Building a PV strategy for Eneco, enabling the large scale roll-out of PV for consumers in the Netherlands



A method for strategy development in highly dynamic multi-actor environments

Steven Sprokholt

MSc Thesis

TU Delft / Eneco

The photos shown on the cover of the thesis have been made by Awizon upon completion of a 4.25 kW_p residential PV system at my parents' house in Beetsterzwaag, Friesland, the Netherlands.

Building a PV strategy for Eneco, enabling the large scale roll-out of PV for consumers in the Netherlands

A method for strategy development in highly dynamic multi-actor environments





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Author: *Steven Sprokholt BSc*
Student number: 1210149
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Delft University of Technology
Faculty of Technology, Policy and Management
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Department: Energy & Industry

Energiebedrijf Eneco
Eneco Shared Energy Solutions (ESES)

Graduation Committee:

Prof. Dr. Ir. P.M. Herder	(Chairperson)
Dr. Ir. G.P.J. Dijkema	(First supervisor)
Dr. R.W. Künneke	(Second supervisor)
Ir. J.P.J. Kursten	(External supervisor)

Preface and Acknowledgements

This Master Thesis is the final deliverable of my graduation project as well as the just over six years that I have studied at the faculty of Technology, Policy and Management at the Delft University of Technology in my MSc programme, Systems Engineering, Policy Analysis and Management (SEPAM).

During these years I have gained extensive knowledge on a number of interdisciplinary skills as well as on a diverging array of subjects in the energy domain. Energy matters are becoming more and more critical in our society and its importance will grow further in the years to come, either by our continuously growing demand for energy, carbon footprint, global warming and because of new technologies and innovations.

The years spent at the TU Delft, have taught me that the energy domain faces many complex problems. Solutions to these complex problems are not simply available from engineers, economists, lawyers or policy makers. Complex problems require that people from different backgrounds cooperate and communicate with each other in finding the right solutions to these complex problems. I hope that this thesis contributes to solve such a problem.

The subject of the thesis, developing a strategy for the roll-out of PV systems, is such a complex problem and is at the basis of this research. The inherent complexity of these strategic issues is what motivates me to find solutions to these problems. Another motivation for my research was the opportunity I got in 2009 to design a PV system for the my parents' home. Designing this system proved to be a fun exercise for me. Many others would have considered it as a process facing a lot of complexity. This complexity in my opinion is one of the reasons why PV is not taking off, while PV can be considered a cost effective investment. I hope that my research project contributes to more consumers investing in PV in the Netherlands.

Reading Guide

For employees of Eneco the following chapters are of interest. In chapter 4 the stakeholders analysis is presented. Chapter 5 describes the main barriers that have been identified during the interviews with the stakeholders. The building blocks for a PV strategy are developed in chapter 6 and are combined into a partial strategy for PV in chapter 7. Chapter 8 presents the conclusions and recommendations for Eneco as well as the reflection on the research conducted.

People who are interested in the methodology how to develop or build a strategy for a complex socio-technical system are referred to the methodology chapter 2.. The scientific recommendation are described in chapter 8.

For those who are genuinely interested in PV I refer to the introduction in chapter 1 the comparative analysis of chapter 3, the selection of the main barriers in chapter 5, the development of the building blocks in chapter 6 and the conclusion in chapter 8.

Acknowledgements

Complex problems are not solved by one person alone. Although the problem is unlikely to culminate in a final and all-encompassing solution to the problem, I did receive a lot of help from others in investigating and solving the problems.

First and foremost I like to thank my graduation commission. Thanking Gerard Dijkema for the help he offered me while formulating my research problem as well as helping me in framing the issues. Secondly, I would like to thank Rolf Künneke who helped my realize that formulating the scientific methodology is especially important. Thirdly, I thank Paulien Herder who pointed me in the direction of the Concentric Systems Approach, providing the base for the method I used to develop a strategy for Eneco as well as for chairing my graduation commission. Fourth and foremost I thank Hans Kursten my Eneco supervisor. Our biweekly meetings were both inspiring and very helpful. These meetings helped to create the framework for this research as well as determining which stakeholders were worthwhile to interview.

Furthermore, I would like to thank all the stakeholders with whom I conducted my interviews, for their views, their knowledge and their help and for providing the necessary information required for my research project.

Lastly, I would like to thank my dad Albert Sprokholt, my mother Ineke Donkervoort and my girlfriend Marije Scheperman for thoroughly reading and supporting me to make the final corrections in finishing my master thesis.

Steven Sprokholt

December 2011

Executive Summary (English)

In the past few years we have seen rising electricity prices and it is expected that this trend continues. At the same time the environmental footprint of our electricity production is becoming more and more apparent. Fossil fuel resources are declining and emissions are damaging the environment. One way to deal with these problems is to invest in renewable electricity. The costs of electricity generated by renewables are fixed at the start because of the high investment costs. The marginal costs of generation are almost zero because there are very little operational and maintenance costs. At the same time no polluting emissions are generated.

Photovoltaic (PV) generated electricity, also called solar electricity, is one of the technologies being widely considered as a well suited solution for those consumers who want to stabilize their electricity costs whilst contributing to the environment. Dutch energy company Eneco has identified this opportunity as a way to increase their business and to strengthen the relationship with their customers. However, one of the issues is that although PV can solve many problems for different parties, investment is not taking off.

Therefore Eneco wishes to formulate a PV strategy to enable the large scale roll-out of PV for consumers in the Netherlands. This translates in the following main research question of this thesis:

> *"How to build a strategy (for Eneco), facilitating the large scale roll-out of PV for retail consumers in the Netherlands, using a concentric systems approach?"*

The Concentric Systems Approach (CSA) consists of performing a systems analysis, including a thorough stakeholder analysis. CSA identifies barriers to the solution for the problem in scope, and aims to narrow down the number of barriers identified. In this thesis the two most important barriers, '*Lack of Standardization*' and '*Lack of Knowledge*' are researched/analysed in much greater detail/more in-depth in order to determine the underlying causes. Subsequently, the underlying causes are analysed by identifying scientific theory that can be used to build a solution for each barrier. For building the PV strategy for Eneco the theoretical concepts of mass customization and bounded rationality were used. From here on the scope of the research diverges again, enabling a broad view to identify potential solutions to overcome the aforementioned barriers.

These potential solutions are called building blocks (in this thesis). The building blocks for both barriers are combined to form a (partial) strategy. Two partial strategies have been developed: one in analogy to Dell's strategy and one in analogy to Club Med's strategy. The best partial strategy is determined by looking at the advantages and disadvantages of these strategies. In short, the Dell strategy is defined as clarifying (complex) information for consumers and enabling the customer to design their own PV system. This is in contrast to the Club Med strategy which offers consumers 'restricted' but complete PV systems offerings where they can add extra service components. After the best partial strategy is selected, it is compared to Eneco's corporate strategy. This partial strategy could be used by Eneco as a basis to build a comprehensive PV strategy for Eneco.

The solution for the Dell strategy is to enable the customer to become part of the production process, allowing him to design and configure his own PV system, suiting his specific needs. The solution for the lack of consumer knowledge, used by the Dell partial strategy is an interactive information provision approach. In this partial strategy the customer is guided step by step through

the process of investing in a PV system. At the same time he receives the necessary information at the appropriate steps. The information is provided by credible stakeholders.

The Club Med partial strategy is based on a current industry standard where two to four different packages are provided to the customer where he can add a prespecified service package. The solution for the lack of consumer knowledge is to use the technique of Information Framing where the information is presented in such a way that the customer becomes compelled to buy the proposed product, analogously to the Club Med strategy.

The Dell strategy is chosen as the best partial PV strategy for Eneco enabling the large roll out of PV in the Netherlands and increasing future PV business for Eneco. This strategy provides a lot of flexibility. It allows Eneco to offer other (energy efficiency) services through the proposition as well, but also provides the flexibility in adapting the strategy to future needs of customers, to changing regulations or to new technological developments. The strategy requires a strong cooperation between the stakeholders. The strategy will also provide Eneco with a lot of market data and data on potential prospects. When this is in place it will be difficult to copy by competitors. Finally it contributes the most of both strategies to the corporate strategy of Eneco. This strategy emphasizes the innovative image of Eneco whilst at the same time locking in customers, stimulating the deployment of renewable energy in the Netherlands as well as increasing business for Eneco.

Management Samenvatting (Nederlands)

In de afgelopen jaren stegen de elektriciteitsprijzen en de verwachting is dat deze trend zal doorzetten. Tegelijkertijd worden de milieugevolgen van onze elektriciteitsproductie steeds duidelijker. Fossiele brandstof reserves dalen en emissies hebben een negatieve invloed op het milieu. Een van de manieren om deze problematiek aan te pakken is het investeren in duurzame energie. De kosten van duurzame elektriciteit kunnen als vast worden beschouwd door de hoge investeringskosten. De marginale kosten van het opwekken van duurzame energie zijn bijna nul, omdat de operationele- en onderhoudskosten minimaal zijn. Tegelijkertijd komen er geen schadelijke emissies vrij.

Photovoltaische (PV) gegenereerde elektriciteit, ook wel zonne-elektriciteit, is een van de technologieën waarvan wordt verondersteld dat deze zeer geschikt is voor consumenten om zelf elektriciteit op te wekken en bij te dragen aan het milieu. Het Nederlandse energiebedrijf Eneco ziet dit als een kans om te groeien en de klantrelaties te versterken. Een van de problemen is dat investeringen in PV achterblijven.

Daarom wil Eneco een PV strategie ontwikkelen, die het mogelijk maakt om PV op grote schaal voor consumenten in Nederland uit te rollen. Dit resulteert in de volgende onderzoeksvraag:

> *"Hoe kan een strategie (voor Eneco) gebouwd worden, die de grootschalige uitrol van PV voor consumenten in Nederland mogelijk maakt, gebruik makende van de Concentrische Systeem Aanpak"*

De Concentrische Systeem Aanpak (CSA) bestaat uit het uitvoeren van een systeem analyse, inclusief een uitgebreide actoren analyse. De CSA identificeert de barrières voor de oplossingen van de problemen in de problematiek, daarnaast beperkt het de aantal geïdentificeerde barrières. In deze scriptie worden twee meest belangrijke barrières, '*Lack of Standaridzation*' en '*Lack of Knowledge*' onderzocht in detail om de onderliggende oorzaken te bepalen. De onderliggende oorzaken worden samen met wetenschappelijke theorie gebruikt om oplossingen te ontwikkelen voor elke barrière. De PV strategie ontwikkelt voor Eneco maakt gebruik van de volgende wetenschappelijke theorieën: *mass customization* en *bounded rationality*. Na het vinden van de theorieën divergeert het onderzoek weer, dit maakt het mogelijk om oplossingen voor de barrières te ontwikkelen.

Deze oplossingen, worden 'building blocks' genoemd in deze scriptie. De 'building blocks' voor beide barrières worden gecombineerd tot een (deel) strategie. Twee deel strategieën zijn ontwikkeld: de eerste is een analogie op de Dell-strategie de tweede is een analogie op de Club Med strategie. De beste deelstrategie is bepaald door het kijken naar de voor- en nadelen van de deelstrategie. De Dell strategie structureert de (complexe) informatie voor consumenten en maakt het mogelijk voor de consument om zijn eigen PV systeem te ontwerpen. De Club Med strategie daarentegen biedt beperkte maar complete PV systemen aan, waar zij extra service aan toe kunnen voegen. De beste deelstrategie wordt vergeleken met Eneco's bedrijfsstrategie. De deelstrategie vormt de basis voor Eneco om een volledige PV strategie te ontwikkelen.

De Dell strategie maakt het door mass customization mogelijk voor consument om deel uit te maken van het productie proces. Het maakt het mogelijk voor de consument zijn eigen systeem te configureren dat aan zijn eisen voldoet. De Dell oplossing voor *'Lack of Knowledge'* is een interactieve informatie management systeem. In deze deelstrategie wordt de consument bij de hand

genomen en door de stappen geleid die nodig zijn voor het investeren in een PV systeem. Tegelijkertijd ontvangt hij de informatie die hij nodig heeft bij de juiste stap. De informatie voor het systeem wordt aangeleverd door betrouwbare actoren.

De Club Med deelstrategie is gebaseerd op de huidige industriestandaard waar twee tot vier pakketten aan de consument worden aangeboden. Waarbij een extra service pakket kan worden toevoegen. De oplossing voor '*Lack of Knowledge'* is gebaseerd op het framen van informatie. Informatie wordt op zo'n manier gepresenteerd dat de consument wordt gedwongen om het product te komen, net zoals bij de strategie van Club Med.

De Dell strategie is gekozen als de beste deelstrategie voor Eneco, die het op grote schaal uitrollen van PV in Nederland mogelijk maakt en de omzet voor Eneco vergroot. Deze strategie bied veel flexibiliteit. Het maakt het mogelijk om ook andere producten en service aan te beiden via deze propositie, maar ook de flexibiliteit om aanpassingen aan de strategie te maken als de eisen van klanten veranderen maar ook in het geval van technische of institutionele ontwikkelingen. Deze strategie vraagt om een intensieve samenwerking tussen actoren. Deze strategie maakt het mogelijk om veel (markt)gegevens te verzamelen. Als deze strategie is geïmplementeerd is het moeilijk om door concurrenten te kopiëren. Als laatste draagt deze strategie het meeste bij aan de bedrijfsstrategie van Eneco. Deze strategie legt de nadruk op het innovatieve imago van Eneco, terwijl het tegelijkertijd consumenten bind, de investeringen in duurzame energie vergroot en de omzet voor Eneco vergroot.

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PART I - Introduction

Nothing is as hard to organise, nothing has such a small chance of success, nothing is as dangerous as spearheading innovations. He who is willing, makes those who profited from the old situation to his enemies. Whilst he cannot count on much enthusiasm from those who will profit from the new situation. There lukewarm reception sprouts forth from, on the one hand the fear of opponents who can appeal to law and tradition, on the other hand they can count on the fact that men is generally superstitious and never trusts innovation before they have benefited from said innovation.

Niccolò Machiavelli, *Il Principe,* 1513

Chapter 1

1. Introduction

About 10 years ago issues such as global warming, climate change and environmental pollution have led to the introduction of CO_2-emission trading and renewable energy goals for nations. The Dutch renewable energy target is that 14% of our energy consumption needs to be renewable by 2020 (Ministerie van EL&I, 2011). Today, in 2011, 9,4% of our electricity consumption is considered as renewable (CBS , 2011). The introduction of these renewable energy targets have increased the generation costs of electricity. Large scale generation of renewable energy is still more expensive than conventional generation of electricity by burning fossil fuels. Therefore subsidies are required to make large scale generation and use of renewable energy attractive. In addition, emission trading has also increased the costs of electricity, because electricity producers have to buy CO_2 emission credits to offset their CO_2-emissions.

The demand for energy, and electricity, is increasing rapidly as well, especially due to the economic developments in the BRIC countries (Brasil, Russia, India and China). In Europe the energy demand is relatively stable due to energy efficiency measures taken. However, it is expected that also Europe's end-use of electricity will rise in the decades to come due to developments in electric mobility and the use of heat pumps for space heating (Ministerie van EL&I, 2011).

As a consequence of the increasing demand for energy in the world, the available fossil resources are declining, leading towards an upward price pressure. According to the *Energierapport* there are still sufficient reserves of fossil fuels available, but the main problem is that these reserves are located in politically unstable countries (Ministerie van EL&I, 2011). This instability will lead to more price and supply fluctuations in the markets for energy when there are disturbances in the supply line. This effect will be reinforced by the fact that the energy import dependency of Europe, including the Netherlands, is increasing. The decline of the Dutch gas reserves will create an upward price pressure on the price of electricity s (Neuhoff, 2005).

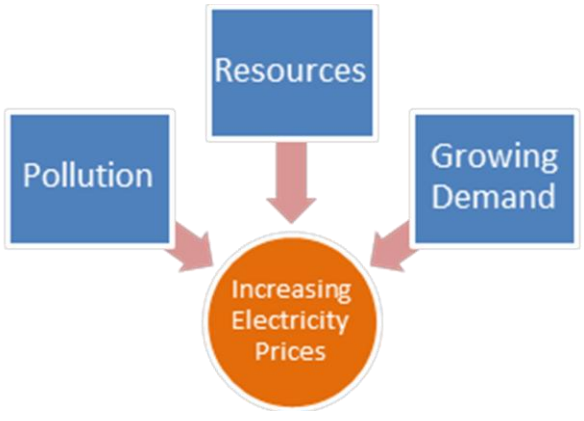


Figure 1: Factors that cause rising electricity prices

As a result the electricity prices are likely to increase. The Energierapport 2011 argues that the prices will increase substantially up to and past 2020. Figure 1 shows a schematic overview of the factors that cause electricity prices to rise.

Renewable Energy

One of the ways to deal with rising electricity costs is to invest in renewable

electricity generation. An advantage of renewable energy is that the costs of electricity generated by this technology can be considered fixed. Most renewable technologies require an upfront investment and have low marginal costs of operating and maintaining, making the total cost more or less stable over time and known. With one important remark: as long as the institutional arrangements, set by national and European policy do not change.

On a customer scale, renewable energy can compete with fossil fuel generated electricity. Because there is governmental policy and regulation in place to stimulate the use of renewable energy, by exempting customers from paying energy taxes and Value Added Tax (VAT) over the self-generated renewable electricity. Furthermore they are allow to use net metering to settle their electricity bill, for more information see appendix A and B.

One of the often mentioned renewable energy technologies which can help consumers, businesses and industries to generate electricity is photovoltaic (PV) or solar electricity. A report of USP Market Consultancy, 2011 substantiates this, 80% of the household in the Netherlands is positive towards PV. Solar PV technology is not a new technology, it exists for over 50 years. Some argue that the slow roll-out of PV is due to a lack of policy and subsidies (Berenschot, et al., 2011). Others blame the significant investment costs blocking the large scale adoption of solar PV in the Netherlands. Textbox 1 provides two typical examples of problems consumers face when investing in a PV system[1].

Example 1 – Individual Homeowner

Imagine that you are a homeowner and you would like to install a PV-system on your roof. You would like to become partly self-sufficient in meeting your households' electricity needs. You start by browsing the internet to gather more information about the possibilities, the costs of installing a PV system and the system payback times. Soon, you will become confused because there are various PV systems and configurations; investment is considerable, proposed payback times vary wildly per system and the financing options seem complex. In the end, you postpone the decision to install a PV system on your roof.

Example 2 – Regulation inhibits investments

Imagine that a rooftop of a community centre is very suitable for the installation of a PV system. A number of neighbours next to the community centre decide to make a collective investment in a PV system on the roof of the centre. After reading regulatory information the neighbours discover that it is impossible to offset the generated electricity from the rooftop with their own electricity consumption. This makes the business case unprofitable because the tax paid on delivered cannot be offset. The result is that the neighbours decide to postpone their investment decision. When regulation would allow the neighbours to offset the electricity generated by the collective system with their own electricity consumption at home, the business case would turn out to be profitable.

Textbox 1: Examples of problems arising when wanting to invest in a PV system.

The two examples discussed in textbox 1 present some barriers preventing consumers from investing in a PV system. These barriers need to be solved if consumers are to invest in PV. Solving these barriers requires the cooperation between stakeholders including regulators.

[1] A PV-system includes the solar panels, the inverter, installation equipment and connection to the distribution grid.

Chapter Outline

This research project investigates the barriers experienced by consumers and other stakeholders and investigates how to build an effective strategy for Eneco to roll-out PV in the Netherlands. Given the problems that consumers and stakeholders meet in the present. The research questions and objectives are thoroughly explained in chapter 2.

In the following paragraphs the motivation for this study, the problem statement, the social and scientific relevance of this study and the outline of the research project, are presented by Figure 2.

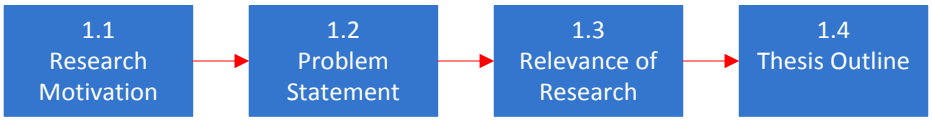


Figure 2: Introduction Chapter Structure

1.1 Research Motivation

This paragraph explains the motivation for this research project, but first the role of the Dutch energy supply company Eneco in paragraph 1.1.1. is illustrated. In paragraph 1.1.2 my personal motivation is explained.

1.1.1. Motivation for Eneco

This research study is written from the perspective of Eneco. Eneco is a sustainable integrated energy supply company in the Netherlands and the *main* problem owner of this research project. The company is specialized in the production, transmission and supply of natural gas, electricity and district heating, as well as ancillary services.

