 800 are involved in CHP operation, EPC (Engineering, Procurement and Construction), and development projects. For this specific case around 20 employees were involved. The company stated that it did not have enough internal expertise to do the retrofit project. Therefore, they hired experts from consultancy companies. The main reason for this was the small full-time staff and that sometimes external competences are necessary such as design or risk of explosion. So, even though the company has many employees and is a large company, it required external expertise.

Although the company sometimes hires external consultants, it has worked on EPC projects for many years. The company has a separate EPC organization within the line organization. The company states that the project management group is strong and can execute these projects.

The top management of the company was very engaged in the retrofit project. It had a board member as a chairman of the steering committee of the project. Aside from this retrofit project, the company was involved in three more retrofits from fossil fuel (coal and gas) to biomass at the same time. "*The top management had a very close eye on the projects. In fact, one of the board members of the CHP division (that was responsible for all the CHP projects), was chairman of this retrofit project. They were very engaged".*

The future orientation of the company is focussed on continuing operations with biomass. The company already converted several power plants and is planning on closing a plant running on fossil fuel within a few years. The retrofit of this plant was cancelled after the company could not come to a decision with the local district heating company. After the closing of this plant, the company will be a 100 percent running on biomass.

The innovations that the company implemented in the last five years concern extending offshore wind power and the development of windfarms. Aside this, the company is involved in reusing waste and is developing the technology to do so.

The involvement of the top management and the innovative behaviour that is in line with the company's future strategy is in line with earlier findings of Kitchell (1995), Jeyaraj, et al. (2006), Del Río González (2005) and Frambach and Schillewaert (2002) that stat that top management support and a future orientation stimulate innovation adoption. However, on the multiple-choice question which corporate strategy was important when making the decision to retrofit, the company chose financial returns for owners. This makes it difficult to say whether the company would be so ambitious when the retrofit involved substantial costs.

Notable findings

- Because the costs of the retrofit were relatively low and the company is large, accessing financial resources was not perceived as difficult.
- The main driver of the company to do the retrofit were consumers demanding greener products.
- The information about the retrofit came from case examples of other companies. After the retrofit, the company is looking into selling its expertise and does not share any information about its retrofit project.

5.7 Individual case description: Petrol producing company

Case description

This retrofit project concerned the co-processing of used cooking oils. The main goal for the retrofit project was an energy transition within the group of companies that this company is part of. The company is involved in next generation biofuels, research, establishing pilot plants, and technologies such as electro mobility or electrical vehicles. One of the core aspects of this company is to invest in renewable energies with the main aim to reduce its carbon footprint.

5.7.1 Business environment

Accessing financial resources was perceived as easy for the company since it is part of a larger group of companies that have good opportunities for funding in general. This group of companies has a good position on the stock market as well as a high turnover. The project was completely funded by their own capabilities. In case the company does require funding, it borrows as a group to get access to the biggest funding institutions worldwide or EU based such as EBRD or EIB. In this case, the size of the company and the financial means that come with its size, supported the access to financial resources which is in line with findings of Lee and Xia (2006) and Frambach and Schillewaert (2002).

The company states that it was pushed by the EU and its national government that formed legislations to invest in renewables and reduce the carbon footprint. The petrol that this company produces is also sold for normal market prices, even though it can be partially biobased. The company states that since the economic crisis, the customers of petrol have only been concerned with the costs of energy products and nobody is pushing for higher percentages of biofuels.

The company emphasizes that concerning funding, the support of policy makers in the EU should be on technology rather than business: "*the EU is asking us to move to 2nd generation biofuels but the existing technology is not enough to produce these fuels. It is nice to have ambitious targets, but the issue is not money but technology in our sector. The EU should fund more R&D and support academics and research because we are losing it compared to the US and China".*

5.7.2 Networks

Since the company had a strategical approach, it was not influenced by other networks. However, the company expresses it is willing to work with any network related to retrofitting.

Aside from information that was already known within the company, it received information from other petroleum companies, peers, and technology suppliers. For the company, these kinds of interactions are purely on commercial basis. "*If we interact with these contacts, we discuss mainly technical and economic issues and other things such as planning. We had some initial meetings to gather information, but this is not a standard procedure, there are no frequent meetings with other companies. We are dealing with retrofitting on a project-based approach".*

So, the company was not influenced by any network when making the decision to retrofit. Also, the interconnectedness, or richness, of the contact with these networks is purely on commercial basis.

5.7.3 Adopter characteristics

The group of companies that this company is part of has over 4000 employees. The projects called for different types and amounts of employees. The R&D department defines which and how many employees are necessary from the different departments of the company and gets them involved. In this R&D department three people that are in the upper level of management oversee these kinds of projects.

Concerning expertise, the company stated it hired external consultants because sometimes costs of hiring internal staff are higher than outsourcing of the work. The reason for hiring consultants is mainly related to costs and expertise. "*We are not doing all of the transition ourselves, and sometimes it costs too much to do it by ourselves only. Aside from this financial issue it is also an issue of expertise; we do not know everything. We hire usually top-level consultant companies and sometimes very specialized consultants to do projects with us. The whole issue is controlled and managed by our own team".* So, even though the company is very large, it had to hire external expertise which is not in line with earlier findings of Lee and Xia (2006) and Frambach and Schillewaert (2002).

Even though the company is now at a stage where sustainability belongs to its core objectives, this was not always incorporate in their corporate culture before. The company stated that sometimes it experienced negative attitudes when implementing something new because employees have been doing the same business for over 20 years. For this reason, the company started the cultural personnel and cultural transformation that is mentioned above. After the company invested time and education in the attitude of its employees, innovation was accepted. "*Everything new you have to implement, an idea or a facility, is a difficult action and especially for big corporations. So, aside from the economic and technology side of the issue (investing in renewables), we are also investing in the culture of the company and its personnel".* Dealing with this managerial issue is remarkable and has not been mentioned in any other case study.

Within the company there is now strong support for the energy transition. The CEO and deputy CEO are focussed on this subject and annual or semi-annual reports contain information on the actions taken to lower the carbon footprint. The company stated that its company strategy is in line with RED II and that it is supporting action against climate change:

"*For us it is a one-way approach; you cannot emit unless you take some surplus action regarding this. We have some targets with numbers which we have to fulfil. On the other hand, we have our social responsibility program and our approach to the customers. We have to fulfil all the carbon goals regarding our corporate strategy. We, as well as other petroleum companies, are supporting actions against climate change. It is part of our strategy to participate in this energy transition. It is not only an obligatory scheme, but also part of our strategy and philosophy on how the world is moving".*

Although the company is influenced by RED II and the accompanying regulations, it also has its own corporate strategy and philosophy related to environmental issues. The innovations that the company implemented in the last five years focus on the energy transition within the company, a digital transformation, and a personnel cultural transformation. The energy transition includes efforts to cut gas and steam losses and to be more efficient. Aside this, the company is working on digitalization of its operations to collect data in a more efficient way. The cultural transformation is further discussed in the

paragraph on corporate culture. This innovative behaviour is part of the key strategy of the company to make an energy transition. Even on the multiple-choice question which corporate strategy was important when making the decision to retrofit, the company chose long-term market growth. Having innovation as a key part of the corporate strategy stimulates innovation adoption (Frambach and Schillewaert, 2002).