Eneco's current corporate strategy is influenced by multiple factors like: rising energy prices, energy dependency from foreign suppliers, climate change, environmental impacts as well as technical developments, such as distributed generation, smart grids and mobility (Eneco, 2011a)[2]. These factors create new opportunities for innovative sustainable energy systems. Eneco wants to benefit from these opportunities to guarantee the company's long term continuity. However Eneco´s interest in PV is not considered as a simple extension of their corporate strategy. There are three other factors motivating Eneco´s PV interest:

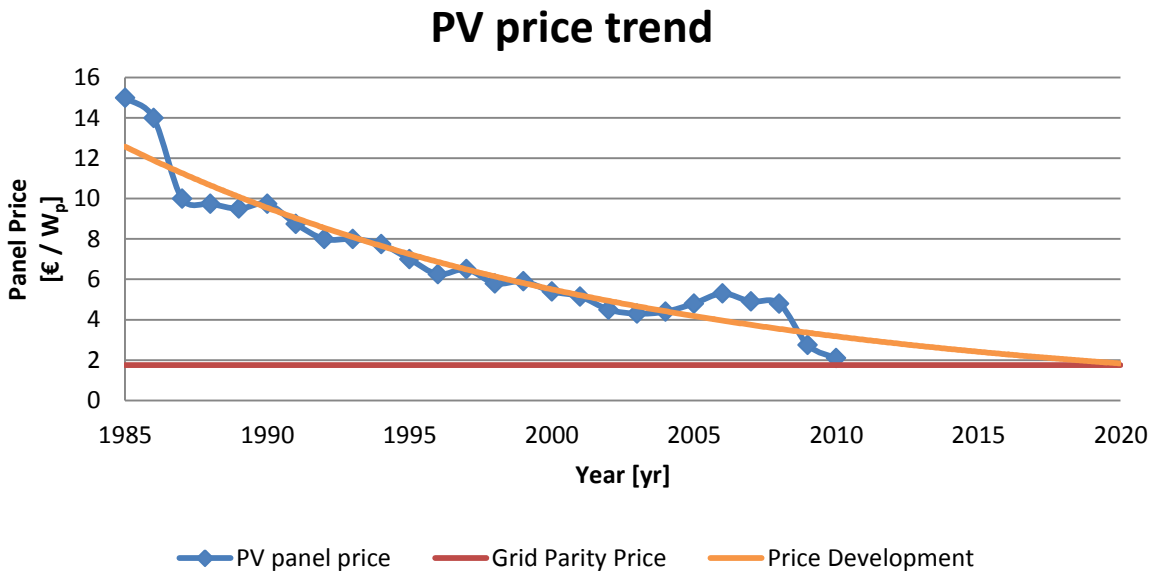
First, Eneco aims to supply their customers with 100% renewable electricity. This goal can be achieved by investing in new sustainable generation capacity or by allowing customers to invest in sustainable generation technologies themselves. PV is considered to be a sustainable electricity generation technology (Alsema, 2012). Eneco should possibly offer (installation) services to its customers to increase their revenues and business.

A second motivation for a PV strategy is to 'lock-in' consumers, as expressed during interviews with Eneco employees (Verbeek, 2011; Weeda, 2011). Due to the liberalisation of the Dutch electricity sector, customers are free to choose their electricity supplier. Therefore it is important for Eneco to increase the bond between Eneco and their customers. Strong bonding will prevent customers to switch to competitors. A PV system could offer Eneco a '*customer lock-in*' that last longer than a one to three year energy supply contract, after which the customer is eligible to switch to another energy

[2] The strategy of Eneco is explained in greater detail in chapter 3.

supplier once again. The '*lock-in*' created by a PV system originates from offering different services and increased service levels to the customer, like electricity monitoring services, insurance and PV system financing. Offering such services might prevent customers from switching to other energy companies.

A third reason is the declining price trend of PV panels. Although PV panels do not make up the complete price of a PV system, panels are responsible for approximately half of the system costs (Shum & Watanabe, 2008). The price of PV electricity is approaching grid parity[3] with the price of retail electricity, as can be seen in Graph 1. These promising developments motivate Eneco to continue the search for possibilities to promote PV systems to their (future) customers.



Graph 1: PV panel Price Trend (Adapted from: (NREL, 2010))

Over the past decade Eneco has made several attempts to develop attractive PV propositions for its customers. Until now these PV propositions have achieved only a limited success (see appendix A). For this reason Eneco has asked me to help them to develop a PV strategy that can be successful independent of renewable energy stimulation measures and subsidies.

1.1.2. Personal Motivation

My personal motivation for carrying out this research project is twofold. Firstly, because I developed experience in the past with installing a PV system. My parents invested in a PV system two years ago under the previous *Stimulering Duurzame Energie* (SDE)-regime (2009) and a separate ruling of the Province of Friesland. Two subsidies were given: one for the installation of the system and one for increasing the price of the energy produced over a 10 year period. A lot of information and work went into actually getting a PV system installed. For example, making a cost benefit analysis was still difficult due to the lack of general and reliable information. It was difficult to figure out what the risks

[3] Grid Parity is the point where electricity generated from a PV system is as expensive as electricity bought from the electricity supply company. There in practice grid parity is presented as here but there are some problems with this definition. Many stakeholders claiming that PV is cheaper than gird-electricity often do not include all relevant costs such as depreciation, maintenance, cost of capital, component lifetimes into account (Bhandari & Stadler, 2009).

were, and to find out, for example which PV system installer could be considered reliable enough to install a PV system. A second problem that I experienced were the large number of stakeholders that were involved with the installation of the PV system itself. A brochure of the SDE regime showed a 6 step approach with different stakeholders to execute the SDE-regime. All in all, this has motivated me to devise a strategy that makes it easier for a customer to invest in a PV system.

Secondly I am personally interested in solving complex problems. To develop a PV strategy for Eneco can be considered as a complex problem and the problem is even more challenging when looking at investing in a PV systems. For Eneco the construction of a natural gas powered power station to generate electricity is procedurally easier than a large scale roll-out of PV. Furthermore it is likely that an investment in a PV system competes with other investments for an ordinary consumer. There are few customers who have the money available to invest in a PV system. Competing investments for a PV system can be buying a new car, a kitchen, a bathroom or even going on a nice holiday cruise. These investments are likely to be more appealing to the average customer. Finding a solution for the problem to influence consumer behaviour to invest PV is an important motivation for my study.

1.2 Problem Statement

Investment in PV in the Netherlands is not taking off as is the case elsewhere in the world. The perception of consumers is that PV is expensive and that a consistent Dutch policy regarding renewable energy is inconsistent and lacking. However, a number of opportunities are present: PV is well suited technology for electricity generation for households: consumers have a positive attitude towards PV, even though they perceive it as expensive and that costs of PV systems continue to decline (USP Marketing Consultancy, 2011).

Because Dutch policy regarding renewable energy is very inconsistent, the research is carried out without taking direct subsidies into account. As a changing subsidy regime would endanger the future of the developed PV strategy.

Despite the negative perceptions of consumers and inconsistent policy, Eneco wants to develop a PV strategy enabling the large scale roll out of PV in the Netherlands. This would not only increase the share of renewable energy in the Netherlands and contribute to the environmental goals set by Eneco, it would also contribute to the continuity of Eneco by generating more business. Moreover such a strategy offers Eneco opportunity to create a strong bond with its customers through the installation of PV as well as contracts for servicing and financing for PV systems.

It is likely that many more barriers preventing the large scale roll-out of PV are present other than solely inconsistent Dutch policy and negative consumer perceptions. This study aims to identify these unknown barriers and to find solutions through the use of a systems analysis method. This results in the following research question:

> *"How to build an effective strategy facilitating the large scale roll-out of PV for retail consumers in the Netherlands, for Eneco, using a concentric systems approach?"*

The methodology to build a PV strategy for Eneco is described in greater detail in chapter 2.

1.3 Relevance

1.3.1 Social Relevance

The main motivation for consumers to invest in a solar PV system is to achieve a return on investment higher than the minimum desired return on investment (DeCanio, 1993; Sansted & Howarth, 1994; Christie, 2010). Consumers can also use their investment in a PV system to protect themselves against the earlier explained rising of electricity prices. But from a customer perspective there are other customer investments that compete with PV. Investments such as a new bathroom, a kitchen or even a holiday. PV here needs to change a paradigm: previously customers used to buy their electricity from the meter, PV offers an opportunity to invest and generate electricity themselves fulfilling financial and environmental objectives. Any strategy developed should be able to accommodate this paradigm shift.

The social relevance of this research project lies in the fact that PV systems reduce the environmental footprint of our electricity consumption (Alsema, 2012). On average a PV system pays itself back in terms of energy required for the production of the system within one to three years depending on location (A.T. Kearney, 2009; Alsema, 2012). Consumers can contribute to lowering their environmental footprint by investing in a PV system. These environmental effects like global warming, scarcity of resources and pollution of our environment become namely more apparent.

The social relevance of the project is therefore not only motivated from a financial perspective. A sold strategy also contributes to a solution for our environmental problems by reducing pollution, increasing the share of renewable electricity in the Netherlands and achieving the targets set by the government and the European Union for renewable energy.

1.3.2 Scientific Relevance

The focus of research at the faculty of Technology, Policy and Management of TU Delft is aimed at the interaction between technology, institutions and processes in complex problems or environments. These interactions often appear in socio-technical systems. At a glance it appears that developing a PV strategy is relatively straightforward. The market for PV systems appears simple, but in contrast it is riddled with complexity. There are complex subsystems interacting at different levels, where institutions, technology and processes meet. The various stakeholders create a lot of complexity due to conflicting objectives, interests and perceptions.

To deal with this complexity the concentric systems approach[4] and the meta design model (Herder & Stikkelman, 2004) are used. Both help to break down the complexity into smaller problems that can be solved more easily, without dismissing the interdependencies between the smaller problems or identified barriers as described in this thesis. The concentric systems approach[5] and the meta design model are used to design so called building blocks for a PV strategy and to investigate system complexity. These methods are particularly valuable to build a PV strategy for Eneco because of the socio-technical complexity of the PV business. The methodological framework is described in much greater detail in chapter 2.

[4] The term concentric systems approach has been coined during one of the graduation committee meetings.

Looking at the literature on socio-technical systems, it is apparent that a socio-technical systems approach is seldom used for building a strategy. However, there is much literature available concerning the design of complex systems such as infrastructures. The application of the concentric systems approach including the meta-design model for building a PV strategy for Eneco is the scientific challenge in this thesis.

1.4 Outline

This thesis has been divided into four different parts. A schematic overview of the thesis structure is presented in Figure 3. Part I serves as an introduction to the study by introducing the research problem and research questions. This chapter 'Introduction' explains the motivation and relevance of this thesis. Chapter 2 specifies and presents the research problem, research questions and methodology used for this thesis.

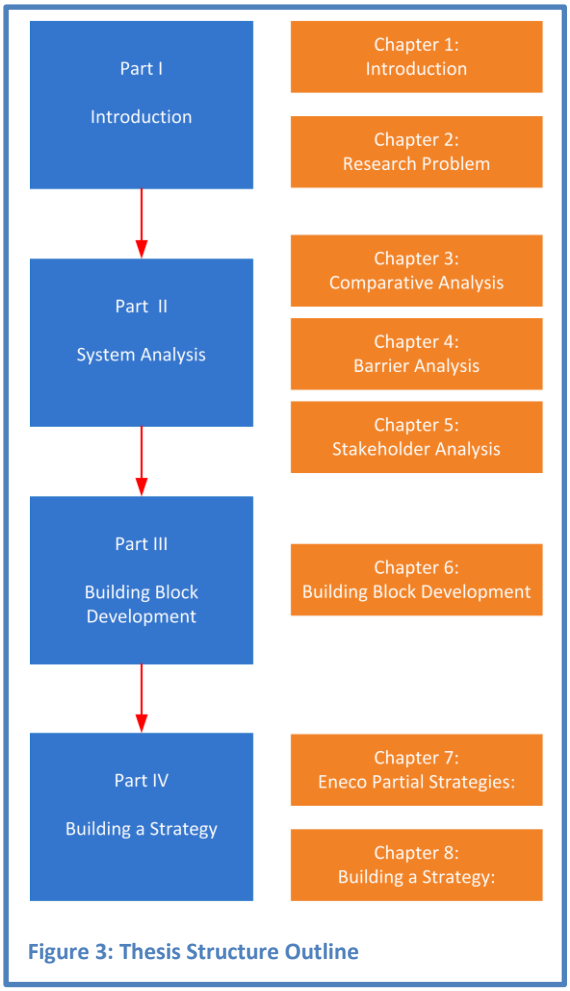


Figure 3: Thesis Structure Outline

Part II presents the systems analysis. The first step in the system analysis is to validate that PV is actually the best technology. Validation of PV in comparison with other renewable technologies is done by means of a comparative analysis in chapter 3. Based on the outcome of this analysis the current strategy of Eneco is analysed. Next, in chapter 4 a stakeholder analysis is carried out, identifying their roles and interests. Finally the systems analysis is concluded with the identification of the barriers obtained from the interviews with the stakeholders. These barriers obstruct thus the large scale roll-out of PV in the Netherlands. Subsequently the two highest ranking barriers are taken for further analysis in Part III

Part III consists of developing the so called building blocks to create an effective strategy for PV. The barriers of chapter 5 are taken as a starting point. For each of the barriers the relevant building blocks are investigated so they can help to overcome the issues represented by the barrier. This is done with the relevant scientific theory for each building block. If the theory demonstrates that the building block can eliminate the issues of the barrier the building block can be built. in Part IV the PV strategy for Eneco is developed

Part IV describes the development of the partial strategies constructed from the building blocks. Thereafter the partial strategies are evaluated and the best one is chosen. In chapter 8 the conclusions, recommendations, validations and a reflection are presented.

Chapter 2

Research Problem

Eneco wants to play an active role in increasing investment and roll-out of PV in the Netherlands. A number of countries in Europe have shown a large growth in the PV installation industry. So far this has not been the case in the Netherlands. This situation creates potentially a significant business opportunity for Eneco. Building an effective PV strategy however is a complex problem due to the vast amount of heterogeneous stakeholders present in the market and their fragmentation.

Chapter 1 has shown that there is a large interest for investment in PV systems in the consumer market. Investments are unfortunately often postponed because of a number of barriers such as technology, institutions or processes. These barriers need to be solved.

In dealing with this research problem I will elaborate on the barriers and the possibilities to solve them by looking both at content and process. This chapter has been split up in the following paragraphs, represented by Figure 4:

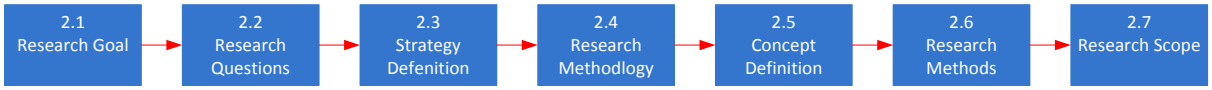


Figure 4: Chapter 2 outline

2.1 Research Goal

The main research goal is to develop an answer and recommendations to the main research question as described in the introductory chapter:

How to build an effective strategy for the PV consumer market for Eneco?

The answer should provide Eneco with the means to develop a PV strategy for a large-scale roll out of PV to retail consumers in the Netherlands in complementing Eneco's DDS-strategy[6]

2.2 Research Questions

The research question, presented in paragraph 2.2.1, has been broken down into different sub-questions to clarify the process of developing a solution in a structural manner in paragraph 2.2.2..

2.2.1 Main Research Question

The main research question for this research project is:

"How to build an effective strategy facilitating the large scale roll-out of PV for retail consumers in the Netherlands, for Eneco, using a concentric systems approach?"

2.2.2 Sub Questions

The sub questions to answer the main research question are:

[6] Eneco's DDS strategy (Duurzaam, Decentraal & Samen) is explained further in paragraph 3.2

1. *Is PV the most appropriate technology choice for Eneco to build a (PV) strategy, considering technological, institutional and process factors?*

2. *Who are the main stakeholders involved in a PV proposition and, what is their role in the process of developing a PV strategy?*

3. *What are the main barriers according to the stakeholders deterring PV investment in the Netherlands, that can be influenced by Eneco looking at the following type of barriers?*
    a. Technical barriers
    b. Institutional barriers
    c. Process barriers

4. *What are the most important barriers of the identified barriers?*

5. *What are the underlying issues of the identified main-barriers, providing starting points to search for scientific theory?*

6. *Is the concentric systems approach suitable to build an effective strategy in a complex market as the PV market?*

7. *Which scientific theories can be applied to solve the main barriers, resulting into building blocks?*

8. *What is the best partial PV strategy for Eneco based on a morphological chart representing the barriers and the different building blocks?*

Before answering these questions I will first define the term strategy.

2.3 What is a strategy?

The term strategy is often used in literature and in daily life. There are (implicit) differences between the terms used in conversations and in publications. Johnson and Scholes define strategy as follows:

> *"Strategy is the direction and scope of an organisation over the long term, which achieves advantage for the organisation through its configuration of resources within a challenging environment, to meet the needs of markets and to fulfil stakeholder expectations"*

(Johnson, Scholes, & Withington, 2008, p. 243)

Strategies can exist at different levels of an organisation as can be seen in Figure 5.

- The highest level is the **corporate strategy** level concerned with the overall purpose and scope of the business to meet stakeholder expectations. For the organisation it is a very important level, since it is heavily influenced by investors and regulators. Both can be considered as external developments acting as a guide for strategic decision making.

Corporate strategy is often stated in the annual reports of companies as the 'mission statement' (Johnson, Scholes, & Withington, 2008).

- The second level of organisation is the **business unit strategy**. The business unit strategy is concerned with how the business competes successfully in individual markets. It provides a framework for strategic decisions about the choice for a product meeting the needs of customers, gaining an advantage over the competitors as well as exploiting and creating new market opportunities (Porter, 1996). This strategy is partially influenced by the main corporate strategy as well as the perception of external developments by the business unit. In the case of Eneco the developments and the perceived barriers of PV are particularly relevant.
- The lower level is the **operational strategy** level. At this level the organisation is concerned how each individual part of the organisation is best organized to deliver the corporate and business unit level strategies. The operational strategy focuses on issues of resources, processes, barriers and people (Slack & Lewis, 2002).

These three strategy levels are often simply referred to as strategy. A choice needs to be made at what level of strategy this research paper is looking at.

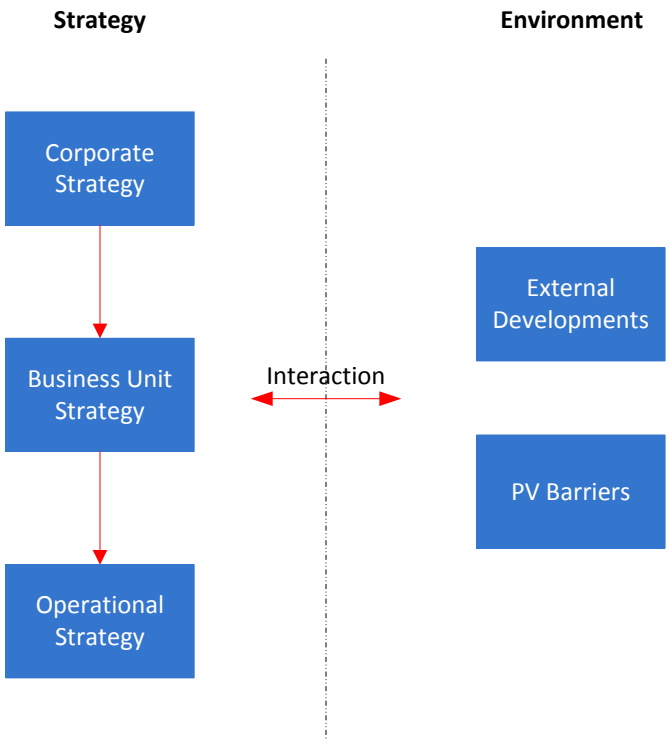


Figure 5: Position of the three different strategy levels and interaction with the environment

Although the results of the research project cannot be anticipated upfront, it is expected that the research in this thesis will touch upon both the business unit strategy level as well as the operational strategy level.

2.4 Research Methodology

The research methodology paragraph is structured as follows. First a summary is given on the research approach used in paragraph 2.4.1. The research methodology is described in greater detail in paragraph 2.4.2. The used systems approach, *in casu,* the Concentric Systems Approach is

explained in paragraph 2.4.3. In paragraph 2.4.4. and 2.4.5. the meta-design model and the concept of the morphological chart are explained in detail. These two concepts form an important part of the Concentric Systems Approach.

2.4.1 Research Approach

Before starting a research project it is important to answer four questions:

1. Why is the research project carried out?
2. How is the research project going to be carried out?
3. Why (are)/is this/(these) research method(s) chosen?
4. What steps need to be carried out for this research?

The answer to the first question has been answered in the previous chapter where the social and scientific relevance of the research project has been described and more importantly, the research motivation for Eneco has been explained.

Paragraph 2.4 provides answers to the other three questions starting with: “How is the research project going to be carried out?”

To answer this question I will use the Concentric Systems Approach (CSA). A model of this approach is shown in Figure 6. The scope of the problem of this research project can be characterised as ‘broadly defined’ and ‘having many issues’. It is important to narrow down the scope, before starting the analysis and investigation of the most important issues. An analysis of the issues will help to define the main barriers for a PV strategy. With the help of CSA the solutions or building blocks will be developed to remove the barriers and creating the basis for an Eneco strategy.

The third question is “Why is this research method chosen?”. Looking at the problem of PV it can be defined as a socio-technical problem. A socio-technical problem is a problem where multiple stakeholders and issues from technical, institutional and process viewpoints merge. The CSA provides a structure allowing the researcher to deal with the complexity arising from the interaction between these issues. CSA allows for selectively converging the scope and diverging it again when solutions and alternatives need to be developed. This diverging scope creates the opportunity for the user to identify potential solutions. These potential solutions create a rich selection of developed building blocks in the end for building partial strategies. Next to the CSA I will use the meta design model because it provides a suitable framework to deal with socio technical problems and solving them.

The answer to question four: “What steps need to be carried out for this research” is given by the successive steps represented in Figure 6:

- First a description of the PV market in the Netherlands is provided including the different subsystems. Next this:
- A stakeholder analysis is carried out because the problem under investigation is dependent on the actions of multiple stakeholders. The stake holder analysis is also an important part of the meta-design model, where the influence of other stakeholders is used to create more robust solutions to identified problems. Followed by:
- An issue analysis in order to gain a broad view of the present problems with PV.

- This will be done by interviews based upon preliminary desk research, with stakeholders from my external supervisor's professional network. These stakeholders have different positions in the stakeholder network concerning PV.
- The findings of the interviews are used to narrow down the selection of the issues to main issues. These main issues will be investigated further leading to the identification of the main barriers preventing the roll-out of PV in The Netherlands.

- Research of scientific literature to develop solutions to overcome the main barriers identified in the previous step.
- The development of the so called building blocks using scientific theory.
- Using and composing the so called building blocks into a morphological chart to formulate recommendations for Eneco in the form of partial PV strategies.

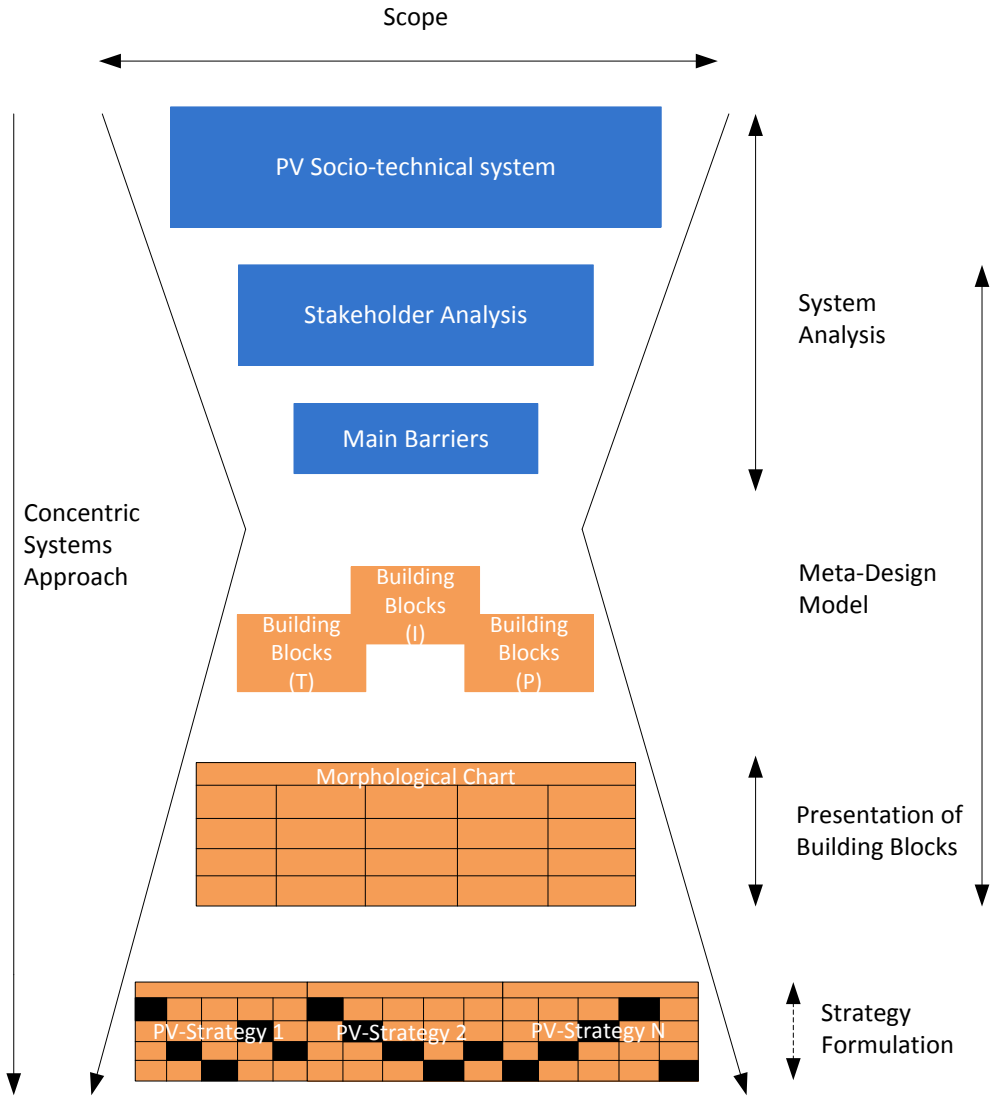


Figure 6: Research Methodology Diagram

2.4.2 Systems Approach

As described in the previous chapter stakeholders, technology and institutions are involved considering the PV socio-technical system. Socio-technical systems are described in greater detail in Textbox 3. Socio-technical design issues are often complex problems being broad and often poorly defined, and changing over time (Rittel & Webber, 1973; Conklin, 2006). Sometimes it is possible to cut the problem in smaller parts, and resolve the main problem by solving these smaller problems. But as these smaller socio-technical problems are often interdependent it becomes difficult to solve them through solving each of the different parts in isolation (Bauer & Herder, 2009). Therefore we need to rely on dynamic approaches, such as the "*Concentric Systems Approach*". Textbox 2 provides a more detailed description of what a systems approach is, which is the basis of the CSA.

Intermezzo: Systems Approach

The socio-technical complexity of systems calls for the synthesis of two different perspectives cited in literature. On the one hand there is the "*Systems Perspective",* often referred to as hard systems approach, and on the other hand the "*Actor perspective*"*,* or often referred to as soft systems approach. Both perspectives have their merits when solving problems. Socio-technical problems contain a high degree of complexity with both a strong technological element, and a more social element. This results in the fact that both perspectives need to be combined in order to obtain the desired results (De Bruijn & Herder, 2009).

The systems perspective:

The 'systems perspective' looks at socio-technical systems as being composed from many subsystems, that are interdependent and have often multiple conflicting objectives. The presumption is that although a socio-technical system may express complicated behaviour it is rational in nature. The complexity in such a system however may have grown to such an extent that it is impossible to model it rigorously. The 'systems perspective' design approach is technical-rational in nature where phases are used to govern the design process.

The actor perspective:

The 'actor perspective' focuses at the stakeholders involved, leading to different types of interdependency. Stakeholders need each other's cooperation even though at times they have conflicting interests in changing the current system. These conflicting interests may lead to strategic behaviour of stakeholders to obtain their goals. Another issue is that information is often contested. Given this strategic behaviour, a network of actors with conflicting interests and contested information, makes rational and planned decision almost impossible. The 'actor perspective' sees design as a highly iterative process with a lot of interaction. Knowing and understanding the stakeholders is crucial to come to a result that is acceptable.

Integration of both perspectives is required in order to solve complex socio-technical issues. These problems cannot be understood without knowledge obtained from each of the perspectives. However in combining both perspectives it is important that the different strengths of the perspective is not lost during the integration.

When these perspectives are combined or used alongside each other it is important that during the issue investigation and the design of building blocks a continuous switching between perspectives takes place to come to a valuable solution. Switching between both perspectives and looking at a problem from both perspectives will enable the design of robust building blocks to build Eneco's strategy. The combination of both perspectives is the main reason why for this research the Concentric Systems Approach is chosen. CSA includes the focus on both the actor and systems perspectives.

Textbox 2: Intermezzo Systems Approach

2.4.3 Concentric Systems Approach

The CSA focuses firstly on the entire system, taking into account the full richness of the environment, as well as both perspectives as explained in Textbox 2. This is done by making a quick scan of the socio-technical system, as described in the first sub-question. Although the system boundaries are open, the barriers – to be identified – need to contribute to the clarification in one form or another of the lack of investment in PV by consumers.

The issues are obtained from literature as well as from interviews held with stakeholders who have different roles in the PV industry - like regulatory bodies, institutions allocating subsidies to the installation of PV systems and companies selling PV systems-. The barriers identified are grouped by their technical, institutional or process attributes. The attributes most frequently cited in literature, and by stakeholders are considered to be the ones that are most applicable for Eneco. These are presented and analysed further in the research project. This helps to narrow down the scope of the research.

After the first part of the systems analysis, when the identification of barriers, has been completed, the next part will focus on narrowing down the number of barriers. For my research project I have made the decision to select two barriers from a different category to develop strategy building blocks. More barriers will cost more time and capacity than is available for a Master thesis project, what this research project is. This is an important limitation to my research project.

The design and development of the building blocks is done with the meta-design model framework developed by Herder and Stikkelman (2004) as explained in paragraph 2.4.4. The building blocks provide possible solutions to the two selected barriers. The meta-design model is used to structure the design process taking into account both the system and actor perspectives. It defines design steps, such as establishing a list of requirements from the stakeholder perspective in order to constrain the design space. The building blocks are developed with the applicable scientific theory for that specific issue in mind. The scientific theory ensures that the systems perspective is well represented. The building blocks and barriers are brought together in a morphological chart (see paragraph 2.4.5). The actor perspective and its requirements are represented through both the stakeholder analysis (see paragraph 2.6.1) and the interviews that have been conducted to identify the barriers that the stakeholders experience in the PV market.

As explained a limited number of barriers are selected to be researched in greater detail in this Master thesis project. Therefore the morphological chart is not complete. This is an important limitation of my research project. The used methodology offers Eneco the option to add building blocks for additional barriers and elements. The result will be more building blocks and a more complete morphological chart. An extensive morphological chart is a powerful tool to design strategies when there are many variables involved (Ritchey, 2002; Ritchey, T., 2011). The morphological chart presents the building blocks in a clear manner as well as the alternative design options of the socio-technical system. By combining the building blocks and screening for contradicting ones an effective and underpinned strategy is obtained.

For this study the CSA can best be described as a funnel. The CSA takes the entire system into account, but with each step the scope and design space converges slightly until the stage of the meta-design model (MDM), which is an integral part of the CSA. The MDM diverges the design space once again by looking for alternatives within the constraints and requirements set by stakeholders. The morphological analysis increases the design space further by combining building blocks into strategies. This is clarified by Figure 6, as shown before.

Intermezzo: Socio-technical system

As the term socio-technical system has been mentioned a number of times it should be explained more in depth. This research project examines a system for providing electricity by means of solar power. This system with all its dependencies on other systems can be considered as a socio-technical system. Socio-technical systems exhibit both technical and social complexity. The systems consist of a combination of social, economic and physical systems with a high level of interdependency. This creates a high degree of complexity.

The infrastructures and many of the systems we use today have not been designed as integrated systems designed for future requirements. A good example of this is the infrastructure of the Dutch electricity system. Over time it evolved into a complex physical network resulting in a patchwork of old and new technologies including numerous stakeholders and institutions as we see today. It has adapted itself to changing economic conditions, changing societal demands and end-user requirements. The system that is in place today has not been planned for nor is it governed by a central authority. Instead it is controlled by many stakeholders who optimise their own interests in making selective (management) decisions and investments for their own subsystem (Weijnen, Herder, & Bouwmans, 2008).

Infrastructure related systems can be considered as a particular class of socio-technical systems. Technology is an important element for both the operation as the organisation for the governance of the infrastructure. This can be extended by including a regulator that ensures that public interests are central to the operation of the different parts of the infrastructure or subsystems. Technological, institutional and process issues arise at different levels within socio-technical systems. Modern societies rely on the smooth and efficient operation of multiple infrastructures for daily life, such as electricity, gas, water, telecom and transport. Social and economic life would grind to a halt without the reliable and sufficient supply of these services and commodities by these infrastructures (Bauer & Herder, 2009).

In this research project building a consumer PV strategy is considered as a complex socio-technical problem. Barriers concerning the investment in PV have different origins. They are technical, institutional or process related and at the same time often interdependent with other barriers. An additional layer of complexity is added because the PV systems under investigation are not stand alone systems. They are connected to the main electricity grid, creating dependencies between both systems. Also the PV system has many stakeholders. Therefore I argue that PV is a socio-technical system.

Textbox 3: Intermezzo Sociotechnical Systems

2.4.4 Meta-design model

The meta-design model is used to develop the building blocks to solve the selected main technical, institutional and/or process issues. The meta-design model is broadly applicable and is a simple model for problem definition and design of alternatives. The meta-model provides a structured approach to develop building blocks or design alternatives for complex socio-technical design problems. MDM uses a systems perspective to ensure that a substantive building block is created and that there is a sufficient level of detail (Herder & Stikkelman, 2004). The main advantage is that

MDM can be used to structure the approach for elements of socio-technical problems. An important remark has to be made here. The MDM is not used in the foreground of the research. The theory however is used in the background to develop the building blocks needed to create a strategy. This is because not all the step as formulated by Herder and Stikkelman (2004) of the MDM are followed exactly. For either these steps are not applicable or superfluous.

The MDM does not only structure the problem by using the systems perspective, it also includes the actor perspective to identify where the various stakeholders play a dominant role. The involvement of the interests of stakeholders, according to Herder and Stikkelman (2004), will create support from the stakeholders for the solutions under consideration (De Bruijn & Herder, System and actor perspectives on sociotechnical systems, 2009). The contributions and influence of the stakeholders are a valuable source of information. This information contributes to the development of innovative alternatives, which the stakeholders can support.

The meta-design model consists of three major elements:

1. the development of a list of requirements,
2. the development of alternatives, or building blocks from the design space and
3. the development of tests or validation

The list of requirements is obtained by executing a stakeholder analysis and conducting interviews with various stakeholders (Herder & Stikkelman, 2004). These requirements are included implicitly in the barriers because the issues are important to the stakeholders and therefore are earmarked as important. The goals and interests of Eneco, the problem owner, are combined with those of the other stakeholders because Eneco cannot simply execute a strategy on its own; partners or other stakeholders have always to be involved. The combined goals and interests are translated into design constraints, resulting in a list of requirements and objectives that the strategy must adhere to. These constraints and objectives narrow the design space.

This design means that Eneco cannot determine the design space on its own but instead implies that all stakeholders should contribute to the formulation and should have influence on the design space. This process will lead to a design space from which credible building blocks can be developed, that eventually will lead, although not in this thesis, to a comprehensive PV strategy for Eneco. The building blocks are evaluated by comparing them to the initial objectives formulated in the meta model and by scoring their performance, as well as by eliminating contradicting building blocks in the morphological chart.

A limitation to the chosen approach is that, although many stakeholders are involved, there is no guarantee that a strategy built by these building blocks will always be successful. The future is uncertain, even though the current and future PV market are looking promising, there is by no means a guarantee that this remains so in the future. A performance in the past is by no means a guarantee for the future, but the model is flexible in nature. The model provides direct insight of what the impact might be of future changes in the environment or the underlying systems. These factors can of course help to change the previously developed strategy.

Due to time constraints it is not possible to test or validate the developed building blocks and partial strategies in this research project. To solve this problem a method of validation is described, which Eneco can apply to validate the partial strategy and its consistent building blocks.

2.4.5 Morphological Chart

Morphological analysis is a research method that has been researched and developed since the 1990´s. It is aimed at creating a methodological framework for building models of systems and processes which are difficult to quantify. The technique has been applied to projects involving policy analysis, scenario development, system design and strategy management (Ritchey, 2002; Ritchey, T., 2011). The morphological analysis is adapted for the purpose of this study. This research project does not include all the steps often used in a full morphological analysis. Mainly due to the fact that only a limited number of building blocks are developed and therefore a lot of the elimination strategies can be skipped, making the elimination steps superfluous. Therefore the visual display of the morphological tool is used to display the function and role of each building block.

The morphological analysis is an analysis method used to structure and analyse complex problems. According to Ritchey (2011), these problems have predominately three characteristics, which were first identified by Ackoff. These are inherently non-quantifiable (i), contain non-solvable uncertainties (ii) and can often not be modelled or simulated in a meaningful way (iii) (Ackoff, 1974). According to Ritchey morphological charts or analysis can be used on two of the three types of complex problems which were identified by Ackoff (Ritchey, T., 2011):

1. The first type of problems where the morphological chart can help is the *'mess'* or *'wicked problem'*. These problems are complex and they do not have a well-defined form or structure. With a mess, one does not exactly know what the problem actually is at the start of the analysis.
2. The next level is the *problem.* This is an issue that does not have a defined form or structure, but it is dimensioned. The issue is known and we know something of the structure of the problem and the ways in which it interacts with other elements concerning the problem.

In these cases there are a number of solutions depending on a set of conditions. The morphological chart and morphological analysis is used to structure problems and messes intro structured problems. These types of problem(s) resemble the type of problems found in socio-technical systems. One important remark has to be made, especially when looking at the following quote:

> *"One of the greatest mistakes that can be made when dealing with a mess is to carve of part of the mess, treat it as a problem and then solve it as a puzzle – ignoring its links with other aspects of the mess"*

(Pidd, 1996, p. 40)

This quote is important because this study focuses on a smaller number of issues and aspects rather than the problem as a whole. When arriving at a possible strategy for Eneco, it is important to keep this in mind by specifically look and test for interdependencies that exist with other systems or subsystems, when developing conclusions and recommendations.

There are a number of advantages in using a morphological chart to present the different building blocks. First and foremost it provides a transparent picture towards the problem owner and stakeholders. Secondly it is easy to update, especially useful given the limited scope of the research project. Because the interviews with the stakeholders take up a long period, new insights can be included easily in the morphological chart without many problems.

The morphological chart makes it easier to develop a PV strategy once all the building blocks are developed. The building blocks support the development of all the possible alternatives. Spotting the contradicting building blocks is relatively straightforward and reduces the number of possible alternatives often by more than 90% (Ritchey, T., 2011). When all the contradictions are spotted and eliminated in the morphological chart the remaining list of alternatives will present the valid solutions space.

Table 1: shows the morphological chart adapted for this study:

	Building Blocks		
Barriers	I	II	III
Barrier A	Building Block A.I	Building Block A.II	Building Block A.III
Barrier B	Building Block B.I	Building Block B.II	
Barrier C	Building Block C.I	Building Block C.II	Building Block C.III
Barrier D	Building Block D.I	Building Block D.II	

Table 1: Adapted morphological Chart

Horizontally the number of building blocks or alternatives are displayed. Vertically the barriers are displayed for which the horizontally displayed building blocks are developed. This chart gives direct insight in the list of building blocks one is able to choose. A combination of building blocks from each barrier in turn forms a (partial) strategy. This should help to build the Eneco PV strategy.

2.5 Concept Definition

This paragraph aims to clarify the concept of a building block, because it may lead to confusion if not thoroughly understood before continuing with the main thesis.

Building Blocks

The socio-technical problem of: "*how to build an effective strategy facilitating the large scale roll-out of PV for retail consumers in the Netherlands, for Eneco,..*" is complex. To solve such a problem, a socio-technical system has to be decomposed into smaller 'independent' problems that can be solved more easily, without dismissing the scope of the research. The solutions to these smaller problems form the building blocks that, when assembled in a particular way, form the constructed (partial) PV strategy for Eneco. According to Wolters:

> *"A system is modular when it consists of distinct, (autonomous) components, which are loosely coupled with each other, with a clear relationship between each component and its function(s) and well-defined, standardized interfaces connecting the components, which require low levels of coordination"*

(Wolters, 2002, p.263).

These autonomous components are comparable with the definition of a building block I am providing here. The decomposed smaller problems are the barriers that will be identified based upon interviews with stakeholders (chapter 4). The barriers are part of the larger socio-technical problem (see Textbox 3) of why investment in PV is not taking off in the Netherlands. Figure 7 shows a representation of the building block. The building blocks built in this thesis have two main requirements:

- The building blocks need to be designed in such a way that they can be moved, changed or rearranged easily to support flexibility and changes in the socio-technical system.
- The building blocks can perform a specific function in the PV strategy or solution.