The future orientation of the company is focussed on bio retrofitting. The company expresses it is facing problems with a stable supply of biomass. "*The problem is the access to biomass. The biomass quest is crucial to us; if you do not have a stable source of biomass, you cannot easily cover a significant amount of your energy needs. Even today most of our energy need is covered by conventional energy sources".* A lack of biomass is even be the most important reason for this company for not intending to retrofit in the future. For this reason, it is important for this company to streamline the supply of biomass with their demand, which requires working with other sectors.

Notable findings

- The company states that EU policy makers should be more supportive concerning technology issues since existing technology is not enough to produce second generation biofuels.
- The contact with other networks is purely on a commercial basis.
- Even though the company counts over 4000 employees, specialized consultants were hired to do the retrofit project due to higher costs of internal personnel and a lack of specific expertise.
- The company had to invest in its corporate culture to get employees enthusiastic about the changes caused by investing in renewables.

6. Analysis and discussion

In this chapter the empirical results are analysed and discussed using a cross-case analysis. The paragraphs correspond with the hypothesis that were proposed. Furthermore, the analysis will be done following the themes and variables that have been used throughout this thesis.

6.1 Hypothesis 1

As mentioned in paragraph 2.3.1 of the literate study, innovation adoption is influenced by the business environment in several ways. Financing innovations and accessing financial resources seemed to be a big issue within the bioenergy sector (Rösch and Kaltschmitt, 1999). Aside this, policy instruments had different effects on the development of the bioenergy sector in European countries (Thornley and Cooper, 2008; Van der Veen and Kasmire, 2015). Furthermore, policies in related industries seemed to affect the bioenergy sector (Huttunen et al., 2014). Finally, the public opinion can negatively influence the development of the bioenergy sector (Radics et al., 2016; Rösch and Kaltschmitt, 1999). Related to the business environment, the following hypothesis was formed:

Hypothesis 1: The uptake of retrofitting will be higher in geographical areas (e.g. countries or provinces) with a more benign business environment (R&D subsidies, investment subsidies, securities/pledges).

In this thesis several variables were researched under the theme of 'business environment'. The effect of the access to financial resources, policy instruments, polices in related industries, and pressure from public opinion on innovation adoption were researched.

The companies that were selected as case studies only represented four European countries which makes conclusions about geographical areas not generalizable to a certain extent. However, the effect access to financial resources, policy instruments, policies in related industries, and the public opinion on the retrofit decision can be discussed.

Companies are both influenced by policy instruments and market conditions. Also, market conditions can change due to price-influencing policy instruments. What is interesting is the effect of both these variables on the companies.

The main issue for companies is that policy instruments and the market determine the availability of biomass. 6 out of 7 companies raised issues with biomass availability. One company mentioned that depending on the amount of waste materials available on the market, the companies are in competition with each other. Furthermore, a different company stated that due to this kind of competition, the price of waste material was rising. Another company mentioned that a lack of biomass is the most important reason for not intending to retrofit in the future. Finally, a company raised the issue of quality assurance of wood pellets since this market is still young and developing. It seems that some companies cannot do business without certain assurances concerning the availability and quality of biomass. The need for biomass connects the bioenergy industry to other industries such as the agricultural sector, the waste sector, forestry, and even the hospitality industry. As Huttunen et al. (2014) mention, it is important that these sectors are coherent in order to trigger the transition to bioenergy.

It is difficult to say which policy instrument is the most successful in developing the bioenergy sector. Just like Thornley and Cooper (2008), this research also found mixed effects of policy instruments on companies within the EU. Still, all companies were influenced one way or another by policy instruments in order to create business models for their retrofit projects. 3 out of 7 companies even stated that without help of certain policy instruments they would not be able to create a finically stable business from their retrofit project or had to refrain from a retrofit project. Some companies were supported by legislation that increased the bio component within diesel. Because of this, the companies could sell more products. Other companies gained financial benefits from retrofitting through higher taxes on fossil fuels compared to

biofuels. Since the market for bioenergy is still developing, these policy instruments are important conditions for companies to invest in retrofit projects.

Even when companies are supported by price-influencing policy instruments to create financial stable business models, some companies are still hesitant to invest. One company was cautious in investing in a retrofit project even when most of the investment was coming from another company and subsidies. The most important reason for refraining the investment was the lack of a reference case. This example shows how cautious companies can be when they decide to invest in retrofit projects.

Due to the risks involved with investing in retrofit projects, several companies call for long-term policy programs. Companies express that the attention to their new business models positively affects because they know that their products are valued in the future. Therefore, almost all companies experience support by the RED II and are following developments within European legislation closely.

Van der Veen and Kasmire (2015) state that price-influencing policy stimulates innovation adoption. For some companies, these policy instruments made the difference in creating a financial stable business model. However, there can be a rebound effect of policy instruments on the prices of available biomass and waste materials. Price fluctuations can make companies more hesitant to retrofit, especially since several companies called for stable long-term policy programs.

Most of the companies have used their own equity in combination with a bank loan or subsidy to finance their retrofit project. One company pointed out that for some company's money is not the issue within the sector but rather the technology. Therefore, one company emphasized that the EU should financially support R&D for companies.

The size of companies seemed to have mixed effects on their access to financial resources. 3 out of 7 companies emphasized that being a large company or being part of a group of companies influenced their access to financial resources in a positive way. However, one company claimed that without a subsidy the retrofitted facility would have been closed. Another company stated that due to a tax, one of the two planned retrofit projects was cancelled. Some companies are depended on a benign business environment, while others do not face difficulties accessing funding. There is also not a clear link between the size of the companies and their dependency on funding. Two large companies mentioned they were depended on funding even though they were big companies. This contradicts previous findings of Frambach and Schillewaert (2002) and Lee and Xia (2006) that state that large companies have more financial means and are therefore more likely to innovate.

So, part of Hypothesis 1 concerning that the uptake of retrofitting will be higher with a more benign business environment can be confirmed for the studied companies. However, nothing can be concluded about the business environment of different geographical areas.