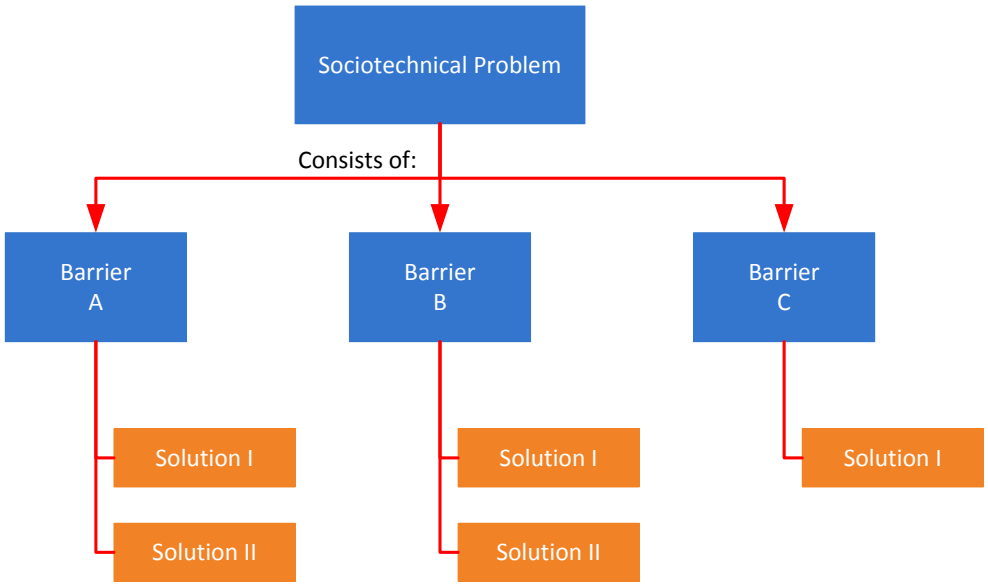


Figure 7: Representation of a building block.

Looking at Figure 7, a building block would have the following 'codename' A.I, referring that the building block provides a solution to barrier 'A' and that its possible solution number is 'I'. As mentioned earlier the building blocks are supposed to be included into the partial strategies that form the basis of a PV strategy for Eneco.

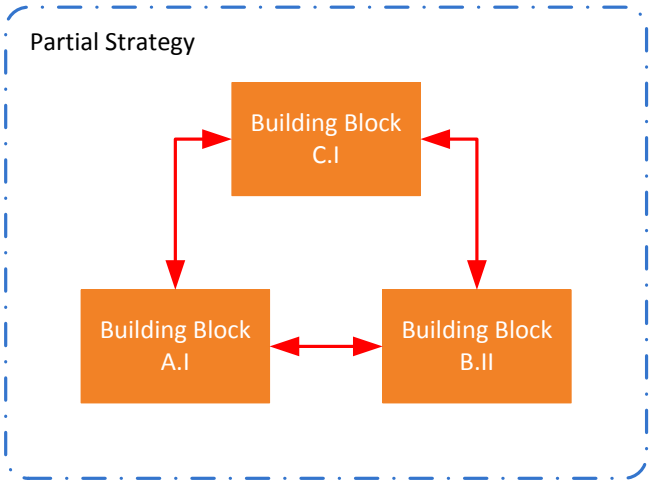


Figure 8: Building blocks constructing a Partial Strategy

Figure 8, presents a partial strategy composed of the building blocks A.I, B.II and C.I. An important remark is that in constructing a partial strategy it is not possible that two building blocks refer to the same barrier. These two building blocks will interfere with each other if they are both concluded. Further information on composing a partial strategy will be given in chapter 7, once the partial strategies are constructed.

2.6 Research Methods

Various research instruments are applied to answer the research questions presented in paragraph 2.4. The research methods used to answer each of the sub questions are presented in Table 2.

Report Structure	Research Question	Research Method
Part II	Sub question 1	Literature review, desk research
	Sub question 2	Stakeholder analysis, interviews
	Sub question 3	Interviews, survey, desk research
	Sub question 4	Desk research, interview
	Sub question 5	Desk research
Part III	Sub-question 6	Desk research, literature review
	Sub-question 7	Desk research
Part IV	Sub-question 8	Desk research
	Main Question	Desk research

Table 2: Research Methods Used

Sub questions 1 through 5 form the basis of the systems analysis or the narrowing of scope, while sub question 6 and 7 focus on the development of the building blocks. Sub question 8 enables the development of the partial strategies in chapter 7. The main research question is answered in Part IV, chapter 8. In this chapter a method to validate the chosen partial strategy is presented.

2.6.1 Stakeholder Analysis

Identification and involvement of stakeholders in any project is a major factor contributing to a project's success. Involvement of stakeholders creates an understanding between stakeholders and increases their contribution to a better final product (Miller & Lessard, 2000; Meredith & Mantel, 2009).

The average number of stakeholders involves in a decision making process is increasing. This adds more complexity to the process. The number of interests, opinions and goals increases and at the same time the number of relationships between stakeholders increases exponentially. When a decision making process is ill-managed across stakeholders, it can easily result in conflict and mistrust between the stakeholders. This results in long project delays, project costs overruns and sometimes even project failure. To avoid this, it is essential that stakeholders understand each other's interests and goals (De Bruijn & Ten Heuvelhof, 2008).

Definition of a Stakeholder

Before continuing, what is exactly a stakeholder? A 'stakeholder' or 'actors' are often referred by most authors as two terms meaning the same. However this is not the case. In scientific literature an actor is defined as "persons, groups, organisations… that is capable of making decisions and act in a more or less coordinated way" (Enserink, Hermans, Kwakkel, Thissen, Koppenjan, & Bots, 2010, p. 81). Actors have an interest in the system and/or have the ability to influence that system, either directly or indirectly (De Bruijn & Ten Heuvelhof, 2008).

The term stakeholder on the other hand refers to persons, groups or organisations that have to be taken into account by an organisation when planning to execute projects, strategies or plans that impacts the interest of others in a positive or negative manner. Before describing the stakeholder analysis for this thesis in greater detail it is important to define what a stakeholder is. The definition used in this thesis is the definition by Eden and Ackerman (1998):

> *"People or small groups with the power to respond to, negotiate with and change the strategic future of the organization"*

(Eden & Ackermann, 1998, p. 117)

Bryson (2004) argues that this definition should be extended to include nominally powerless actors as well adding for greater social justice and elements of democracy. The definition of Eden and Ackerman according to Bryson is too much oriented towards the public and business domain. As this thesis concerns, I will use the definition of Eden and Ackermann.

Why a Stakeholder Analysis?

The two main motivations for carrying out a stakeholder analysis are the following:

- Public and infrastructure issues are often situated in a multi-actor environment. Different actors are involved with different perspectives, goals and values. Eneco is active in the electricity supply sector and faces multi-actor complexity. An actor analysis can help them to structure the actor environment and to identify potential problems at an early stage. The multi-actor perspective is characterized by many different stakeholders with diverging interests and resources. In the multi-actor setting, coalitions or networks are formed. Coalitions of different actors may exist that attempt to forward their shared goals (De Bruijn, In 't veld, & Ten Heuvelhoff, 2002).
- At the same time the analysis is an important element in the meta-design model as explained in paragraph 2.4.4. The stakeholder analysis is specifically used to make the relationships between the stakeholders more insightful. Stakeholders can create robustness and flexibility in a PV-strategy by contributing information and other resources.

The stakeholder analysis used for this research is an extension of the "classical stakeholder analysis". This extension has been developed by the TU Delft and has been extensively taught to students in the BSc and MSc SEPAM programmes. The purpose of this type of stakeholder analysis is to:

1. Identify the stakeholders involved, with their characteristics;
2. Gain insight into the multi-actor environment ;
3. Stimulate cooperation between stakeholders;
4. And find robust solutions for the issues that Eneco faces.

Interviews are part of the stakeholder analysis and form a useful tool to obtain the information required for the analyses. In the next paragraph 2.6.2 the interviews are explained in greater detail for gathering information on the barriers. The interview is used to conduct the stakeholder analysis:

1. Performing semi-structured interviews helps to gather more information than could be obtained by classical desk research.
2. It is possible to ask the interviewee open questions allowing him/her to identify what problems he/she faces which is of great importance because of the meta-design model.
3. Semi-structured interviews can provide ideas and suggestions on how different stakeholders perceive certain problems and potential solutions. The potential solutions can be used as starting points for building block development.
4. Stakeholders can exemplify what relations they have with regard to other stakeholders and provide answers to questions why they do or do not cooperate with other stakeholders.
5. Interviews can serve to validate findings obtained from other interviewees and literature research. This is especially important when a stakeholder does not want to be interviewed.

The stakeholder analysis is an important part of the meta-design model of Herder and Stikkelman (2004). It is used to gather a broad set of constraints and requirements for the building blocks that build a solar PV-strategy of Eneco. These constraints are however not explicit because of the nature of the conducted interviews, as explained in paragraph 2.4.4. These constraints and requirement are set by the barriers that they perceive. Because the potential solutions are used as a starting point for developing the building blocks, Eneco will probably be able to reduce the resistance of stakeholders in the future as the requirements of these stakeholders are used in developing possible solutions and taken into account during the design process. Stakeholders that were not interviewed were analysed by means of their respective internet website and other sources.

Stakeholder Identification

To execute a stakeholder analysis it is necessary to identify the relevant stakeholders. This can be done in a number of ways. According to Enserink et al, 2010 there are different methods and tactics to identify stakeholders:

- *Imperative*: "who has an interest in or feel the consequences of the issues around which the problem resolves. Or the solutions that are being considered" (Enserink et al, 2010, p. 85.);
- *Positional*: Review the existing policy making structures, identifying parties that currently have a formal position in decision making (Enserink et al, 2010, p. 85.);
- *Opinion leadership*: "Identify actors who tend to shape the opinion of other actors. Universities or research groups, international organisations may influence individuals or other groups" (Enserink et al, 2010, p. 85.);. ;

- *Reputational*: "(Snowballing) use key informants and asks them to identify important actors" (Enserink et al, 2010, p. 86.);

On the basis of scientific literature and a meeting with my supervisor Hans Kursten at Eneco a first list of stakeholders has been identified. By using the three tactics, *imperative, positional* and *opinion leadership* other stakeholders were added to the list. The list is further extended by investigating the value chain of PV to identify any remaining stakeholders that were missed. During the interviews the list could be further extended by using the *reputational* tactic. In chapter 4 the practical execution of the stakeholder analysis is presented.

Advantages and Drawbacks of the chosen method

The main advantages of the chosen method to identify stakeholders are:

- An easy analysis of the actors involved with their characteristics and relations.
- The analysis provides the required level of detail and quality for the thesis and research project.
- The outcome of the analysis are presented in easy to understand figures and tables

There are a number of disadvantages as well:

- The accuracy of the analysis depends on the skills of the analyst and the data availability.
- The analysis provides a snapshot of a dynamic process. Stakeholders, opinion and interests change over time and during the process as well. The outcomes of a stakeholder analysis made at the beginning, during and after a process can be radically different from each other.

2.6.2 Interviews / Survey

Not much literature is available on the barriers that affect consumer investment in the Dutch consumer PV market. Different stakeholders active on the PV market can experience different barriers. For the study 20 stakeholders as can be seen in Table 21 of Appendix F were approached for an interview to capture the most recent information on the potential barriers of the Dutch PV market. Eleven stakeholders gave a positive response and another two were interviewed for additional information. For these thirteen respondents interviews were scheduled. The interviews were held to obtain information on the following issues:

- To identify the issues that stakeholders experience on the consumer PV market.
- To identify the requirements and constraints as perceived by the stakeholders to develop solutions to underpin the roll-out of PV; although as said previously these were taken implicitly (paragraph 2.4.3).
- To obtain information on possible starting points for developing building blocks for underpinning the PV strategy.
- To gain an understanding of the relations between stakeholders active in the consumer market.

The interviewees were selected on their background as well as their field experience. The majority of the interviewees have been involved over a number of years in the (consumer) PV market and have obtained a wealth of knowledge and experience. The interviewed stakeholders are active in different areas of the (consumer) PV market like financiers, PV system installers, services providers, policy

developers and infrastructure operators. Furthermore a trustworthy image of the stakeholders in question is important. The Ministry of Economic Affairs, Agriculture and Innovation (ELI), made a remark in the interview that the *Consumentenbond* and *AgentschapNL* should be included in the stakeholder analysis.

Interview Approach

The interviewees were approached with an introductory email, by the author. An example of this introductory email can be found in Appendix C. The email explained the nature of the research and the information required for the research project. This email was followed up by a reminder if there was no response. In the case of a positive response an appointment was scheduled. The interviews were scheduled over a three month period.

Before conducting the interviews it is important to know what kind of information you exactly want to gain from the interviews. The interview questions were based upon preliminary desk research. The interview protocol itself has been set up in such way that it allows a structured gathering of information, but also allowing for capturing data that was not included in the protocol; *in casu* a semi-structured interview. The extended protocol with interview questions can be found in Appendix C. The protocol was aimed to get an clear sight of barriers for PV in the Netherlands, as well as a clear understanding of the position and perception of the interviewee in the network as a stakeholder. The interviews had an open character consisting of a number of qualitative questions, necessary to discover missing, incomplete or lacking information.

Before the interviews took place a number of example questions were emailed to let the stakeholders prepare for the interview. Not all questions were emailed in order to avoid that stakeholders would be overly prepared and unwilling to provide (crucial) information. The interviews took between one and one-and-a-half hours.

To ensure that the interviewees were interpreted and understood correctly, they were asked to validate the interview. This was done by making a transcript of the interview and summarizing the findings. The interview transcripts are available in a separate thesis Transcript Addendum.

2.6.3 Literature Review

Desk research was undertaken using the data and/or conclusions of others to formulate or to carry out the researcher's analysis and to underpin conclusions. This type of reserach involves collating and synthesizing existing research from various fields. The main difference between this form of research and others is that it does not use primary data. Primary data have a greater reliability and contain more information than data collected by desk research and found in published articles. The knowledge that is required for the desk research is obtained from the personal conducted interviews with the different stakeholders (primary data) as well as the literature review performed during the first chapters (secondary data), complemented by a literature review after the specific issues that deter investment in PV.

2.7 Research Scope

In this paragraph the research demarcation is explained in greater detail. The scope of this research is confined along the lines of geography, time and customer group. The definition of scope starts with the consumer.

2.7.1 Consumer

Eneco is aiming at a large scale application of PV in the near future. Electricity generated by PV systems is approaching grid-parity in the retail market, as seen in Graph 1. Retail electricity prices are higher than the electricity wholesale prices. This is due to Value Added Tax (VAT) and energy taxes levied on the use of electricity. Taxes make up over two-thirds of the electricity retail price for consumers. Depending on the electricity demand and energy usage, taxes make up less than half of the electricity price for businesses because VAT is tax deductible, as is shown in Table 3 below.

Green Electricity		Electricity-supply tariff	Energy Tax	VAT	Electricity Price incl. VAT
Consumer Retail	< 10 MWh	€ 0.06765	€ 0.11210	€ 0.03415	**€ 0.21390**
Business Retail	< 10 MWh	€ 0.06613	€ 0.11210	---	**€ 0.17823**
	> 10 MWh < 50 MWh	€ 0.06613	€ 0.04080	---	**€ 0.10693**
	> 50 MWh < 10.000 MWh	€ 0.06613	€ 0.01090	---	**€ 0.07703**

Table 3: Energy retail price comparison between consumers and business (Adapted from: (Eneco, 2011b; Eneco, 2011c))

Because sustainable electricity generation concepts are often more expensive than conventional generated electricity there is a noticeable price difference between the actual costs of electricity generation. The price difference between the cost of electricity generated by a PV system and the retail price for electricity is the smallest for consumers. Consumers pay relatively a high electricity price due to taxes, while businesses pay much less for their electricity. Literature is unanimous in the conclusion that grid parity will occur first in the retail market for consumers (Bhandari & Stadler, 2009). Therefore the focus of this study is placed on consumers because the costs of renewable electricity and the electricity price paid by retail consumers is nearing parity soon.

Looking at consumers the issue remains that retail consumers form a very broad group, which can be divided as follows:

- The individual consumer living in a privately owned house.
- The *Vereniging van Eigenaren* (VvE) consumer; representing a group of consumers living in the same apartment block and having a number of shared services which they want to power with PV.
- The collective; a group consisting of a multitude of consumers who would like to invest as a group in a PV project as an investment to off-set their electricity consumption and to reduce their carbon-footprint.
- Consumers, collectives and VvE's who own a building with a roof unsuited for PV; either because the roof is not orientated towards the sun, or the roof is shaded by surrounding trees, or the presence of many roof obstacles. These consumers might favour investing in a PV installation on another more suited roof for PV in their neighbourhood. They would like to use net metering[7] to discount the electricity generated by the system with their own energy

[7] Net metering, also called ´*salderen*´ in Dutch. Net metering is settling the energy that is self-generated by a PV system with electricity consumed from the grid on the electricity bill. The owner of the PV system receives the same price (including taxes and VAT!) as what would be paid for electricity during any other time when electricity is bought from the grid.

consumption. Net metering is described in greater detail in Appendix B.. Today implementing net metering favouring this opportunity is virtually impossible due to regulatory difficulties.

Although housing corporations represent a large share of the market, they are not taken into account. Housing corporations have the problem of split incentives (Sansted & Howarth, 1994; Maruejolsa & Younga, 2011). In this case split incentives present themselves when the owner of the home wants to achieve the highest possible returns on investment. This is in contrast to the user of the home who wants to have the lowest possible bills. Investing in PV presents a particular problem for housing corporations when they want to invest in the PV system, whilst the tenant does not want to pay a higher rent, but at the same time the tenant experiences the lower electricity costs of the PV system.

Therefore, the choice has been made to focus on individual consumers willing to install a PV system. This group includes a majority of the best suited homes resulting in the easiest group for the installation of a PV system. When considering a VvE or a consumer collective, collective decisions need to be taken and other barriers will play a role as well. This would go beyond the limits for this research as has been explained before.

2.7.2 The Netherlands

The first reason why the scope is limited to the Netherlands is the following: in comparison to other countries, the Netherlands is lagging behind with the roll-out of PV systems. Therefore this study limits itself to an analysis of the barriers why the investment in PV is not taking off. This is followed by developing a strategy which overcomes the identified barriers.

Secondly, there are significant market opportunities for PV in the Netherlands because of its limited penetration in the Dutch electricity system (IEA, 2010). Eneco already has an effective strategy in marketing PV in neighbouring countries such as Belgium, France and Germany under the name of Ecostream (Weeda, 2011). However the strategy used in these countries cannot be transplanted to the Dutch market due to differences in market conditions and regulatory differences between European Member States requiring a different strategy for the Netherlands (Haas, Panzer, Resch, Ragwitz, Reece, & Held, 2011). This also implies that the conclusion forthcoming from my research can therefore not be directly replicated to other countries.

2.7.3 Timespan

Due to the fast decline in PV system prices when looking at Graph 1, a PV strategy has to be developed with due haste. From the interviews conducted with stakeholders it has become clear that in the period 2015 – 2020 the need for a separate PV strategy will decline. The technology will become cheap enough to become a genuine alternative for household consumers. From that moment onwards it is expected that a lot of new market parties will enter the market. At the same time consumers require less services because the technology quickly becomes more familiar. It is nevertheless important for Eneco to gain a foothold before this time in the PV market due to the following reasons:

- The service contracts that are sold with a PV system create a stable income over a longer period of time. There are still households that pay for a service contract for a boiler that is over 30 years old (Morren, 2011).

- When a lot of PV systems are sold to customers and they are ‘locked-in’, it provides an easy way for Eneco to offer new products, such as solar water heaters or other energy efficiency investments.
- A larger market share creates lower costs for Eneco; the lower costs originate from utilizing learning effects and economies of scale by being able to purchase at a large scale. This will become quite helpful once grid-parity is achieved in the Netherlands and competition is likely to increase. Eneco can then use their lower costs as a competitive edge.
- PV is part of their sustainable image and strategy; therefore they have to invest in renewable energy projects and PV is a very appealing and visible project to consumers.

Furthermore with regard to the timespan it should be noted that currently there is little policy in place to stimulate investment in PV in the Netherlands for consumers as can be seen in appendix B. It is unlikely this will change in the near future (Buddenbaum & Vrijmoed, 2011), unless early elections are held and a change of government ensues. Therefore the scope of the research is focused on the period 2011-2015.

2.7.4 The scale

The benefits of implementing PV on a small scale are limited. Benefits are likely to present themselves when adequate economies of scale and scope are achieved. It is not attractive for Eneco as a company to consider the small scale facilitation of a PV roll out, except when the motivation is different such as the Zonnestroom proposition to which Appendix A reffered where learning was the main motivation. According to Weeda (2011), developing a roll-out of PV systems on a large scale involves selling over 10.000 systems a year. During the study it will be taken as a given that the strategy is developed to be implemented on a large scale

PART II – System Analysis

"Sooner or later we shall have to go directly to the sun for our major supply of power. This problem of the direct conversion from sunlight into power will occupy more and more of our attention as time goes on, for eventually it must be solved"

Edison Pettit, Wilson Observatory, 1932

Chapter 3

3. Eneco PV motivation

Chapter three tests the assumption whether PV actually is the best suited technology for consumers to generate their own electricity and for Eneco to build a strategy. The sub question to be answered in this chapter is:

> *Is PV the most appropriate technological choice for Eneco to build a PV strategy, considering technological, institutional and process factors?*

To answer this research question it is important to obtain insights in the Dutch renewable energy market and specifically for PV. The Dutch PV market can be considered as a market consisting of three different systems: a technological system, an institutional system and a process system (Weijnen, Herder, & Bouwmans, 2008).

Chapter 3 is divided into five paragraphs, represented by Figure 9: Chapter 3 Outline Paragraph 3.1 describes the Dutch renewable energy market. Paragraph 3.2 describes Eneco's strategy. In paragraph 3.3. a comparative analysis is carried out to investigate whether there are other competitive technologies that perform better or are cheaper. The fit with Eneco's strategy is presented in paragraph 3.4, followed by the conclusion in paragraph 3.5 answering the sub research question.



Figure 9: Chapter 3 Outline

3.1. Dutch renewable energy market

Below a short overview is given of the Dutch renewable energy market from three different perspectives. It starts with a technical perspective, followed by an institutional perspective and finishes with a process perspective.

3.1.1. Technical Market

Although many global developments take place concerning our energy supply, the focal point of this study is PV electricity for (retail) consumers[8]. Consumers face a set of compelling challenges, such as rising electricity costs, environmental damage and security and reliability of our supply (Shum & Watanabe, 2008; Del Rio, 2011; Clastres, 2011). These challenges force consumers to look for alternative sources in order to satisfy their (rising) energy demand (Ministerie van EL&I, 2011). One such alternative is generating electricity at home. This is a huge step from the current

[8] During this thesis the terms customer and consumer are used. The word consumer is often used when the thesis refers to electricity consumers, while customer is used when referring to a person aiming to buy a PV system. Although both terms are at times used interchangeably.

paradigm/situation where electricity is generated by centralized power plants, which are often fired on fossil fuels (Verbong & Geels, 2010). The produced electricity is transported from these central power plants to the consumer through an elaborate transmission and distribution grid.

In contrast, generating electricity at home means electricity is generated very close to the point of consumption. The consumer becomes to a certain degree self-sufficient in satisfying his electricity demand. The concept of generating electricity close to the point of consumption is often referred to as "distributed generation"[9]. There are a number of technologies that can generate electricity on a residential scale, such as photovoltaics (Zeman, 2010), μ-CHP (Combined Heat and Power) (Peacock & Newborough, 2005) and urban wind turbines (NWEA, 2009). A more detailed analysis of advantages and disadvantages of these technologies can be found in appendix D.

Photovoltaics does not solely generate electricity but it also solves large societal energy issues such as energy dependency, global warming and energy security. The main advantage of PV for the consumer market is that it is well-suited for application in the built environment on rooftops.

When consumers invest in a PV system they also contribute to solve large societal issues like global warming and pollution. Each installed PV system contributes for example to national renewable energy goals as set by the European Union.

3.1.2. Institutional Market

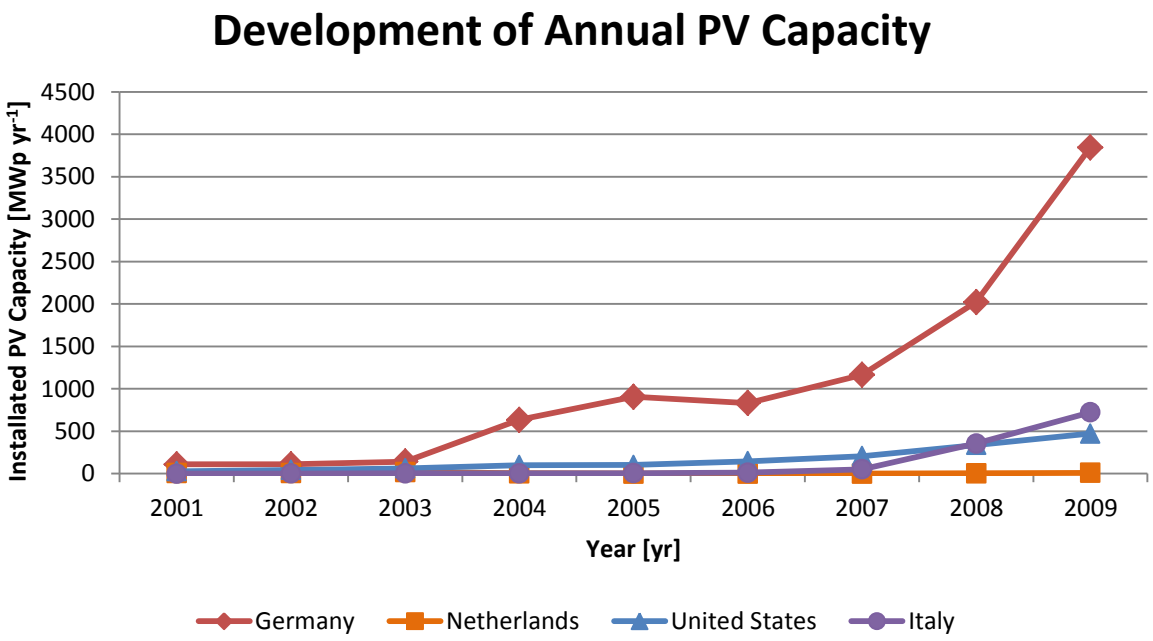
In the past the Dutch government stressed the importance of PV for our national electricity supply (Negro, Vasseur, van Sark, & Hekkert, 2009). Recent elections and the financial/economic crises have caused PV stimulation measures to be reduced or abolished. Subsidies for PV are no longer available for consumer/residential systems under the new ruling *Stimulering Duurzame Energie +* scheme (SDE+) (Ministry of Economic Affaris, Agriculture and Innovation, 2011). Only large PV installation (> 15 $kW_{p)}$ are eligible for subsidies. These systems are however too large for consumers to install and generate[10] electricity. The lower limit of 15 kW_p applies to other renewable energy technologies as well.

From an interview conducted for this research project with representatives of the Ministry of Economic Affairs, Agriculture and Innovation (EL&I) it has become clear that the Dutch government will only stimulate the Dutch PV industry instead of the generation of electricity by consumer PV systems (Buddenbaum & Vrijmoed, 2011). The Dutch industry includes business that produce solar panels as well as the companies building the machinery that produces these PV panels. An elaborate description of Dutch policy with regard to PV stimulation in the Netherlands can be found in Appendix A. From the analysis in the appendix it can be concluded that inconsistent Dutch renewable energy policy creates a significant barrier for the large scale roll-out of PV and for building PV strategy for a company like Eneco.

[9] Distributed Generation, generation of electricity involves small amounts of generation located on a utility's distribution network for the purpose of meeting local demand and/or to displace the need to build additional or upgrade local distribution/transmission lines (source: www.hi-energy.org.uk/glossary.html) last queried: 20-10-2011.

[10] An average household in the Netherlands consumes 3450 kWh yr^{-1}, while a 15 kW_p system is able to generate in excess of 12750 kWh yr^{-1} (assuming an insolation of 850 load hours per year).

The lack of stimulation measures and the continuously changing renewable energy policy in the Netherlands resulted in a strong slowdown of solar PV installations in the Netherlands, while in Germany the promotion of investment in PV has been very successful. Also countries like the United States and Italy are quickly picking up pace. In 2009 The Netherlands installed 7 MW_p whilst Germany installed over 3845 MW_p of PV system (IEA, 2010), as is demonstrated in Graph 2.



Graph 2: Annual solar PV installation in the Netherlands, Germany and Belgium (Source: (IEA, 2010))

On the other hand, the lack of progress in the Dutch PV market presents a significant opportunity for any competitive proposition for the introduction of PV and building a PV strategy that is able to conquer the Dutch PV market.

3.1.3. Process Market

In recent years initiatives such as *WijWillenZon*[11] and *Greenchoice*[12] have proven that a promising/large demand by consumers for affordable solar PV propositions in the Netherlands exists. A market study carried out by USP market consultancy (2011) reconfirms this observation. Although consumers are enthusiastic about PV, they are sceptical at the same time. The constant change of governmental policy and the absence of stable stimulation measures are two of the most often cited reasons why PV investments are not taking off. Consumers continue to perceive PV as expensive (USP Marketing Consultancy, 2011) and feel that an investment in PV is only profitable if subsidies are provided by the (local) government. Although PV without subsidy is approaching grid parity for consumers (Berenschot, et al., 2011).

[11] WijWillenZon is a collective initiative promoting household to invest in PV, the collective nature of the organisation is used to create high discounts for the PV systems sold to consumers. Website: http://www.wijwillenzon.nl/ last queried 25-10-2011

[12] Greenchoice promoted an initiative where the consumer could install a PV system at no upfront costs. The consumer finances the system by paying for the electricity generated by the PV system. Website: http://www.greenchoice.nl/thuis/zelf-opwekken/met-zon/ZonVast last queried: 25-10-2011.

3.2 Eneco Strategy

This paragraph describes Eneco's corporate strategy and how Eneco envisages its future. Eneco is the only integrated energy supply company in the Netherlands. It has adopted a strategy to play a leading role in the transition towards a completely sustainable energy supply. Eneco has a broad portfolio of activities regarding energy, like production, trading, transmission and supply of gas, electricity, district heating and related services. Eneco's current strategy is influenced by rising energy prices, energy dependence, climate change and environmental impacts. Technological developments play an important role in their strategy such as smart grids, electric mobility and distributed generation creating many new business opportunities for Eneco (Eneco, 2011a). These developments create pressure on the classical role of energy supply companies. Eneco feels that the best strategy to ensure continuity of their business is to become a truly sustainable energy supply company (Eneco, 2011a).

Eneco's sustainable strategy '*Duurzaam, Decentraal en Samen*' (DDS) is based on three pillars: sustainable energy generation, decentralised local solutions and cooperation with stakeholders both external and internal. Eneco's role therefore changes from a traditional energy supplier to an orchestrator or facilitator. Eneco shares knowledge, provides services and stimulates the development of sustainable energy. Through investments in both small and large projects innovative solutions are created in cooperation with stakeholders. The strategy is aimed not only to offer reliable and affordable energy, but also the supply of renewable electricity. The main aim is to offer a completely sustainable energy supply by the year 2030. To reach these goals Eneco is investing in the use of renewable sources such as wind, solar and biomass (Eneco, 2011a).

The second pillar of Eneco's strategy '*Decentraa*l' aims to transform their current energy supply from a centralized to a decentralized system using the renewable energy from local sources. This supports the reduction of environmental impacts because transmission losses of electricity are decreased by small distributed production facilities (Kaplan, 1998). Decentralised generation creates an energy system that is no longer one way traffic where the consumer is solely dependent on the energy supply company, instead the energy supply company is dependent on the consumer for their energy supply and becomes the orchestrator that balances needs in the local grid (Eneco, 2011a). This pillar promotes knowledge sharing when renewable energy is becoming the more dominant source of supply for electricity in Dutch society. To fulfil its strategy Eneco wants to stimulate investments by consumers in sustainable energy.

Finally, the pillar '*Samen*' or 'Together' means cooperation between both internal and external stakeholders. Internally it refers to better cooperation between the different business units within Eneco. The external stakeholders are those who have a stake or direct interest in the market for renewable energy. 'Together' refers also to the position that Eneco takes in the value chain of energy supply and the envisaged transition to a sustainable energy supply system. Consumers are expected to generate part of their own energy needs in the future. Eneco will take the role of dealing with shortages or excesses in generation of energy and balancing total energy supply. Eneco has to take an active and visible role in dealing with these issues in cooperation with the consumers. Eneco indicated it does not have the power to execute the energy transition from fossil to renewable by itself. Eneco has to act both as an initiator and a participant in projects, connecting the stakeholders and developing partnerships required for successful project execution (Eneco, 2011a).

3.3. Comparative Analysis

Eneco considers PV as a promising technology for consumers to generate part of their electricity needs themselves contributing at the same time to their sustainability goals (Eneco, 2011a). These sustainability goals have been described in paragraph 3.2. A thorough motivation for this technology choice is however lacking and should be further substantiated, if Eneco wishes to proceed with their strategy. The comparative analysis in this paragraph compares alternative technologies that can fulfil a similar role as PV and that may outperform PV at multiple levels. Alternative technologies could be cheaper or have greater advantages for Eneco and its customers.

The execution of this analysis prevents the development of a strategy based upon an inferior or immature technology harming Eneco's long-term objectives through a wrongful allocation of resources. Finally, the comparative analysis expands the system boundaries to find out what other developments could be used to achieve the main strategic goals of Eneco.

The comparative analysis focuses on the technology for the generation of renewable electricity with characteristics similar to PV. The condition is that these technologies can be applied on a similar scale as a consumer PV system having a power output between 1 to 15 kW. This output enables consumers to invest in a technical solution meeting part or all of their electricity requirements. The technologies can be installed "behind the meter" (see Appendix B.)

The consumers will use the electricity generated largely by themselves. If the consumer generates an excess of electricity, this excess of electricity can be sold to the grid[13]. In case there is none or insufficient electricity production to meet the electricity requirements, the shortage can be supplied by the grid.

For individual consumers, there are multiple ways to make their electricity consumption more sustainable. The most important options are listed below with their respective advantages and disadvantages:

- Energy collectives. These are collectives where a number of consumers join forces. A collective has the advantage of creating economies of scale and scope, resulting in relatively low investment costs per consumer. There are disadvantages as well: the uncertainty whether the electricity generated by the collective installation can be used to settle the consumer's electricity demand (Ernst & Young, 2009). Energy collectives are not in the scope of the definition of this thesis as explained in paragraph 2.7.1.
- Green certificates. Green certificates ensure that the electricity bought has a renewable origin. Green certificates are bought by consumers as '*groene stroom'* from their energy supply company. Nearly all Dutch energy supply companies offer *'groene stroom'* as part of their product portfolio. The main advantages are that a consumer does not face any system investment costs and the product is easily chosen and provided. The disadvantage is that green electricity certificates can be from a disputable origin, for example not all biomass can be considered to be renewable (Sebastián, Royo, & Gómeza, 2011).
- Another option is to invest in large scale wind and biomass installations. However, Individual investments are too large for a single consumer to bear. Therefore it requires a form of

[13] Grid, in this instance refers to the electricity supply company

collective installation. It also results in electricity generation 'in front of the meter'. As explained before, collectives are beyond the scope of this thesis.

The first alternative technology is micro-Combined Heat and Power (μ-CHP), the second technology is the urban or micro wind turbine. Both technologies are cheap enough for an individual consumer to invest in. The alternatives are well suited to be placed behind the meter and generate electricity at a household's scale.

The choice for μ-CHP can be considered to be disputable as it can run on two fuels: biogas and natural gas. In case the installation runs on natural gas, substantial CO_2 reductions can be achieved in comparison to electricity from the grid. The CO_2-reduction is achieved by producing electricity at the same time as there is a heat demand in the system, increasing overall system efficiency (Peacock & Newborough, 2005; Kuhn, Klemeš, & Bulatov, 2008). However this system still uses a non-renewable energy source When the system runs on biogas it is fuelled by a renewable energy source and μ-CHP can be considered as renewable energy.

Urban wind turbines generate electricity by converting wind power to electricity. Wind turbines can be placed in gardens or on rooftops. The main-advantages, disadvantages and characteristics of these technologies are explained below, more details can be found in Appendix D.

An objective tree is created to define the selection criteria for PV, μ-CHP and urban wind turbines. The objective tree translates the objectives of Eneco into criteria. These criteria are used to evaluate the different technologies and to analyse which alternative has the best overall performance. The results are presented in Appendix D. The objective tree can be found in Appendix C.

Criteria	Photovoltaic systems	Micro-CHP	Urban wind turbines
Installed investment costs [€ kW^{-1}_{el}]	1	3	2
Electricity Costs [€ kWh^{-1}]	2	1	3
Maintenance Costs [%]	1	2	2
(Economic) Lifetime [yr]	1	2	3
Capacity Factor [kWh / kW]	1	2	3
Safety	1	1	2
Input	1	2	1
(LCA) Carbon Emission [g CO2 kWh^{-1}]	2	2	1
Unit Production Resources	3	1	2
Recycling [% of components]	1	1	1
Energy payback [yr]	1	2	1
Sizing	1	2	2
Installation	1	2	2
Capacity potential of the technology	1	3	2
Site Specificity	1	2	3
Permit Procedures	2	1	3
TOTAL	**21**	**29**	**33**
SCORE	**1**	**2**	**3**

Table 4: SMART-Card Comparative Analysis

As can be seen from Table 4, a PV system ranks as the best technology considering the requirements for generating electricity behind the meter, whilst the urban wind turbines ranks as the worst technology. The scoring works by means of ranking, a '1' refers to highest ranking technology, while '3' refers to the lowest ranking. Therefore the technology with the lowest 'score' is the best technology. The urban wind turbine suffers from the fact that the technology is positioned at the start of the learning curve (NWEA, 2009), while PV is further ahead.

The main issue with the μ-CHP is that it suffers from high costs as well as the fact that it is disputable whether it is genuinely sustainable. A second problem is the required heat load characteristic of the system. Electricity generation only occurs when there is a sufficiently high heat demand, while at the same time insulation requirements for homes are increasing (ECN, 2009). This further reduces the attractiveness for μ-CHP. Therefor μ-CHP is not a preferred alternative. In the following paragraph it is investigated whether PV fits in Eneco corporate strategy.

3.4. PV fitting into Eneco's strategy

This study aims to answer the question how to build a PV strategy which should contribute to the main business strategy explained in the previous section. It is required that the characteristics of PV systems and application of these systems match the strategy requirements of Eneco's main strategy.

PV is a renewable source of energy. It generates electricity directly from sunlight and converts it into electricity without producing hazardous wastes or using fossil fuels (Zeman, 2010). Therefore PV matches this first pillar of the strategy of Eneco. PV is an excellent technology to generate distributed energy and is suitable to generate electricity for a family on the roof of their own house (Shum & Watanabe, 2009). When the system generates too much electricity it delivers that energy back to the distribution grid, effectively 'selling' it to their neighbours, thereby reducing overall transmission and distribution system losses (Kaplan, 1998). PV therefore does contribute also to the second pillar of the Eneco strategy. The third pillar, is 'Together' with stakeholders. Although this study focuses specifically on the consumer market and its stakeholders it is very likely that any strategy will require the support of multiple stakeholders.

Looking at the pillars of Eneco's corporate strategy and at a potential operational strategy based on PV technology it becomes apparent that there is a high degree of correspondence between the two. PV is one of the options to generate sustainable energy at a local level. Small residential PV projects need a high degree of cooperation between different stakeholders to successfully execute the project. From an interview (with Weeda) it became clear that Eneco already operates a number of PV assets, although most of them are situated abroad. These are large PV projects in France and Belgium. In the Benelux Eneco has 17 MW of large scale PV projects selling electricity directly to consumers. Eneco would like to expend their solar PV footprint, either by increasing these assets or by selling service packages to consumers (Weeda, 2011)

3.5. Conclusion

PV is the right technology as has been indicated by Eneco from the start of the research. PV is the best suited, although not perfect, technology for generating electricity behind the meter. Based on the comparative analysis PV-systems can be very well used to substantiate a new Eneco strategy. Although PV does provide a number of important benefits, the Dutch renewable energy market for PV remains difficult at best. There are no renewable energy subsidies except for net metering. At the same time competitors are moving in similar directions, indicating that the customer is willing to consider investing in PV, but he remains hesitant to make an investment decision at the same time.

Finally, PV has a great benefit for Eneco's corporate strategy. It will not only reduce the electricity system losses, but it also creates an opportunity for Eneco to expand its generation assets and service contracts with their customers. An important remark has to be made: the technological developments in the field of renewable energy sources are going fast. It is therefore important to check the attractiveness of the different technologies from time to time in order to validate the strategy is still the best strategy.

Chapter 4

4. Stakeholder Analysis

Eneco is present in many activities of the energy sector such as: electricity generation, trade, supply, distribution and installation. This involves many different stakeholders with opposing interests and goals. Also in a large scale roll-out of solar PV for the consumer market in the Netherlands many stakeholders will be involved. These stakeholders, including Eneco, will often have conflicting opinions, goals and interests. If Eneco wants to be successful, it needs to take account of the interests of the stakeholders by incorporating these into the decision making process.