6.2 Hypothesis 2

Several reports in paragraph 2.3.1 have shown the influence of networks on innovation adoption. The interconnectedness or network participation, which can be defined as the frequency and richness of interaction, influence innovation adoption (Frambach and Schillewaert, 2002). Related to networks, the following hypothesis was formed:

Hypothesis 2: Strong links with other energy companies or consultants with retrofitting experience in your network has a positive effect on the uptake of retrofitting.

Concerning the frequency of meetings, 3 out of 7 companies stated that their connection for the exchange of information with other companies in their industry were relatively strong. One company even stated it was very strong. 2 out of 7 companies perceived the connection as neither strong nor weak. One company stated it did not get influenced by any network when making the retrofit decision. Over half of the companies, 4 out of 7, mentioned that they are part of industry platforms that are connected to the EU.

Concerning the frequency of the contact, 2 out of 7 companies meet on monthly basis, 2 out of 7 companies meet once to twice a year, and 2 out of 7 companies meet less than once a year. One company stated it did not engage in any network when making the retrofit decision. So, the companies engage with networks before, during, and after the retrofit implementation. Even though companies do not often visit each other face to face, participating in networks stimulates the uptake of retrofitting.

Concerning the sources of information, 6 out of 7 companies got their first information on retrofit through peers and/or colleagues in their professional network. 2 out of 7 companies got their first information from symposiums and/or conferences. Other companies got their first information about retrofitting through the internet, books/magazines, industry associations, and study visits. So, when it comes to gaining information about retrofitting, companies consult their peers and/or colleagues in their professional network.

Companies stated they share information through conferences, energy journals, discussions within platforms that are mentioned above, international workshops, seminars, symposia, and presentations. This shows that a diverse set of platforms is used to share information. An interesting aspect is that 2 out of 7 companies mention that this is a time-consuming activity and that sometimes they lack time to interact with their networks.

Gava et al. (2017) mention that upstream industry and self-accessible information resources are important for innovation adoption. However, this research shows that companies often contact their networks for information about retrofitting.

Aside from the frequency of interaction and the sources of information, the richness of the interaction can influence innovation adoption. Companies express that they share information about operations, experiences, technical issues, and general developments in the sector such as market developments. 2 out of 7 companies state they do not discuss any information about retrofitting to others. One of these companies even gained information through study visits and is now looking into selling their own expertise they gained through their own retrofit project. Also, companies express that they are hesitant to share information about their investments, financial aspects, and the way they do business meaning how they created a financial stable business model from the retrofit project.

So, Hypothesis 2, Strong links with other energy companies or consultants with retrofitting experience in your network has a positive effect on the uptake of retrofitting, can be confirmed for the studied companies.

6.3 Hypothesis 3

As mentioned in paragraph 2.3.3 of the literature review, several adopter characteristics influence innovation adoption. Size seems to have mixed effects on innovation adoption (Lee and Xia 2006; Germain 1996; Frambach and Schillewaert, 2002). The organizational structure of companies can also influence innovation adoption (Frambach and Schillewaert, 2002). In this thesis the definition of organizational innovativeness and strategic posture of Frambach and Schillewaert (2002) included having long term goals and a future orientation, which are two variables mentioned by Kitchell (1995). Aside these two variables, top management support, a variable that is mentioned Jeyaraj, et al. (2006) and Del Río González (2005), was also added to the definition of organizational innovativeness or strategic posture of Frambach and Schillewaert (2002).

Aside adopter characteristics, the public opinion can influence innovation adoption in a negative way (Rösch and Kaltschmitt, 1999). Furthermore, the public worries about several issues related to bioenergy (Radics, et al. (2016)

Related to these variables the following hypothesis was formed:

Hypothesis 3: Companies with an integral sustainability orientation and strategy, and companies with a customer base of sustainable companies are more inclined to uptake retrofitting.

This hypothesis consists of two parts. The first part is the influence of an integral sustainability orientation and strategy on the uptake of retrofitting. The second part is the influence of the customer base of a company on the uptake of retrofitting.

By asking companies if they could mention three innovations that they have implemented in the last five years, the innovative behaviour can be researched. Also, the innovations that the company has implemented can be compared to the long-term goals of the company and its future orientation in order to see if innovation is part of their key strategy.

3 out of 7 companies mention having implemented innovations that relate to a sustainable energy transition such as upgrading by-products or cutting gas and steam losses. Some companies were eager to talk about sustainable innovations that they had implemented in the past years, while others were working on reducing costs and the modernization of the installations. Modernization process included digitalization of operations and improving constructions. It is interesting to see whether companies with long term goals and a future orientation that relate to sustainability, implemented sustainable innovations in the last years.

Over half of the companies is taking actions related to sustainability. 4 out of 7 companies stated the retrofitting was a follow-up step according to their company's core strategy. However, only 2 of these companies stated that they implemented sustainability related innovations in the last 5 years. 4 out of 7 companies is currently involved in sustainability programs. Moreover, 4 out of 7 companies has strategic sustainability goals with specific emission targets. Interestingly, 2 of these companies that stated that they have strategic sustainability goals concerning emissions did not implement innovations in the last five years that relate to sustainability. These findings suggest that although companies are taking actions concerning sustainability, the innovations that they implemented do not necessarily also concern sustainability. A reason for this could be that these innovations are part of another corporate strategy such as reducing operational costs. However, the fact remains that not every company with a sustainability orientation is implementing sustainable innovations.

Another interesting finding is that 3 out of 7 companies intend to retrofit in the future. Some arguments for doing so were reducing emissions, paying CO2 taxes, reducing risks, because it is a good technical solution, it provides continuity for the company, and it provides positive outcomes. Although some of these arguments relate to sustainability, most of them do not. The companies were also asked to mention the most important argument to get involved in retrofitting. Here companies mention arguments such as managing CO2 emissions, fuel cost optimization, emission reduction, lower capital investment than building a separate unit, competitive advantage, clean energy production, risk mitigation, the end user wanted a CO2 neutral product, and no need for overall new solutions/equipment. Even here some arguments are related to sustainability and some do not.

On the multiple-choice question which corporate strategy was important when making the decision to retrofit 3 out of 7 companies answered financial returns for owners. 2 out of 7 companies stated long-term market growth was important. 2 out of 7 companies stated technology leadership was important. None of the companies answered that short-term profitability was important.

There are mixed outcomes when comparing the main arguments to retrofit in the future and the corporate strategy that was perceived as important by the companies. Some companies implemented sustainable innovations because it saved costs, which is not necessarily a sustainable goal, but which has positive impacts on the environmental performance of the company. For some companies, being more sustainable is a key strategy and innovations related to sustainability are implemented.