A stakeholder analysis aims to identify the main stakeholders and answer the following research question:

> *Who are the main stakeholders involved in a PV proposition and, what is their role in the process of developing a PV strategy?*



Figure 10: Chapter 4 Outline, the Stakeholder Analysis

Figure 10 shows the outline of the stakeholder analysis. Paragraph 4.1., describes the identified stakeholders based upon the methodology presented in paragraph 2.6.1. Paragraph 4.2 describes the stakeholder profile of the main problem owner Eneco in greater detail. This is complemented by the identified stakeholders in the stakeholder analysis of paragraph 4.3 and is followed by a number of important stakeholder relations in paragraph 4.4. Finally, the conclusion of the stakeholder analysis is presented in paragraph 4.5.

4.1 Identified Stakeholders

In paragraph 2.6.1 the process of executing a stakeholder analysis was explained in greater detail. The stakeholder analysis is executed for in short the following reasons: it helps to structure the actor environment, it identifies potential problems at an early stage and it provides insight in the relationships between the stakeholders. Stakeholders can create robustness and flexibility for a PV-strategy by contributing information and other resources. The stakeholder analysis is an important part of the CSA, because the stakeholder analysis is an important part of the MDM explained in paragraph 2.4.4.

The stakeholder analysis used for this research is an extension of the “classical stakeholder analysis”. This adaptation has been developed by the TU Delft. This type of stakeholder analysis has been extensively taught to students in the BSc and MSc SEPAM programmes.

A first list of stakeholders was identified together with my supervisor Hans Kursten at Eneco. Other stakeholders were added to the list by using the three tactics, *imperative, positional* and *opinion*

leadership see paragraph 2.6.1. The list was further extended by investigating the value chain of PV to check if any stakeholder was overlooked. A list of important stakeholders identified through the value chain can be found in Appendix F.

Finally the interviews conducted with the stakeholders yielded a number of stakeholders which they felt were important and that were not identified during the previous steps. The *reputational* tactic completed the list of stakeholders by adding the *Consumentenbond, Welstandscommissie* and *Vereniging Eigen Huis.* The complete list of identified stakeholders (21) can be found in Table 5. A more elaborate description of each identified stakeholder is provided in Table 21 in Appendix F.

Identified Stakeholders	
Eneco	Members of Parliament (MP Samsom)
Ministry of Finance	Scientific Institutions (ECN)
Ministry of EL&I	Distribution Grid Operators (Stedin)
Ministry of Internal Affairs (IA)	AgentschapNL
Consumers	Environmental Organisations
Holland Solar	Consumentenbond - Vereniging Eigen Huis
Consumer Collective (Bewonerscollectief Biesland)	Real-Estate developers
Renewable Energy (project) companies (Green Spread)	Local Government – Municipalities and Provinces
Financial Institutions (ASN Bank)	Welstandcommissie
PV Installation companies (GSU)	ODE
PV system supplier	

Table 5: Identified Stakeholders for the Stakeholder Analysis

The first step is to investigate the stakeholder profile of Eneco in more detail in paragraph 4.2. as Eneco is a complex stakeholder and the problem owner in this research. In the subsequent paragraphs the stakeholder analysis is completed by the inclusion of the other stakeholders as presented in Table 5.

4.2 Stakeholder Profile: Eneco

Eneco is a composed stakeholder. Composed stakeholders can be seen as an individual stakeholder consisting of different parts or subgroups. Parts of the group can have different perceptions, views, opinions and resources. In this stakeholder analysis composed stakeholders are included as one group, if their parts do not have differing views and perceptions. They are split up in subgroups if they have different views and opinions of the matter at hand. Another example of a composed stakeholder in the stakeholder analysis is the Ministry of Economic Affairs, Agriculture and Innovation (EL&I) and AgentschapNL. The Ministry of EL&I in its turn is part of the composed stakeholder 'national government'. Because Eneco is the main problem owner the stakeholder analysis is executed up to the business unit level, where the PV strategy plays an important role.

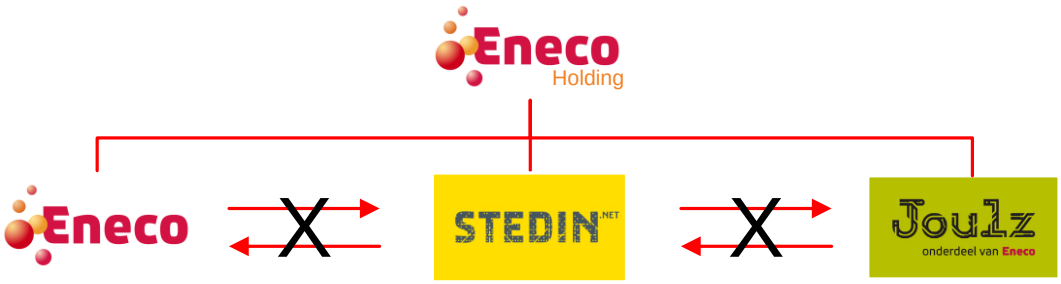


Figure 11: Organizational Chart of the Eneco Holding (Source: (Eneco, 2011a)).

Figure 11 shows the structure of the Eneco Holding, consisting of the stakeholders: Eneco Energiebedrijf, Stedin and Joulz. According to the Dutch Electricity Act the intra-corporate relations between Eneco Energiebedrijf, Stedin and Joulz are prohibited, often referred to as the "Chinese Wall" (Eneco, 2011d). In practice this comes down to the three companies not being allowed to provide any preferential treatment of any kind to each other.

- **Eneco** is the Energy supply company of the Eneco Holding, tasked with generating, wholesaling, retailing, supplying electricity, gas and heat for consumers as well as investing in sustainable energy solutions.
- **Stedin** is the distribution system operator of Eneco for electricity and gas in large areas of the Randstad[14]. Stedin is also concerned with the maintenance and operation of the energy-infrastructures. Stedin facilitates the transport of electricity and gas for all energy suppliers to their customers in their service areas. Stedin is an important stakeholder because it has the obligation to connect the solar PV systems to their electricity distribution grid.
- **Joulz** constructs and maintains the electricity, gas and heating infrastructure as well as it provides advice. Their customers are distribution system operators such as Stedin, as well as large energy consumers who are responsible for certain aspects of their own energy infrastructure. Joulz is not included further in the stakeholder analysis for the reason that their activities do not concern the small and residential consumers.

Figure 12 provides a more detailed view of Energiebedrijf Eneco, from here on referred to as Eneco. Eneco consists of multiple business units. Not all the business units are represented in this picture. Only the most important business units having a connection to the PV proposition are shown:

[14] The Randstad is a conurbation in the Netherlands, consisting of the four largest Dutch cities, Amsterdam, Rotterdam, The Hague and Utrecht, of which the former three are included in the area where Stedin is active. Source: www.en.wikipedia.org/wiki/Randstad Queried: 31-10-2011

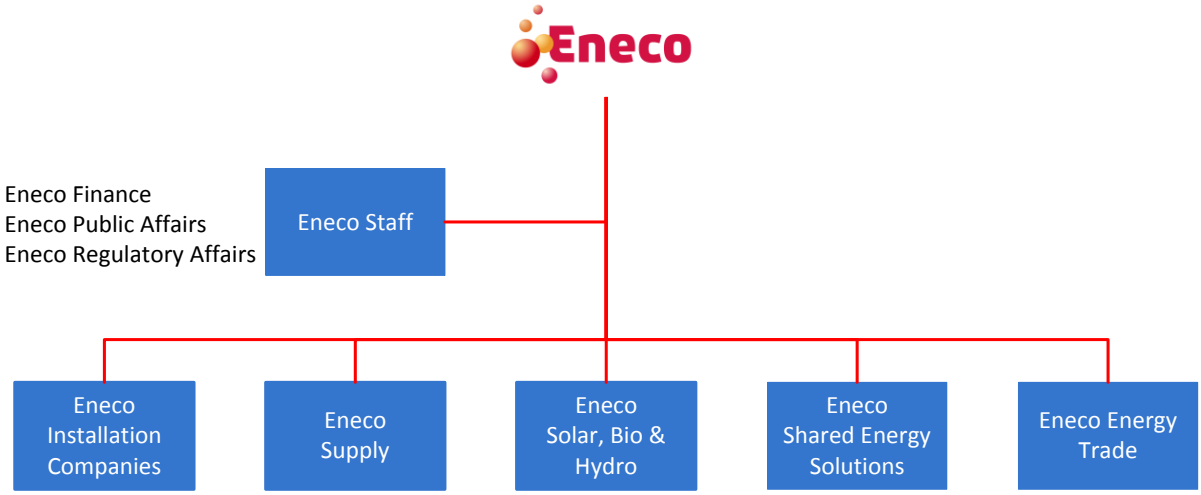


Figure 12: Organizational Chart of Eneco Energiebedrijf, adapted from (Eneco, 2011a)

Eneco Staff

The Eneco Staff supports the business units of Eneco with finance related issues as well as public and regulatory affairs. Regulatory affairs includes current laws and regulations in the field of electricity production, distribution and regulation from the central government, such as the Dutch Electricity Act and the regulator NMa. Regulatory affairs is an on-going process of trying to change current regulations of the institutions for the benefit of Eneco. This staff unit is important because from the interviews it became apparent that a number of stakeholders have issues with the regulations concerning renewable energy. They would like to see changes with regard to policy to stimulate investment in renewable energy. Public Affairs is mainly concerned with improving public opinion and relations as well as influencing members of parliament in the development of new regulation and adapting existing regulation (Eneco, 2011e). Finally Eneco Finance deals with the day to day financing of the Eneco Energiebedrijf business as well accounting and other financial obligations.

Eneco Installation Companies

Eneco has three installation companies operating in different geographical areas in the Netherlands: *Tempus* in Zuid-Holland, *Metapart* in Noord-Holland and Flevoland and *GSU* primarily in the Utrecht region. The Eneco installation companies will have an important role to play in a large scale roll-out of PV for two important reasons: contracting with them should be less of an issue as with external parties because they are part of Eneco (i), Eneco will capture a larger share of the added value because these activities are carried out by a company belonging to Eneco (ii) (Eneco, 2011e; Morren, 2011). However it remains unclear how the companies will deal with installations outside their geographical operating region.

Eneco Supply

Eneco Supply consists of a large number of divisions. The divisions Retail and Services will also be involved in the large scale roll-out of PV for consumers. The structure of Eneco Supply is shown in Figure 13. Eneco Retail does the consumer affairs, connecting consumers to the local grid smaller than 3 x 80 Amperes. Eneco Retail manages the retail delivery of electricity to consumers including sales. The division Retail has been involved with promoting the *Zonnestroom* PV proposition (Verbeek, 2011). Services is concerned with contracting billing and support activities.

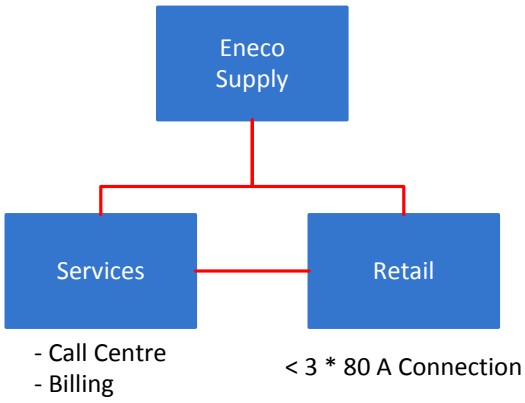


Figure 13: Eneco Supply divisions concerned with consumer solar PV adapted from (Eneco, 2011e).

Eneco Solar Bio & Hydro

The divisions of the business unit Eneco SBH concerned with solar PV are shown below Figure 14. Eneco Solar manages the solar PV assets of Eneco in the Netherlands as well as in the rest of Europe. Depending on the proposed strategy of Eneco's solar PV proposition Eneco Solar will be the asset manager of the solar PV project. Ecostream France is the division responsible for procuring solar PV systems. Ecostream did the procurement for the *Zonnestroom* proposition during the summer of 2011. Ecostream France will probably have an important role in procuring the solar PV systems needed for the large scale roll-out of PV for Eneco in the Netherlands (Verbeek, 2011; Weeda, 2011).

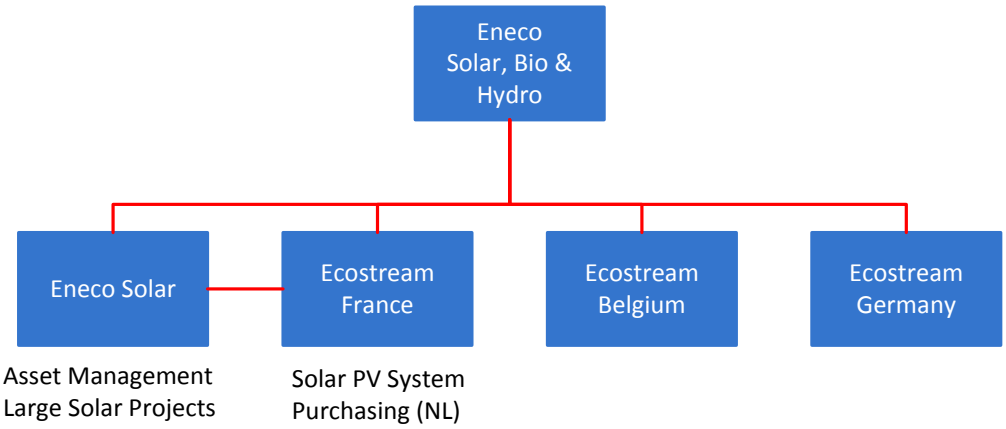


Figure 14: Organizational Chart Eneco BSH (adapted from (Eneco, 2011e))

Concluding

Looking at the organizational chart of Eneco the first thing that catches the eye is the fragmented structure of Eneco by business activity. When working on any market oriented project, multiple business units and divisions have to be involved to build a proposition. This could be a source for significant coordination problems and issues around business interests and related governance issues, like budget responsibility. Other questions are: who should take the lead in developing a compelling proposition enabling the large scale roll-out of solar PV in the Netherlands for consumers? Eneco SBH might be a good option as they have the necessary knowledge to source components and calculate the business case. However they do not have the relationship with customers as Eneco Retail has.

Another issue is that the business units will have specific targets with regard to profit and revenue. In achieving their targets they make use of internal mark-ups for intercompany transfers. These are based on the internal cost-accounting practices of large organisational firms. These mark-ups support the accomplishment of the targets of the individual business unit but it might raise the overall costs. The mark-ups may be good for the business unit, but it is not in the interest of the organisation as a whole and it inhibits innovation (Morren, 2011; Verbeek, 2011; Berck & DeMarzo, 2007).

The perception of the business units between each other is at times problematic. Business units perceive each other as slow and too rigid with regard to procedures. This might culminate into a perception where external parties are perceived as more successful, innovative and aggressive in launching propositions. This attitude is surprising because Eneco positions itself as a sustainable energy supply company, having the knowledge with regard to sustainability (Weeda, 2011; Verbeek, 2011).

The above issues are recognized by Eneco and have the attention of management, although the issues are not solved yet. When Eneco Retail launched the Zonnestroom proposition it was presented as a take it or leave approach to the other business units: it was a question of, either to play ball or to leave the business to other market parties. This approach was taken to learn and to increase cooperation between the business units responsible for PV. In the end it was a successful approach (Verbeek, 2011).

The issues as described above may be problems of a temporary nature as a stakeholder analysis is always a snapshot view of a dynamic process. This means that the interests and goals of the business units can become less fragmented and more aligned in the future. This would be beneficial to the development and roll-out of a PV strategy in the Netherlands.

4.3 Stakeholder Analysis

Facilitating the large-scale roll out of solar PV in the Netherlands is not a task Eneco can take up alone. Eneco needs other stakeholders to contribute and cooperate in facilitating the roll-out of PV successfully. To form a coalition of stakeholders or to gain their cooperation it is important to obtain an overview of the stakeholders involved with solar PV for consumers in the Netherlands. The problem formulation for the stakeholder analysis is therefore, which differs slightly from the sub question for this chapter:

> *How does the stakeholder network for the large scale roll-out of PV for consumers in the Netherlands look like, and who are the possible (conflicting) partners for Eneco concerning the facilitation of the large scale roll-out?*

To answer this question a list of relevant stakeholders involved with the large scale roll-out of PV in the Netherlands (see paragraph 4.1), needs to be setup. The stakeholders have been categorized into four groups. Next interviews have been set up with the stakeholders as explained in paragraph 2.6.3. These are marked green in Table 6. The transcripts can be found in the Transcript Addendum. The stakeholder analyses is presented in much greater detail in Appendix F.

Governmental Stakeholder	Stakeholder on the Value Chain	Scientific Institutions	Interest Groups / Organisations
– Ministry of ELI – Ministry of Finance – Ministry of IA – AgentschapNL – Local Government (Provincial States & Municipalities)	– PV-system suppliers – PV-system installers (GSU) – Eneco – DSO (Stedin) – Financial Institutions (ASN Bank) – Competitors (Green Spread) – Energy Companies – Real Estate Developers	– ECN	– Consumers – ODE – Holland Solar – Consumer Association – Consumer Collectives – Members of Parliament (MP Samsom) – Building Inspectorate – Environmental Organisations

Table 6: Stakeholder Overview – Interviewed Stakeholders are Marked Green

The information obtained from the interviewed stakeholders was combined with information from literature and the respective stakeholders' websites to complete their own and other stakeholder profiles, required for the subsequent stakeholder analyses. The orange coloured stakeholders were mentioned by the interviewed stakeholders as important. Their profiles were constructed by the information provided by the interviewed stakeholder and their respective websites. The complete profiles can be found in Table 23: Quick Scan. This does not detract from the quality of the analysis, other than it has not been fully completed. However with the stakeholders that have been interviewed, a very substantial amount of representative information is obtained without these stakeholders.

After the quick scan it is important to recognize the formal relations between the different stakeholders. The formal tasks of stakeholders, their relationship with other partners and government legislation are extensive. It is difficult to show all the formal and informal relations in a diagram or figure. Therefore a number of relationships are not shown and others are simplified in Figure 15, Figure 30 in Appendix F, provides a more comprehensive view. The (in)formal relations form a 'spaghetti' of relations in the stakeholder network (De Bruijn & Ten Heuvelhof, 2008). It shows that the stakeholder network is very complex with both formal and informal relationships between stakeholders. This complexity does provide opportunities as well. A selected group of stakeholders can exert a maximum amount of influence by using their relationships with other stakeholders. To maintain a readable representation of the stakeholder network, a fewer number of stakeholders are depicted, as shown in Figure 15. A very interesting relation is the relation between the Ministry of Finance, Ministry of EL&I and the energy supply companies. The Ministry of Finance collects the energy taxes and influences the budget of Ministry of EL&I. If net metering would be applied on a wider scale the ministry of Finance would collect less tax and might make objections to such a measure (Samsom D. , 2011). For more information Appendix B.

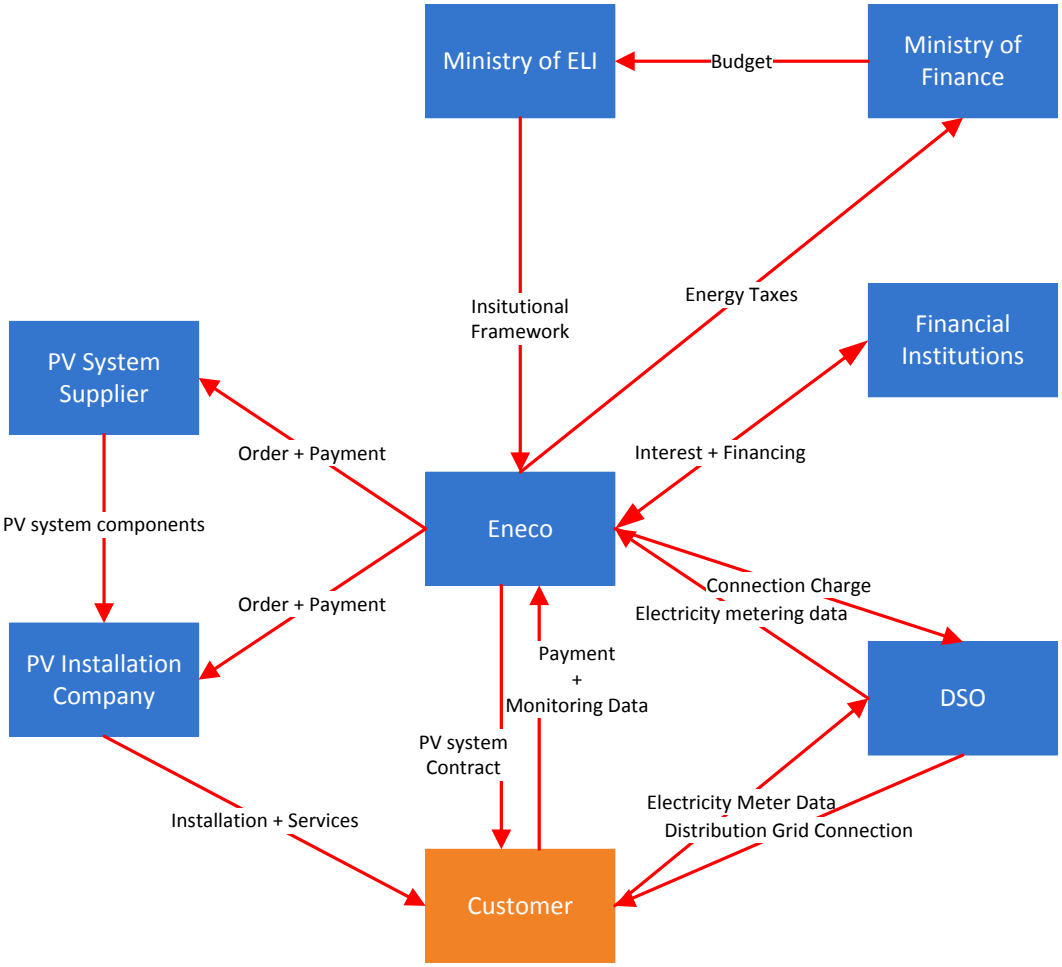


Figure 15: Formal relations between a selected group of stakeholders

Figure 15 provides a better understanding of the relationships in the stakeholder network (Enserink et al, 2010). In the Netherlands the stakeholder network is often characterised by a high degree of cooperation, even though a hierarchical nature is present. This hierarchical relation does however not imply that a stakeholder can simply push his interests through. This is also known as the *'poldermodel'*.