All the companies stated that their top management was involved in the retrofit project. However, there was a difference in the way and how much the top management was or still is involved in these projects. At some companies the top management is supporting from a distant, meaning that they are involved from time to time but are not personally working on the retrofit project. At 3 out of 7 companies a board member

was a member or chairman of a steering group of the retrofit project. This means that they were or are personally involved in the project. Interestingly, at these three companies the retrofit was part of their core corporate strategy. It seems as if top management support stimulates the adoption of sustainable innovations as found by Jeyaraj et al. (2006) and Del Río González (2005).

4 out of 7 companies expressed that investing in renewables positively affects their corporate image. Although companies genuinely know that investing in renewables attracts positive attention, it did not influence their retrofit decision that much. Only one company expressed that investing in renewables was part of the core strategy of the company and that it strived to have a good corporate image through these investments. So, public opinion is not affecting the retrofit decision of companies that much rather they follow the demands of their customers. Aside this, most of the companies did not interact with any citizens living close to their installation. Del Río González (2005) also found that improving corporate image was an important driver for companies within the pulp and paper industry to adopt clean technologies. Further research should be directed at the link between corporate strategy, corporate image, and how active these companies are in implementing sustainable innovations. Since this study provided mixed results on the connection between these variables, it would be interesting to see what holds companies back to invest in renewables even when there is a will from within the company to become more sustainable. Even the effect of long-term goals and future orientation as studied by Kitchell (1996) do not immediately influence a company invest in innovations. Sometimes investing in a retrofitting is even part of another strategic goal that does not even relate to sustainability but rather cost reductions.

As said above, companies mention that investing in renewables positively affects their corporate image. Some companies actively involve their customers in these investments. For example, for biodiesel produces the customers can demand how pure they would like the diesel to be and this has consequences for the production process. One company expressed that the most important reason to retrofit was that their customers demanded cleaner energy. Overall the companies care about their customers and sometimes involve them in the developments towards sustainability within the company. However, a direct link between customers demanding cleaner energy and the decision of the company to retrofit was only found for one company. There are clearly other factors that companies consider when making the retrofit decision.

So, not all the companies that had a sustainability orientation also actively implemented sustainable innovations. Aside this, several companies that had a sustainability orientation state that financial returns for owners is their most important corporate strategy. Due to these results, it is difficult to say whether a sustainability orientation stimulates the adoption of sustainable innovations. Aside this, the role of the top management is very important for the acceptance of retrofit proposals. In all companies the top management was involved in some way with the retrofit project. Concerning the influence of the customers base of companies, only one direct link found between the demands of the customer base and the retrofit decision of a company.

So, part 1 of hypothesis 3, companies with an integral sustainability orientation and strategy are more inclined to uptake retrofitting is rejected for the studied companies. Part 2 of hypothesis 6, companies with a customer base of sustainable companies are more inclined to uptake retrofitting, is also rejected. Still, promising results were found between top management support and innovation adoption.

6.4 Hypothesis 4

As mentioned in the literature, there are mixed findings on the effect of the size of companies on innovation adoption. Some studies state that large companies have more equipped personnel and capital which stimulates innovation adoption (Frambach and Schillewaert, 2002; Lee and Xia, 2006). However, some studies state that small organizations have a more flexible organizational structure which stimulates innovation adoption (Frambach and Schillewaert, 2002). Consequently, this thesis researched both the

effect of size and organizational structure on innovation adoption. Related to these variables the following hypothesis was formed:

Hypothesis 4: Companies with high turnover and equipped personnel that are familiar with retrofitting are more likely to uptake retrofitting.

This hypothesis consists of two parts. The first part is the influence of high turnover on the uptake of retrofitting. The second part is the influence of equipped personnel that is familiar with retrofitting on the uptake of retrofitting.

Turnover did not influence the retrofit decision of companies that much. Only one company mentioned that the significant turnover of 10 billion euros contributed to accessing funds for the retrofit project. However, this was after the retrofit decision was made. Usually, when an employee and/or R&D department gets aware of retrofitting, it sends a proposal to ask for approval from the higher management within the company. When there is enough funding, the project is approved. The turnover of a company then does not immediately influence the retrofit decision. Aside this, as mentioned above, a large size of a company has positive as well as negative aspects. Some companies stated that because of their significant size and turnover the ascertaining of funds was easy. However, one company missed out on a specific subsidy because its output was too big.

Concerning equipped personnel, only one company was advised by an industry specific consultant with retrofitting experience. Also, 3 out of 7 companies stated that their employees have experience with retrofitting and that they did not receive training. Only one company let their employees follow training/courses regarding retrofitting because they did not have experience with it. Still, 3 out of 7 companies stated that their employees did not have experience with retrofitting. Moreover, five companies did not have a specialized energy efficiency manager within the management team. So, not all companies had enough internal expertise when they decided to retrofit.

4 out of 7 companies hired external experts to help with the retrofit project. These experts were consultants, engineers, and researchers. All these companies stated they required these external experts because there was/is a lack of expertise within the company. Two companies expressed that they have a limited number of internal experts. This is interesting since one of these companies has over 4000 employees, and the other 240. In total 3 companies with more than 4000 employees had to hire external experts. This suggests that large companies do not immediately have equipped personal, which is contracting Frambach and Schillewaert (2002) and Lee and Xia (2006).

One company hired external expertise because the retrofit did not concern their core business, leaving them with a lack of expertise. Another company stated that its internal personnel sometimes costs more than hiring an external expert. So, most of the companies required external experts to help with the retrofit. Nevertheless, all the companies are executing or are finished with retrofit projects. One company also stated that it had a lack of internal expertise but gained more knowledge through research and tests at their own R&D department. This example shows that although the company did not have enough expertise, this did not influence the retrofit decision.

The complexity of the corporate structure did not affect the retrofit decision of any company. The speed and difficulty of implementing the retrofit rather depends on the costs of the retrofit project. Companies mention that when the cost of the retrofit project are low, it is easier to get a green light from higher management to proceed with the retrofit project. Aside the costs of the retrofit, the financial condition of the company influences whether the retrofit project receives a green light.

The turnover of companies does not directly influence the retrofit decision. However, it does significantly influence the access to financial resources to fund the retrofit project. This means that indirectly the turnover of a company might influence the retrofit decision. Since this thesis studied companies who have already retrofitted, further research is required to study the direct link between turnover and (potential)

retrofitting. Concerning equipped personnel, more than half of the companies had to hire external expertise to do the retrofit project. Still, this did not prevent the companies from doing a retrofit project. When it is decided to retrofit, usually companies seek which and how many experts are needed to do the job. This means that a direct link between internal equipped personnel is not proven, but both internal and external expertise are important for the implementation of retrofit projects.

So, part 1 of Hypothesis 4, companies with a high turnover are more likely to uptake retrofitting is rejected for the studied companies. Part 2 of Hypothesis 4, companies with equipped personnel that are familiar with retrofitting are more likely to uptake retrofitting, is also rejected.

7. Conclusion and recommendations

In this final chapter the analysis of the empirical results will be concluded and recommendations for (EU) policy makers will be formed. First, the conclusions of the research questions are presented in paragraph 7.1. Then, the limitations of this research are described in paragraph 7.2. Finally, the suggestions for further research are presented in paragraph 7.3.

7.1 Conclusions of research questions

The central research question of this thesis was:

What variables of innovation adoption determine the uptake of retrofitting within the bioenergy sector in Europe?

Within the bioenergy sector in Europe, several variables stimulate the uptake of retrofitting. The uptake of retrofitting was referred to in this thesis as the retrofit decision or adoption decision.

On the system level, climate change provided an incentive for national and international governments and institutions to create more ambitious sustainability goals. These sustainability goals resulted in rules and regulations that influenced innovation adoption within the bioenergy sector.

On the network level, a distinction was made between variables within the business environment of bioenergy companies, and the social networks in which bioenergy companies participate (or not). Within the business environment, access to financial resources influenced innovation adoption. Even companies that were large and supposed to have more financial means and expertise compared to small companies, were facing difficulties with accessing funding for their retrofit projects. For this reason, policy instruments were developed to support the bioenergy sector. Policy instruments played a crucial role in all the retrofit cases that were studied in this thesis. These instruments stimulate balanced competition between the bioenergy and fossil fuel market and help to creates value for bioenergy products. Policies in related industries such as the agricultural sector or forestry were also very important for bioenergy companies because they influence the biomass market. All the companies studied in this thesis were concerned with the availability and quality of biomass. Therefore, cooperation between these sectors and the bioenergy sector is necessary to maintain enough biomass in the future. Finally, public opinion did not seem to influence the innovation adoption decision of bioenergy companies that were studied in this research.

The networks that bioenergy companies participate in are influencing their innovation adoption decisions in several ways. First, bioenergy companies consult other companies about their previous retrofit projects to gain knowledge about retrofitting before undertaking their own projects. Second, companies feel they have a stronger voice to address problems to their governments and within the EU. Finally, an interesting finding was that companies share specific information about their own retrofit projects which mostly concerns technical aspects. Creating a financial business model from the retrofit project or other strategic business aspects are not discussed with others.

On the agent level, several adopter characteristics were supposed to influence innovation adoption. By doing a literature study it was found that size, organizational structure, and organizational innovativeness or strategic posture were influencing innovation adoption. The size of companies did not seem to influence their financial means or expertise of companies to do retrofit projects and therefore did not influence their innovation adoption decision. Aside this, organizational structure did not influence innovation adoption. Having long term goals, a future orientation, and having innovation as a key strategy did not influence innovation adoption for the studied companies. Only the support of top management seemed to stimulate the retrofit decision. corporate image was a variable that was found to also influence innovation adoption within the bioenergy sector. So, on the agent level only organizational innovativeness or strategic posture concerning top management support and corporate image influenced innovation adoption.

The four research questions that contributed to answering the central research question will form the basis of the next paragraphs.

1. According to the literature, how is the phenomenon of innovation adoption described and defined, and what are the main variables that stimulate innovation adoption?

According to the literature, innovation adoption is defined mostly as the decision of an organization or an individual to use an innovation whereby an innovation is defined as something that is perceived as 'new'. Innovation adoption is described as a process that consists of different phases which can occur on several levels. On these different levels and during these different phases, innovation adoption is influenced by different variables. This shows that innovation adoption is a complicated process that can differ from time to time and within different industries or even companies.

The main variables that influence innovation adoption can be categorized in four categories: business environment, networks, perceived innovation characteristics, and adopter characteristics.

Within the category business environment, the following variables influence innovation adoption: price-influencing policy instruments, supplier marketing efforts, environmental influences, access to financial resources, the capital intensity of the innovation, policy instruments, regulations in related industries, and the public opinion.

Within the category networks the following variables influence innovation adoption: the networks itself meaning the actors involved in the networks, the frequency of interaction, and the richness of the interaction.

In the category perceived innovation characteristics, the following variables influence innovation adoption: compatibility of the innovation, the relative advantage, the triability, observability, the innovativeness/strategic posture, targeting and communication of the suppliers of the innovations towards its (potential) users.

Finally, within the category of adopter characteristics the following variables influence innovation adoption: size of the company defined in the amount of capital and equipped personnel, the support of top management, external pressures such as competition, corporate culture, corporate image, and complying with regulatory requirements.

2. How can variables that stimulate innovation adoption within the bioenergy sector be analysed?

Since innovation adoption is a complex process whereby many different factors play a role, specific research strategies are required. The bioenergy sector is still developing and being shaped by regulations on national and international levels. This means that drawing general conclusions about innovation adoption in different industries is not easy. Furthermore, companies act strategic and only share specific information about their innovations. This could form an obstacle for further research. However, the importance of such research is also derived from the fact that the sector is still developing. When companies are involved from the beginning, policy instruments can adapt or change in order to facilitate the industry to stimulate sustainable innovation adoption such as retrofits. Aside this, rebound effects of certain policies can be spotted earlier and policy makers can anticipate earlier. For future research an inductive approach is advised. Such a method also prevents researchers from testing variables that may not even be relevant for innovation adoption within the bioenergy sector. Aside this, an inductive method is advised because it focusses on a company perspective on its changing environment.

3. Which variables stimulate innovation adoption within the bioenergy sector?

Based on the findings from this thesis, some variables were proven to influence innovation adoption within the bioenergy sector and others were not. Aside this there were some variables that were not mentioned in the literature that are worth studying in future research. Several variables within the business environment, networks, and adopter characteristics influenced the retrofit decision of the companies.

Within the business environment the following variables influence innovation adoption: access to financial resources, policy instruments, and policies in related industries.

Within the category networks the following variables influence innovation adoption: the interconnectedness or network participation, and the information exchange within these networks.

The following variable influenced innovation adoption within the category adopter characteristics: top management support and corporate image.

4. What recommendations can be made for policy development based on innovation adoption literature and previous retrofitting experiences?

The bioenergy sector is still developing which makes it difficult to create suiting policy. Still, there are some lessons that can be learned from literature as well as these previous retrofitting cases.

The market for biomass requires to be stabilized through standardization of for example wood pellets. For many companies the availability and supply of biomass is a huge concern for the future. Moreover, biomass is traded among European countries which requires consistent international legislation. The bioenergy sector is related to many other industries which requires policy makers to look at how legislation in different industries can be made more consistent. Various sectors require to cooperate to create sustainable regulations for biomass in the future.

The companies studied in this research showed that long-term programs such as the RED ll provide them with the security that their product will be valued in the future. Moreover, all companies were following closely the developments of RED ll because complying to regulations is an important incentive for companies to retrofit.