The next step involves identifying what the interests, objectives, problem perceptions and desired solutions of the stakeholders are. This is a very extensive step in the stakeholder analysis, which has been carried out in Appendix F. This step is important because it helps to identify who the main stakeholders are. The complete analysis can be found in Appendix F in order to keep this text concise.

Next it is important to identify which stakeholders have important resources, if they are critical or if they can be replaced. Important resources can be considered as any of the following eight identified resources:

- Authority
- Money
- Organisation
- Legal Procedures
- Position
- Knowledge
- Information
- Protests

The degree of replicability indicates if a stakeholder can be replaced by another stakeholder in his category. The level of dependency refers to if an actor has much influence on the problem or finding a solution.

In the end this determines whether the stakeholder in question is a critical actor, meaning he has the ability to realise a solution or whether he has the power to block possible solutions. These then are the stakeholders that simply cannot be ignored when dealing with problems or developing solutions (Enserink et al, 2010). Table 25 in Appendix F shows the complete table of scores for each stakeholder. The above leads to the following identified critical stakeholders.

- Eneco
- Ministry of EL&I
- Consumers
- Distribution Grid operators (Stedin)
- Financial Institutions (ASN Bank)
- PV Installation Companies (GSU)
- PV system suppliers
-

The identification of the critical stakeholders and their 'dedication' to the perceived problem creates the following important table for Eneco. Dedicated stakeholders are intensely involved and are affected by the problem, while non-dedicated stakeholders are not affected or don not perceive the problem as an immediate threat or opportunity. Finally it is important to classify the stakeholders with regard to their alignment with the interests of Eneco. The results are displayed in Table 7.

A number of stakeholders are mentioned more than once in Table 7, this is because they have contradictory interests. For example: the Ministry of EL&I has internally conflicting interests. On the one hand their policy is to increase renewable energy in the Netherlands, and on the other hand policy is designed to keep the Dutch energy infrastructure affordable. Another example relates to members of parliament. The members of parliament are member of different political parties, with different interests and objectives. With regard to renewable energy there is a significant difference between members of the Christian Democratic Party, (CDA), or of the left wing party GroenLinks. Consumers are chosen as a non-dedicated stakeholder because they have conflicting interests too. An investment in a PV system competes with an investment in a new car, holiday or cruise and if they were dedicated, one might assume they would have already installed a PV system in the first place. A more in depth explanation of this table can be found in Appendix F.

	Dedicated Actors		Non-Dedicated Actors	
	Critical Actors	**Non-Critical Actors**	**Critical Actors**	**Non-Critical Actors**
Similar / Supportive Interests and Objectives	– Eneco – DSO's (Stedin, Liander etc.) – PV system installers (GSU, Tempus, Green Spread, etc.) – PV system suppliers – Ministry of ELI *Actors that are likely to participate and are potentially strong allies*	– Consumers – Consumer Collectives – Holland Solar – Environmental Organisations – AgentschapNL – Financial Institutions (ASN Bank, Triodos) – Local government – ODE *Actors that probably will participate and are potentially weak allies*	– Ministry of IA – Consumer Association – Real Estate Developers – Members of Parliament – Consumers *Indispensable potential allies that are hard to activate*	– Scientific Institutions (ECN, TU Delft, etc.) – Members of Parliament *Actors that do not have to be involved initially*
Conflicting Interests and Objectives	– Ministry of EL&I *Potential blockers of certain changes (biting dogs)*	– Direct Competitors (Awizon, Greenchoice, etc.) – Other energy companies *Potential critics of certain changes (Barking dogs)*	– Ministry of Finance – Members of Parliament *Potential blockers that will not act immediately (sleeping dogs)*	– Members of Parliament *Actors that need little attention initially*

Table 7 Overview of the alignment of interests and dedication of the different stakeholders

As a result of the analysis, the following stakeholders are qualified as the main stakeholders:

- Eneco
- Ministry of EL&I
- Consumers
- Distribution Grid operators (Stedin)
- Financial Institutions (ASN Bank)
- PV Installation Companies (GSU)
- PV system suppliers

These stakeholders do not differ from the critical stakeholders identified before. These main stakeholders should be taken into account during the development of solutions for the issues identified in chapter 5.

For each of the main stakeholders a short description is given to provide an impression about the organisation and their role in the stakeholder network regarding the large scale roll-out of solar PV for consumers in the Netherlands.

4.3.1 Ministry of Economic Affairs, Agriculture and Innovation (EL&I)

The Ministry of EL&I is responsible for a good investment climate in the Netherlands, improving the competitiveness of businesses as well as keeping an eye for sustainability. Energy is one of the policy areas of the Ministry. Energy is important for businesses as well as consumers. The energy supply needs to be reliable, affordable and sustainable. The Ministry is tasked to accomplish the sustainability targets set by the EU and Dutch parliament. One of their responsibilities is to stimulate the transition from a fossil fuel based energy system to a renewable energy system. Currently the Ministry of EL&I has set its focus on setting up a Green Deal[15] with other market players for the wider use of renewable and sustainable forms of energy production. The green deal should also reduce the institutional barriers experienced by many stakeholders to invest in renewable energy sources.

4.3.2 Consumers

Consumers are in principle interested in PV systems. Consumers are motivated by the fact that a PV system: (1) can lower their monthly utility bills, (2) can help in energy conservation and environmental issues and (3) it can act as an insurance for raising energy prices in the future. Consumers are motivated by price, although within the consumer stakeholder group there are different groups who prioritize differently. An important consideration is that an investment in a PV system will compete with other household investments. Therefore consumers can be considered as less dedicated but their interests are very important to listen to, as they will need to take the final investment decision.

4.3.3 Distribution System Operators (DSO's)

The distribution system operators in the Netherlands manage the distribution grids of the electricity and gas infrastructures of a specific region. The largest DSO's in the Netherlands are Stedin, Enexis, Liander and Delta. The DSO's have the obligation to connect distributed generation sources, to meter the electricity flows through the connections to the distribution grid and to manage the distribution grid ensuring a high level of reliability. The DSO's are important for a number of reasons. DSO's have the metering data as well as the power to delay or inhibit the connection of distributed generation sources such as solar PV systems to their network.

[15] For more information on the Green Deal, the website of ELI has more information: http://www.rijksoverheid.nl/onderwerpen/energie/green-deal last queried 1-11-2011

4.3.4 Financial Institutions

Financial institutions are interested in realising PV in the Netherlands, because it can expand their business whilst at the same time obtaining a renewable or sustainable image. Financing a PV system can be considered to be a low risk investment for a financial institution. The revenues of a PV system can be considered fixed as well as the costs. Financial institutions are important for a PV proposition, because a large part of the consumers do not have the financial means to invest on their own in a PV system. A condition for Eneco to become successful in PV either Eneco or the financial institutions need to provide the necessary financing. In view of the fact that cash and working capital for Eneco are as important as for any other company, financial institutions inclined to finance PV investments of consumers are important.

4.3.5 PV system installers

The PV system installers are responsible for the installation and design of the PV systems as well as delivering the necessary quality. The majority of the installation companies see PV as a way to generate additional business and ensure the continuity of their business. The PV system installers also fulfil an important role in maintaining and servicing the installed systems.

Eneco Holding owns a number of PV system installers, however these do not have a complete national coverage. They are predominately active in the Randstad area. If the large scale roll-out of PV is to become in effect and a national proposition is launched, Eneco will have to either expand their installation companies or cooperate with other installation companies in areas outside of the Randstad.

4.3.6 PV system suppliers

The solar PV system suppliers sell the packages of PV modules and inverters. They are responsible for the delivery of the system, product guarantees and the optimal combination of inverters and solar panels. The PV system suppliers buy their components directly from the industrial producers. There are large differences in the quality of the systems they offer. Many of these stakeholders are relatively small. Relations between Eneco and the suppliers are important to obtain genuinely high quality PV systems.

4.4 Stakeholder Relations

Figure 15: Formal relations between a selected group of stakeholders represents the formal relations between the stakeholders involved in the large scale roll-out of solar PV in the Netherlands. There are some other important remarks to be made. Eneco has a great deal of influence over a number of the stakeholders involved. More specifically DSO Stedin and a number of PV installation companies are owned by Eneco (as described in paragraph 4.2). These strong relations have to be kept in mind when looking at the various stakeholder relations.

A possible conclusion of the stakeholder analysis and relations could be that Eneco takes up a project management role, to coordinate the relations between the stakeholders involved in rolling out a PV strategy for Eneco. It is possible for Eneco to bring together the competencies and roles of the financing institutions, the PV system installers, PV system suppliers and the distribution system operators. In doing so Eneco is able to exploit its existing customer base to market a PV product, while asking other stakeholders to provide specific system functions, where Eneco does not have the necessary competencies.

The project management role would fit Eneco further because of the billing they currently do for their network partners. Eneco obtains the metering data of its customers through the DSO (Wijgerse, 2011). This administrative competency could be exploited further when Eneco decides to offer PV system services to its customers.

4.5 Conclusion

From the stakeholder analysis of Eneco the following conclusions can be made

1. Eneco is a fragmented organisation, which could create significant coordination problems Important is that one business unit will take the project lead, like a party such as Eneco SBH.
2. Tension could emerge between the three business units having specific targets with regard to profit and revenue. Internal mark-ups may cause suboptimal behaviour for projects that cross business unit boundaries. Because of this marked-up transition costs of the internal services the viability of any proposition drops. The mark-ups may harm the interest of the organisation as a whole and it inhibits innovation across multiple business units.
3. Eneco can take confidence from the successful launch of the *Zonnestroom* proposition and apply these learnings in considering a large scale roll-out of PV in the Netherlands.

Based on the analysis the following can be concluded about the other stakeholders in the PV market and their relationships.

1. There is a large number of stakeholders relevant for the PV market. Some develop competitive PV products, others play an important role in the institutional framework or have an important role in the implementation of PV systems. Building inspectorates and consumer associations may not have an active role, but are watching from the side-line.
2. The following stakeholders are critical stakeholders: the Ministry of EL&I, the Ministry of Finance, financial institutions, PV system suppliers as well as the installation companies, DSO's, customers, and of course Eneco itself.
3. These critical stakeholders are important for a large scale PV proposition. The roles that these stakeholders are going to perform in the process of developing a PV proposition have to be determined when Eneco makes a choice concerning the PV strategy.
4. According to the stakeholders interviewed many perceive that the Dutch government or the Ministry of ELI should do more to stimulate the roll-out of PV in the Netherlands. However under the current political and economic climate it is unlikely that significant progress will be made. New subsidies are unlikely, due to the general status of the economy. A reform and lowering of the energy tax is unlikely as well because this tax is required to finance the national budget (Buddenbaum & Vrijmoed, 2011; Samsom D. , 2011). Under the new 'Green Deal' EL&I is trying to remove barriers for sustainable energy in the Netherlands. Multiple parties are deliberating with EL&I about improving the investment climate, however this can be a lengthy processes before action is taken. Therefore an improvement of the business climate for PV is not taken into account in this study.
5. Uncertainty remains about the roles that the stakeholders will take in a PV proposition by Eneco because the proposition is still under development. However it is certain the a majority of the stakeholders are positive towards cooperating with Eneco on the development of a PV proposition. This conclusion can be made on the basis of the interviews conducted with the stakeholders (see the Transcript Addendum).

Chapter 5

5. Barrier Identification

This chapter investigates the barriers inhibiting the investment in PV in the Netherlands. The following sub questions will be answered:

3. *What are the main barriers according to the stakeholders deterring PV investment in the Netherlands, that can be influenced by Eneco looking at the following type of barriers?*
    a. Technical barriers
    b. Institutional barriers
    c. Process barriers

4. *What are the most important barriers of the identified barriers?*

5. *What are the underlying issues of the identified main-barriers, providing starting points to search for scientific theory?*

All potential barriers are identified by stakeholder interviews as explained in the methodology chapter. If necessary, the information about the barriers is complemented or further explained using scientific literature. The most important barriers are selected and described in greater detail at the end of this chapter. In the subsequent chapters of Part III the building blocks for these identified barriers are developed.

Figure 16 shows the outline for this chapter. Paragraph 5.1. describes the barrier identification process through the interviews. The next paragraph describes the process of identifying and selecting the barriers in greater detail. Paragraph 5.3. presents the most important barriers per category and selects the main barriers for further analysis. In paragraph 5.4 and 5.5. the underlying causes of the two identified main barriers are investigated. Followed by paragraph 5.6. where the conclusion of this chapter is presented.

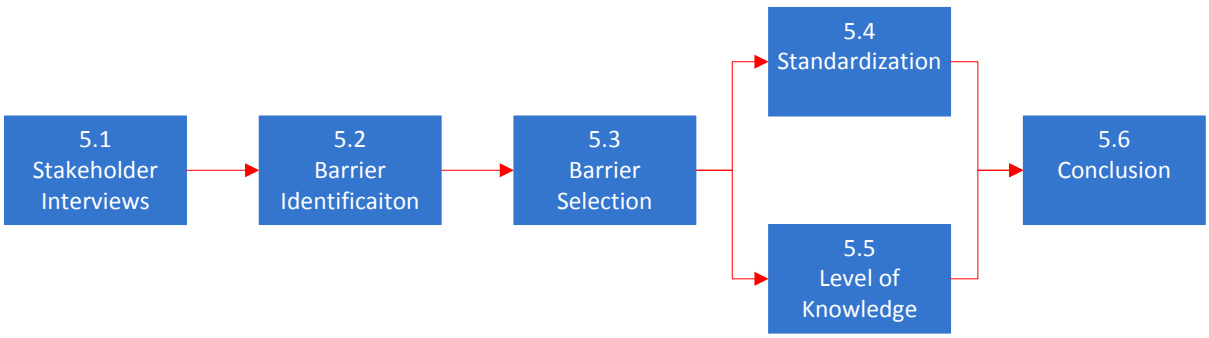


Figure 16: Chapter 5 Outline, Barrier Identification

5.1 Stakeholder Interviews

The stakeholder interviews are used to gather the information needed to identify the barriers which prevent a large scale roll-out of PV in the Netherlands. In the previous chapter the same interviews were used to gather more information from the stakeholders to perform the stakeholder analysis in chapter 4.

A total of 23 stakeholders[16] were approached for an interview. The approach for the interviews is described in paragraph 4.1. Eleven stakeholders responded positively on the interview invitations. These eleven stakeholders included all the main stakeholders except for the PV system suppliers and consumers identified in chapter 4. The lack of a consumer interview was solved by interviewing a representative of a consumers collective "Bewonersvereniging Biesland". The lack of PV system supplier is compensated by interviewing dhr. Schootstra of Holland Solar the PV industry trade association. The most important stakeholders are thus included. The list of interviewed stakeholders can be found in Table 8. The transcripts referred to in the table can be found in the separate Transcript Addendum.

Interviewee	Company / Association	Transcript
Dhr. Ed Buddenbaum **Mevr. Suzanne Vrijmoed**	Ministry of EL&I – Energy Directorate	Transcript I
Dhr. Peter Paul Weeda	Eneco Solar Bio & Hydro	Transcript II
Dhr. Martijn Schootstra	Holland Solar	Transcript III
Dhr. Ardo de Graaf	*Bewonerscollectief Biesland*	Transcript IV
Dhr. Jan Willem Zwang	Green Spread	Transcript V
Dhr. Mark Jan Roesing	ASN Bank	Transcript VI
Dhr. Rien Morren	Eneco *Installatiebedrijf* GSU	Transcript VII
Dhr. Diederik Samsom	Member of Parliament Kamerlid PvdA	Transcript VIII
Dhr. Wim Sinke	ECN	Transcript IX
Mevr. Inge Wijgerse	Stedin	Transcript X
Dhr. Bert Janson	AgentschapNL	Transcript XI

Table 8: Interviewed Stakeholders

During a later stage of this study I interviewed another two employees of Eneco. These have not been included for the analysis in this chapter. They were used to gain more information about both marketing as well as financial aspects. The interviews were scheduled and an interview protocol was set up to structure the interviews. The interview protocol can be found in Appendix C. The goal of the interview protocol was twofold: to identify in a structured way the barriers perceived by the individual stakeholders and to gather information about the stakeholders. During the interviews the interviewees were also asked to identify opportunities for PV in the Netherlands.

The interviews were conducted in an open atmosphere, where stakeholders could speak freely and be open and forthcoming with information about the issues. The result was often that stakeholders gave more information on what they perceived as important in relation to the problem.

[16] 23 stakeholders are more stakeholders than the 21 identified during the stakeholder analysis. The higher number of interview requests is due to the fact that a number of stakeholders more sent than one person. The complete list of invited stakeholder can be found in Table 21 in Appendix F.

5.2 Barrier Identification

The complete list of barriers is presented in Appendix G. A shortlist of the most important barriers can be found in Table 11. The barriers were identified by information provided by the stakeholders and literature. Many barriers are similar in nature, but phrased differently. These barriers were combined and defined as one barrier making the barrier list more accessible and readable.

The issues were arranged into four different categories (see Table 11 and Appendix G). The research question stated that there are three different categories. The interviewed stakeholders however mentioned a large number of financial barriers regarding consumer PV systems, thus a Financial barrier category was added. This results in four categories:

1. Financial Barriers
2. Technical Barriers
3. Institutional Barriers
4. Process Barriers

The most important barriers are selected by means of the following protocol. First the number of stakeholders that mentioned the barrier explicitly or implicitly were counted. During the interviews stakeholders often did not mention the barrier explicitly but in a more implicit or descriptive way. These cases have been included as well. If a stakeholder mentioned the issue, one point was added to the barrier-score.

Because the problem owner of this research is Eneco and the strategy is built for Eneco, their influence on the issue is measured as well. For this purpose a scoring table was set up measuring the level of influence by Eneco over a given issue on an ordinal scale, see Table 9[17]. If Eneco has no influence over the issue, the issue is ranked with a score of 0. If Eneco has a high level of influence over the issue a score of 3 is added up to the barrier-score. In the case Eneco can exert indirect influence on the issue, through other stakeholders or their network the barrier is ranked with a score of 1 or 2, depending largely on the strength of the relation. For more information regarding indirect influence, I refer to the work of De Bruijn & Ten Heuvelhoff (2008) and Enserink et al., (2010).

	Ordinal-Scale			
	None	*Low*	*Medium*	*High*
Score	0	1	2	3

Table 9: Eneco influence scoring table

The sum of Eneco's influence and the stakeholder score are compared with the other barriers. An example of this is given in Table 10. If the score is tied in a certain case, the influence score takes precedence over the stakeholder importance, thus barrier ZZZZ is chosen, This is done because Eneco is the problem owner for this study.

[17] An ordinal scale has been chosen because it is hard to say that a medium level of influence is twice as influential as a low level of influence, therefore a ratio-scoring method is dismissed **Ongeldige bron opgegeven.**– Dictaat TBM SPM 4121.