From this study it became clear that companies only share specific information with each other concerning retrofit projects, or even not at all. This could be a concern for the diffusion of information among industry members. For this reason, policy should be directed at providing companies with an increased amount of information about retrofitting and provide them with tangible case examples. Through this study it also became clear that companies gain information from case examples of previous retrofits at other companies, but then do not share much information about their own projects. This may imply that R&D support for companies may not be an effective policy instrument for the diffusion of innovations since information exchange between companies is limited. Companies also expressed that participating in discussions and platforms is a time-consuming activity for which some companies do not have time. This means that policy makers should rethink communication strategies with bioenergy companies to provide them with information and include them in the creation of future agreements and policies.

Finally, policy makers are intervening in a developing market for bioenergy. This means that they should be aware of possible rebound effects in the market that are caused by price-influencing policy instruments. Coming back to the point of availability of biomass, policy makers should be aware of the long-term effects of certain price-influencing policy instruments.

7.2 Limitations

The first and foremost limitation of this research concerns the low response rate. This made it very hard to draw general conclusions about which variables mainly influenced innovation adoption for all the companies studied in this thesis. The companies implemented different retrofit projects and are also operating in different industries. This meant that drawing general conclusions for the overall European bioenergy sector was difficult. Still, this research concerned companies from all five different industries, which positively affect the reliability of the research.

The significant variables that were found in the literature study were partly based on empirical evidence from specific different industry sectors such as the IT sector. By doing this, there was a risk that some variables would not be relevant for the bioenergy sector specifically. So, although the operational measures

for this research were based on literature, some were found not relevant at all for the bioenergy sector which negatively influenced the construct validity.

7.3 Further research

Further research concerning variables that influence innovation adoption within the business environment could focus on the effects of different policy instruments on the market as well as the formation of business models by companies. To prevent a possible rebound effect of certain policy measures, further research could focus on comparing different effects of policy instruments across countries in Europe.

Further research concerning networks could focus on how information about retrofitting is gained by companies and how they spread information. So far, we know that companies discuss select information when they meet face to face. What is also known through this thesis is that companies do not meet very often, and that participating in platforms, discussions, and conferences is sometimes perceived as time consuming or even impossible due to a lack of time. Future research could focus on how the information exchange between companies can be improved.

Further research concerning variables of adoption characteristics influences innovation adoption could focus on the link between a sustainable orientation and strategy of companies and the execution of sustainable innovations. Due to the mixed results of this study, there might be critical factors that hamper companies from investing in renewables even though they have a sustainable strategy. Aside this, corporate image as a variable that influences innovation adoption could be further studied.

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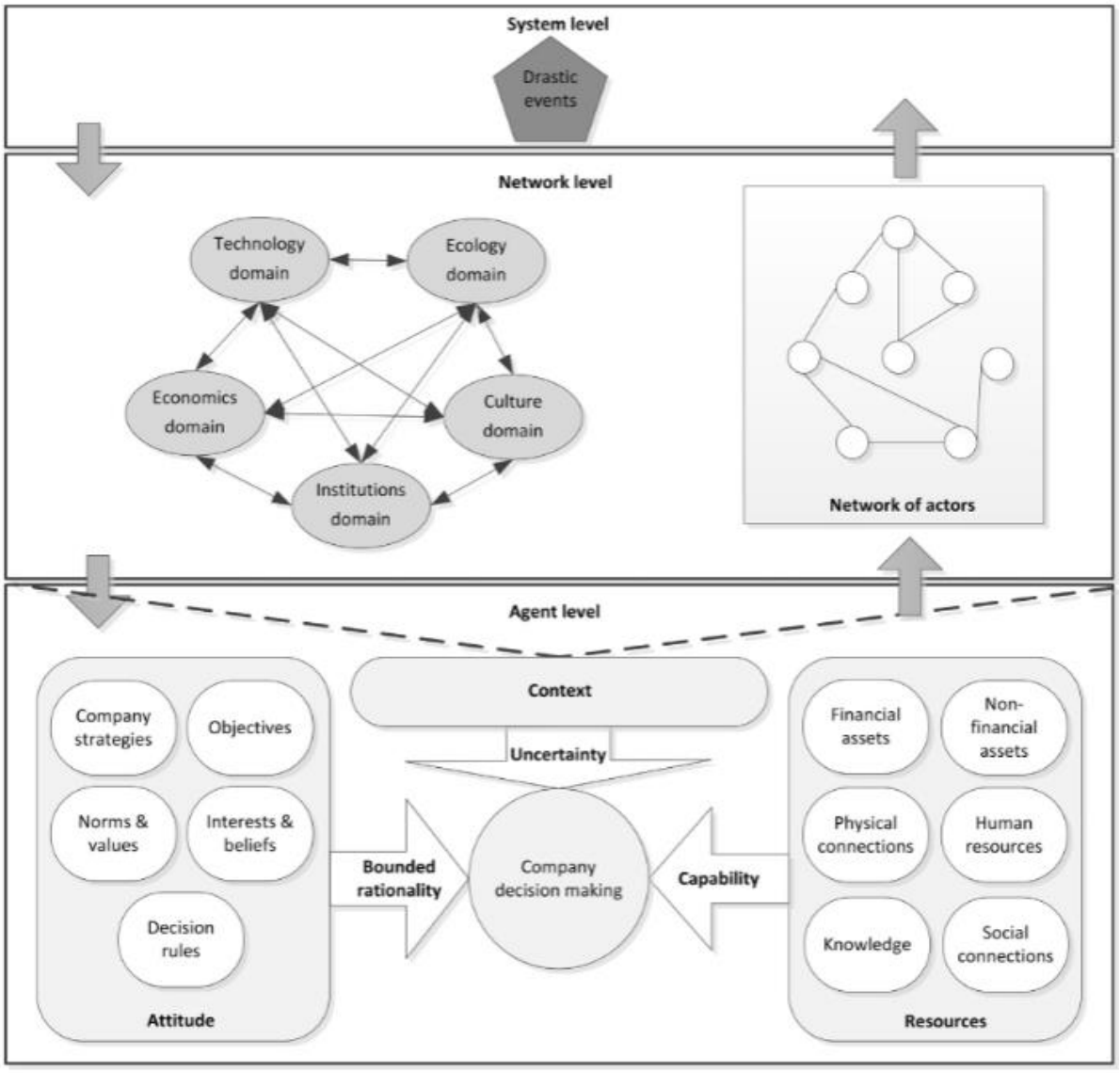
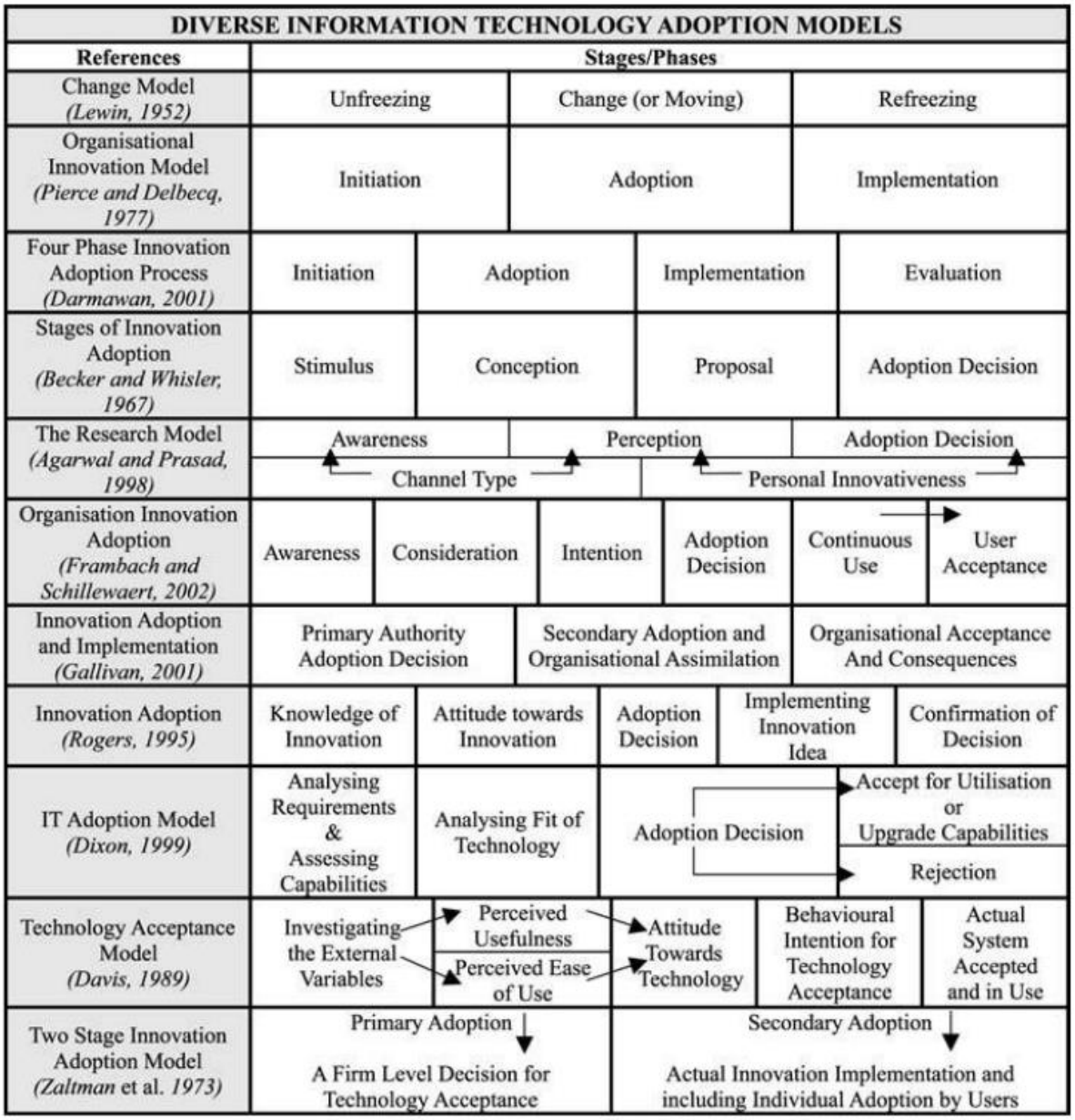
Appendix 1: The Sectoral Diffusion Analysis Framework



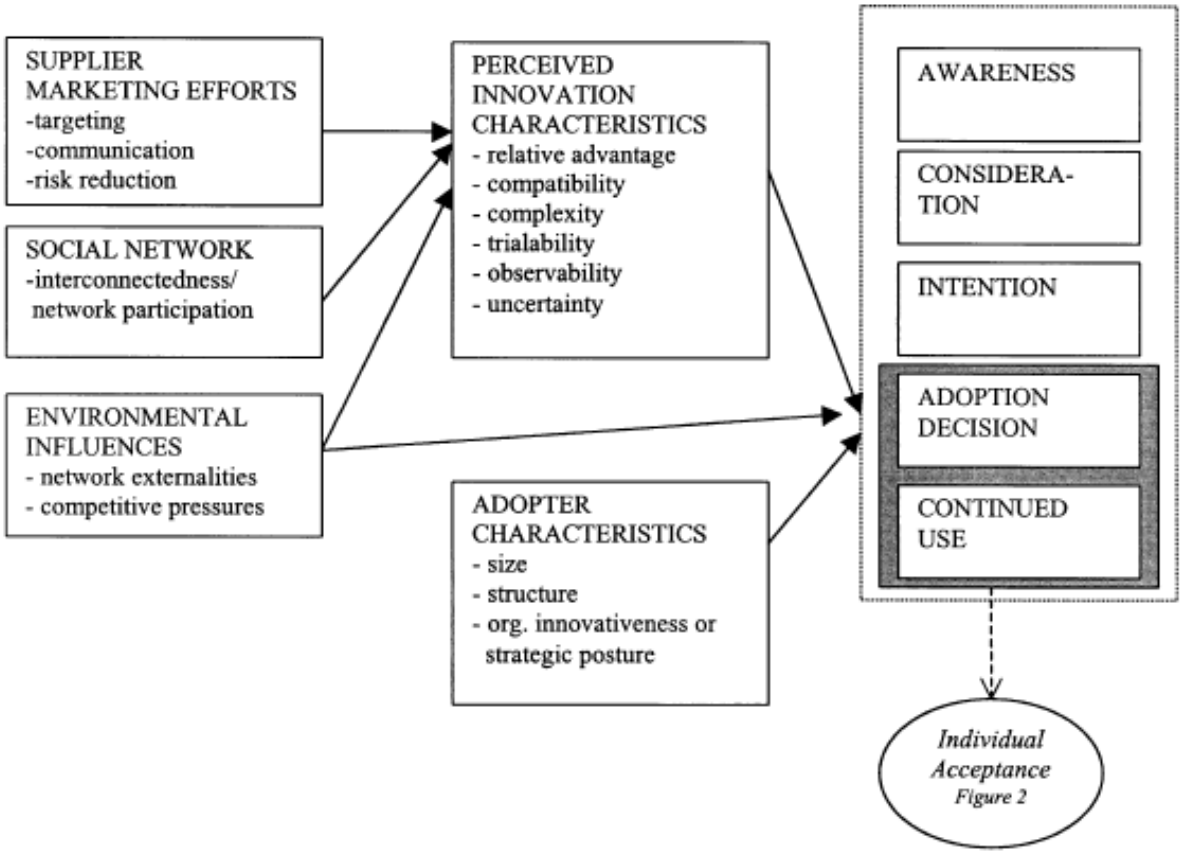
The Sectoral Diffusion Analysis Framework, encompassing drastic events on the system level, societal domains and the network of actors on the network level, and company decision making aspects on the agent level. Adapted by Van der Veen and Kasmire (2015).

Appendix 2: Diverse information technology adoption models



IT innovation adoption models and processes. Adapted from Kamal (2006).

Appendix 3: Organizational innovation adoption



A conceptual framework of organizational innovation adoption. Adapted from Frambach and Schillewaert (2002).

Appendix 4: Interview protocol

The interview protocol contains rules and procedures that are followed when doing interviews (Yin, 2003). Within this interview protocol the rules and procedures of the preparatory work, interview guidelines, and interview completion will be described. Furthermore, the interview form, interview questionnaire, and survey questions are included in this appendix.

Preparatory work

Before the interview takes place, information will be gathered about the companies that are chosen to be case studies of this research. This small desk study will focus on the following aspects of the company:

- the type of retrofit that was implemented

- the share of the retrofit in terms of core activities of the company

- corporate social responsibility statements

- sustainability goals;

- how these goals are measured,

- the volume of the bioenergy or fuel that is used or produced

- annual reports on CSR or bioenergy

- the partners that are involved with the company during the retrofitting process

Prior to the interview, the company representative is asked to fill in the survey that was established by the BIOFIT team. With this survey a description of the purpose of the project is send to the company representative. When scheduling the appointment, it is made clear what the subject of the interviews is going to be and why additional interviews are required aside from the survey.

Interview guidelines

Before the interview takes place, the researcher has studied the answers that were given to the survey.

The company representative will first be asked if the interview can be recorded. After the interview the responded is asked whether a transcribed report of the interview can show his or her name (the report can be anonymous). After the interview, the transcript is sent to the responded to correct before it is analysed. The interview will have an introduction which can be found in the interview form below.

Interview completion

After the interview the transcribed report is send to the company representative. The responded is asked to make suggestions or to approve the transcript. Only after approval the transcribed interview is analysed. The responded is also asked how the company name can be incorporated in the research report. After this, the researcher informs the responded about the date when he/she can expect the BIOFIT report that contains information about the motivation of other companies that have retrofitted.

Interview form

Interviewee

Name:

Function:

Company:

Contact details:

Interviewer

Name:

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Background information

This interview is part of a research project focusing on the non-technical variables that stimulate retrofitting within the bioenergy and fuels sector. This interview is focused on the motivations for retrofitting within your company. Symbolically we see the retrofit decision as a 'pie'. Within this pie different aspects play a role. For this thesis we want to know which aspects play a role and how important they are within the decision-making. If we go back to the example of the pie, we want to know which pieces make the pie and how big they are.

Purpose of interview

The aim of our study is to facilitate the further adoption of bioenergy retrofitting and renewable energy production in the EU. The project concerns the following five industries: First-generation biofuels, pulp and paper, fossil refineries, fossil firing power and combined heat and power (CHP) plants. The research is designed to investigate the (non-technical) conditions under which bioenergy retrofit is feasible. After the research, we will send you a small report summarizing the conditions under which other companies across Europe decided onto retrofitting. These results will be also included in a report that contains policy recommendations.

Definition of retrofitting

Retrofitting means switching from traditional fossil fuel to renewable bio-based energy sources or integrating the production of (advanced) biofuels. This can be done by adding or replacing features of installations to match current/new technologies.

Interview questionnaire

Date and time:

Could you first shortly explain your retrofit and your role within the implementation of the retrofit?

1. Did you consider the political climate benign when it was decided to retrofit? What were key influencer(s) in the retrofit decision?

2. If any, how did your network influence the retrofit decision?

3. Who in your network was most influential in the decision to retrofit?

4. How frequent did you interact with this network before retrofitting and during the retrofit implementation? (and via which platform?)

5. What type of information about retrofitting did you gain from your network before retrofitting? And reversely, what type of information does your company share about retrofitting?

6. Was it difficult or easy to ascertain financial resources for your retrofit project?

7. What stakeholders were critical during the retrofit decision? For example, in other industries (waste/agriculture/nature conservation), customers (with sustainability orientation), or citizens living close to bioenergy installation?

8. When it was decided to retrofit, what was the influence of the company size and/or financial reserves?

9. How many full-time employees did your company have when it was decided to retrofit? How many employees worked on the retrofit transition?

10. Did your company have enough internal expertise when it was decided to retrofit?

11. Was the complexity of your organizational structure influencing your retrofit decision concerning the speed and difficulty of implementing the retrofit?

12. How was your top management involved in the retrofit decision in terms of personal support and exerted influence during the decision-making process?

13. From the following 4 options can you choose a corporate strategy that was important when making the decision to retrofit?

a) Long-term market growth

b) Technology leadership

c) Short-term profitability

d) Financial returns for owners

14. Can you shortly describe three of the more important innovations that have been implemented in your company in recent years, say in approximately the last 5 years?

15. Ultimately, what percentage of your plant is going to be retrofitted and when is this going to be realized?

16. Are there relevant non-technical reasons for or against retrofitting that were not mentioned yet in this questionnaire?

Depending on what the interviewee answered to the survey one of the following questions will be asked:

17a. If you intent to retrofit in the future, do you experience a shift in non-technical reasons for retrofitting?

17b. If you do not intent to retrofit in the future, what is the most important reason for this?

Appendix 5: Inclusion and exclusion criteria for literature study

Inclusion Criteria	**Argumentation for Inclusion Criteria**
From year 1950	Literature on innovation started to increase after Rogers Diffusion of Innovations Theory in 1962.
Review papers	To get an overview of variables of innovation adoption that have been studied
Qualitative and quantitative empirical studies	To get an overview of variables of innovation adoption that are supported by empirical studies
Studies with the most citations in Google Scholar	To get an overview of the most prominent ideas about innovation adoption in general within the literature and to define variables that are supported by empirical studies.
Non-technical studies on innovation adoption and retrofitting within the bioenergy industry	For this research the focus is on non-technical variables that stimulate innovation adoption
Exclusion Criteria	**Argumentation for Exclusion Criteria**
Technical studies on innovation adoption and retrofitting within the bioenergy industry	For this research the focus is on non-technical variables that stimulate innovation adoption
Theoretical studies on innovation adoption	To get an overview of what empirical data is applicable within the bioenergy industry and how this research is contributing to this empirical evidence.

Inclusion and exclusion criteria for literature including arguments.