Barrier	Eneco Influence	Stakeholder Importance	Total Score
XXXX	None (0)	4	4
YYYY	Low (1)	6	7
ZZZZ	High (3)	4	7

Table 10: Barrier scoring table

From each of the four categories the highest ranking barriers are selected with a maximum of two barriers in total each from a different category. The maximum of two issues is set because this master thesis project needs to be manageable and doable in the allotted time. This means that two categories are not represented explicitly in the development of alternatives. Ultimately, the barriers that are not selected for further research are used as criteria or requirements for the development of the building blocks to build a solution. This is in line with the methodology presented in paragraph 2.4.4. on the meta-design model. If a building block touches upon a previously identified barrier it should be designed in such a way that it is complementary or contributing to solving this barrier.

5.3 Barrier Selection

In favour of the readability of this paragraph the barriers are condensed into Table 11. The lowest scoring barriers have been left out of this table according to the procedure as explained. The barriers that do have a low score can be found in Appendix G. The highest and thus most important barriers are presented in Table 11 below. The two highest ranking barriers are selected for further research, with only one barrier per category. The number shown in parenthesis, is the Eneco influence score. This is shown because the influence score decides which barrier is chosen in the case of a tie.

Issue	Final Score Total (Influence-score)	Taken to the underlying issues
Financial Barriers		
Lack of capital	**4** (2)	No
System Size	**7** (3)	No
Technical Barriers		
Standardization	**8** (3)	Yes
Quality uncertainty	**7** (2)	No
Institutional Barriers		
Contracting / Cost and Benefits Allocation	**8** (3)	Yes
Policy In(consistency)	**8** (1)	No
Process Issues		
Level of Knowledge	**10** (3)	Yes
Level of Cooperation	**9** (2)	No

Table 11: Barrier Score-Card

Although a number of financial barriers were mentioned by the following stakeholders: Eneco BSH, Holland Solar, Green Spread, ASN Bank, GSU, PvdA and Bewonerscollectief Biesland, the barriers rank low compared to the technical, institutional and process barriers. Process barriers are the highest ranking barriers according to the stakeholders. The following two main barriers have been selected, for further research in paragraphs 5.4 and 5.5 respectively:

1. Standardization
2. Level of Knowledge

The barrier “level of cooperation” has a higher score than the other two highest scoring barriers in the institutional and technical categories. Nevertheless, the level of cooperation has not been analysed further in this research. This is because the aim of this study is to analyse two barriers further to develop building blocks to substantiate a PV strategy. When both the barriers analysed are from the process category, it would result in a very narrow analysis. This is the main reason why the level of cooperation has been dropped, because it allows for a broader and more rich analysis.

Both ‘standardization’ and ‘contracting / cost and benefit allocation’ have exactly the same scores. The choice was made in favour of standardization. This is motivated by taking into account the following questions: for whom Eneco is developing a PV strategy? Who are they going to serve? In this case the focus is on the consumers. Investigating an issue such as contracting with external stakeholders and the allocation of costs and benefits between them is of less interest to the customer. To serve the customers interests it is important for Eneco to keep the costs down as much as possible, where standardization is more likely to achieve this than (better) contracting.

Another barrier which requires a comment with regard to the selection process is ‘Policy (in)Consistency’. Inconsistency in policy making was mentioned by many stakeholders; seven in total. This barrier is regarded as very important by the stakeholders but is not analysed further because the policy for the stimulation of renewable energy is largely established by the Dutch government. Because policy making takes a long time and multiple stakeholders with conflicting goals and interests are involved. Therefore the influence Eneco can exert on the policy process is very limited. Therefore it is dismissed in comparison to the other barriers where Eneco can exert far more influence.

5.4 Standardization

In the previous paragraph standardization has been marked as an important barrier for PV in the Netherlands. This paragraph further investigates the underlying reasons of the identified barrier.

5.4.1. The Standardization Issues

Standardization was mentioned by a number of stakeholders to achieve different objectives. The objectives are summarized below and described in greater detail onwards:

- Standardization is a mean to achieve (significant) cost reductions for PV system. Costs were mentioned by many stakeholders during the interviews: Holland Solar (Schootstra, Holland Solar, 2011), Eneco (Weeda, 2011), Green Spread (Zwang, 2011), ECN (Sinke, 2011).
- Reducing system maintenance costs in the case of system component failures. This objective was mentioned by Eneco (Weeda, 2011), Green Spread (Zwang, 2011) and the PvdA (Samsom D. , 2011) respectively.
- Improvement of the aesthetic quality of solar PV installation was mentioned by ECN and AgentschapNL (Sinke, 2011; Janson, 2011).

Eneco can exert a lot of influence over standardization, especially when Eneco would take up a project management role. The project management role is a likely role for Eneco as it was one of the conclusions of chapter 4. Eneco has an existing relationship with the customers (Verbeek, 2011; Weeda, 2011), and the project manager makes the agreements with the project partners and guides the entire process of preparing the PV proposition. Eneco could use the existing relationships with stakeholders to develop the necessary standards by utilizing the existing knowledge of other stakeholders reducing costs in the long run (Newman, Doig, Hansen, & Lacy, 2010).

Before continuing the detailed description of standardization as perceived by the interviewees, it is important that although the interviewees perceive that only few standards are in place, there are technical standards present in the PV industry to ensure compatibility and interoperability of PV components. However performance tolerances can differ substantially between suppliers (PV Resources, 2011). Resulting in the feeling of stakeholders that standards are lacking in general.

PV system cost reduction by standardization

A large degree of customization is required when installing and designing PV systems. Customization creates additional costs which is a significant barrier for PV in the Netherlands. Cost reductions are necessary to make PV more affordable for the consumer market. Standardizing the use of components, design, as well as service are possible solutions to keep the costs of PV down.

Standardisation is an important requirement to create a low cost PV proposition. Yet, it is something that is not easily achieved. Rooftops in the Netherlands are anything but standard. Different orientations, constructions as well as obstacles make every roof unique. A fair amount of customization is still required when a PV system is to be installed on a consumer roof. This problem is not unique to consumers, commercial and industrial rooftops face similar problems (Bryan, Fases , Rallapalli, & Jo, 2010). What is necessary is that a lot of the customized work needed for a PV system installation becomes standardized in the future.

PV system costs can be reduced through standardization because experienced workers using standard work practices can cut installation times. By working structurally with (roof) designers and

PV system installers, including Eneco installation companies, unnecessary racking components can be eliminated and move away from inappropriate rules-of-thumb practices. Cost reductions are hard to achieve when many different system components are used. Using one type of solar panel is often cheaper than using five different solar panels, not in the least part by utilizing economies of scale and scope (Newman, Doig, Hansen, & Lacy, 2010).

Reduction of maintenance costs by standardization

Standardisation does not only achieve investment cost reductions but maintenance cost reductions as well. Although maintenance costs are low for a PV system, using standardized components can reduce maintenance costs further. When a component needs to be replaced it can be sourced easily, or be held in inventory. Reducing both system downtime as well as costs. Currently, PV system offers are often one-time deals, with newer or older PV panels and components that are not similar to other components used in the Netherlands. This results in difficulties and delays when components break down and need to be replaced with similar but different products.

Maintenance costs can be reduced further if servicemen develop detailed knowledge about the standardized and most frequently used components. This will reduce cost over time due to faster service times and faster problem diagnosis (Tambach, Hasselaar, & Itard, 2010).

Aesthetic Quality by standardization

Standardization of components and installation can improve the aesthetic quality of PV systems by creating a more uniform and appealing appearance, although at a first glance this looks like a contradiction. The aesthetics are important to home owners as the PV panels and the installation will change the appearance of their home. This is an important aspect for PV that can be improved by an attractive design. Today, there are large differences in appearance between thin film, mono crystalline and poly-crystalline solar panels and even within these groups. Also a lot of different configurations, mounting systems are used, creating a chaotic image observed from the street, especially in areas where a lot of PV systems are installed (Morren, 2011; Janson, 2011; Sinke, 2011). Standardizing the use of PV panels, system lay-out and fixings can help to create a more serene appearance in the neighbourhood. This part of the standardization barrier was first included separately, however after the interview with AgentschapNL, it became clear that it could be included with standardization (Janson, 2011). AgentschapNL noted that if the appearance of a PV system remains unregulated it is likely that at some point regulation will be developed with regard to the appearance, creating standards by itself.

5.4.2. Standardization of Scope

The approach dealing with standardization should be aimed at the entire product, not just the technical system. The entire product of PV for consumers does involve installation and the provision of services as well. Table 12 below shows the different components of a PV system:

System Components	Installation	Services
Technical system components: – Solar PV panels – Inverters – Cables – System fixings	Design Installation	Financing Monitoring Maintenance Ancillary services Contracts

Table 12: Components making up Standardization (Adapted from (Ulrich, 1995; Duray, Ward, Milligan, & Berry, 2000; DaSilveira, Borenstein, & Fogliatto, 2001)

The components shown above are where standardization can be applied. As mentioned before system components are standardized to some extent. Standard interfaces are present to connect the PV panels, inverters, cables and fixings. Therefore the barrier cannot be aimed specifically at only the technical component level of the PV system.

A PV system involves more than just system design and installation. It includes service and contracting as well, presenting a major opportunity for standardization. Although system design has not been mentioned by the stakeholders explicitly (apart from aesthetics) it is possible to develop a design for a standard layout of a PV system. This standardized layout could then be offered to the market and installed on multiple roofs without the need for many structural changes (Morren, 2011), as long as the roof meets some basic requirements.

Services are an important element of a PV product too. Services such as financing, monitoring, maintenance contracts as well as providing ancillary services such as integration with other products and billing could be offered by Eneco. As an example a financial service could be developed as a standard financial product specifically engineered to the requirements (amount, duration, credibility) and offered as part of the PV product proposition to customers. The advantage of creating standardized services is the reduction in transaction costs (Williamson, 1979). The cost of setting up financing individually is much higher than financing as part of a larger group. Lower costs and ease of conducting a transaction reduces the barriers for PV.

Because the technical components are already standardized to a high degree, like interfaces and technical standards (PV Resources, 2011), the research will focus on standardization of the entire product, rather than the constituent parts themselves.

5.5 Level of Knowledge

During the interviews with stakeholders a number of issues became apparent concerning information. Market parties explained they lack important and accurate information about the PV market in the Netherlands. Companies encounter difficulties in tracking unbiased information concerning technological as well as institutional PV developments (Janson, 2011; Schootstra, Holland Solar, 2011). The main problem is that the information is very fragmented due to the large number of companies active in the PV market in the Netherlands (Janson, 2011). In an interview with AgentschapNL it was said that a programme is initiated to bring important stakeholders from the PV industry as well as from other organisations related to the PV industry together to identify what information they need, how the information should be collected and who should manage this information (Janson, 2011).

These initiatives tell that this problem is already being worked on by the market, with the help of the Dutch government. In that way a central place is created where professional and commercial knowledge is managed. Therefore the issue lack of professional knowledge is not taken into account because it is already addressed.

The lack of knowledge on part of the consumer is more complex and is not addressed by the industry or AgentschapNL. In a market study by USP Market Consultancy (2011) it becomes apparent that a lot of consumers are interested to invest in PV. Over 70% of the respondents claim they really would like to invest in a roof mounted PV system. From the interviews it becomes clear that consumers face multiple problems, such as technological, institutional and process issues. These issues are a

significant barrier for regular consumers. Interviewees mentioned for example that one of the problems is the lack of certification of PV system installers, creating a quality uncertainty and a trust concern (Janson, 2011; de Graaff, 2011; Zwang, 2011). The PV installers are often mentioned as a source of uncertainty for consumers amongst other installation quality concerns.

European law states that the certification for solar PV installers is mandatory from the 31st of December 2012, according to Directive 2009/28/EC[18]. During the interviews AgentschapNL mentioned that they were working on establishing a certification process with market parties. Holland Solar claims that up until now not much has happened with regard to the certification process (Janson, 2011; Schootstra, Holland Solar, 2011). However, for the purposes of this analysis it is assumed that the stakeholders involved will address these issues. Therefore this is not investigated further.

The perception of complexity for a consumer is increased by the large number of business cases presented to them by market parties. The majority of business cases are too optimistic about the returns of PV systems, as well as that they include different methods of costs calculations, benefits, electricity rates etc.[19] From others companies/market parties the customer receives conflicting information: PV is very expensive and investing in PV is not worthwhile. This information creates an overload of inconsistent information amplified by the fact that most consumers are often unaware of their energy situation. This creates difficulties for consumers to judge whether investing in a solar PV system is in his or her best interest (de Graaff, 2011; Morren, 2011; Weeda, 2011; Zwang, 2011). As long as consumers are confused about the potential costs and benefits of an investment in PV systems, due to a combination of a lack of knowledge and conflicting information, they will postpone their investment decisions.

Eneco is in a position to influence these issues. Eneco is seen as a large and reliable institution, that presents trust and reliability towards consumers (Roesink, 2011; Verbeek, 2011; Weeda, 2011). Eneco can use their position in the stakeholder network as will be shown in chapter 6, to inform and educate consumers to reduce perceived complexity and to convince consumers that a PV system is a safe investment (Saeijs, 2011).

In chapter 6.5 an 6.6. scientific literature is researched to find theories that can help solving the barrier of consumer knowledge and product complexity causing the lagging investment in solar PV. The literature contributes to developing alternatives which, if adopted, can stimulate consumer investments in PV. Paragraph 6.7 and 6.8 shows the building blocks developed for Eneco to solve the issues at hand, reducing complexity as well as educating consumers.

[18] http://www.epia.org/projects/ec-projects/quality-certification-and-accreditation-for-installers.html last queried on: 01-09-2011.

[19] During a visit to the Solar Days 2011 (7th until the 15th of May), many PV installation companies were present, using different payback times, discount rates, investment costs, electricity price increases, creating a very non-transparent picture.

5.6 Conclusion

This chapter set out to answer three research sub questions. The first question:

> *What are the barriers according to the stakeholders that deter PV investment in the Netherlands, that can be influenced by Eneco looking at the following type of barriers?*
>
> a. Technical barriers
> b. Institutional barriers
> c. Process barriers

The complete list with all the barriers identified can be found in Appendix G. However the important barriers per category were the following: '*standardization*' and '*quality uncertainty*', '*contracting cost/benefit allocation*' and '*policy (in)consistency'*, '*level of knowledge'* and '*level of cooperation'*. The second question to be answered in this chapter:

> *Which of the identified barriers are the most important barriers?*

A ranking method was used to determine which of the identified barriers were the most important. The influence of Eneco and the number of stakeholders that mentioned the barrier were used to score the barriers. The score on the influence of Eneco was weighted more heavily. This resulted in the following two main barriers: '*level of knowledge' and* '*standardization*'. The answer to the third research question:

> *What are the underlying causes of the previously identified main-barriers, providing starting points to search for scientific theory?*

Looking at the argument of the lack of standardization, it appears that standards are in place at a technology level, but that a number of elements have to be customized for each single home, creating problems for the stakeholders. Further standardization is necessary. One of the methods identified as a possibility to combine both the needs for standardization and customization is mass customization. Therefore mass customization is used in the next chapter to develop building blocks for building a PV strategy for Eneco.

The barrier, lack of consumer knowledge presents itself in a level of complexity, , where a customer is unable to cope with. Activities should be undertaken to improve the provision of information to customers as well as facilitating investment decisions. In the following chapter proposals are made to overcome and where possible solve these barriers. In the next chapter the building blocks for these barriers are developed.

PART III – Building Block Design

"As we meet tonight many citizens are struggling with the high cost of energy. We have a serious energy problem that demands a national energy policy….. The United States is confronting a major energy shortage that has resulted in high prices and uncertainty. I have asked federal agencies to work with California officials to help speed construction of new energy sources. And I have directed the Vice President, Commerce Secretary, Energy Secretary and other senior members of my administration to develop a national energy policy…. Our demand outstrips our supply. We can produce more energy at home while protecting our environment and we must We can produce more electricity to meet demand, and we must. We can promote alternative energy sources and conservation, and we must. America must become more energy independent and we will."

President George W. Bush, February 27, 2001

Chapter 6

6. Building Block Development

Two scientific theories for finding and defining the necessary building blocks for Eneco's strategy have been used. The ideas for the application of these scientific theories is based on searching scientific literature and personal interests, but most importantly they have to fit with the underlying causes identified earlier in chapter 5. This chapter aims to answer the following research questions:

6. *Is the concentric systems approach suitable to build an effective strategy in a complex market as the PV market?*

7. *Which scientific theories can be applied to solve the main barriers, resulting into building blocks?*

Figure 17 clarifies the outline of this chapter. To explain the design of the building blocks I will first develop the scientific framework for the main identified barrier, standardization in paragraph 6.1. In paragraph 6.2. the theory of mass customization is described. Next building blocks for the aforementioned barrier are developed in paragraph 6.3 and 6.4.

Paragraph 6.5 and 6.6 develop the scientific reference framework for the barriers of the lack of consumer knowledge and the development of alternative building blocks in paragraphs 6.7 and 6.8.

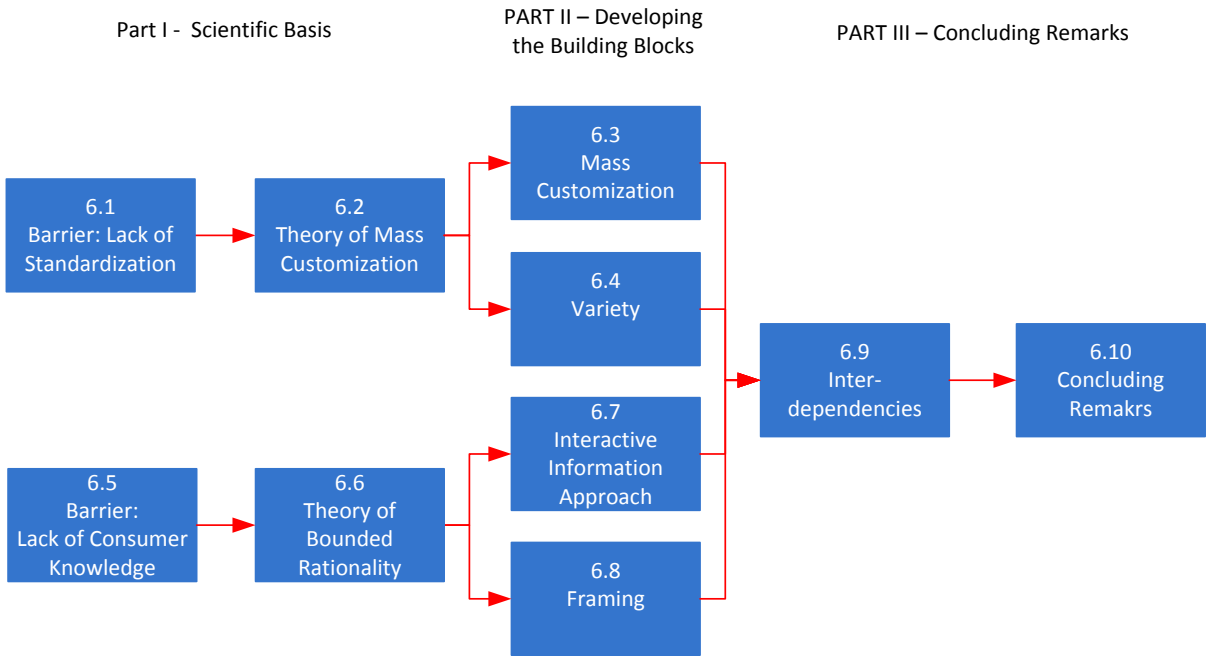


Figure 17: Building Block Development Chapter Outline

Paragraph 6.9 describes the interdependencies between the building blocks. Interdependencies are often present in socio-technical systems (Weijnen, Herder, & Bouwmans, 2008; Bauer & Herder, 2009). These interdependencies are further analysed by analysing the relations between the building blocks developed for the different barriers, as well as between the other barriers found in chapter 5.

The chapter ends with paragraph 6.10, where the concluding marks regarding the development of building blocks are presented.

The answer to sub-question 6 is given by using the scientific theory explained in paragraph 6.2 and 6.6 of this chapter to identify the various different building blocks for the morphological chart. The theories however need to be selected according to requirements set by barriers at which they are aimed. There is always a risk that building blocks become too complex, with many (inter)dependencies .This should be avoided. Complex building blocks create problems when building blocks have to be combined to form a strategy in chapter 7. From a design perspective it is necessary is that these building blocks can largely operate autonomously as loosely coupled systems as described in the paragraph 2.5.

During the building block development it could become apparent that Eneco does not have the necessary knowledge, skills or resources to roll-out a PV strategy. In this case other stakeholders should become involved. When other stakeholders are needed for the solution this will be mentioned explicitly for Eneco in developing the PV strategy in reality.

In the context of the research approach developed in chapter 2, it is important to emphasize that this chapter is the point where the research scope is diverging again. During the previous phases, the aim was to converge the scope each time, ensuring a feasible study, as well as maintaining consistency with the concentric systems approach. To identify and develop the necessary building blocks it is required to think out of the box again and look for inspiration elsewhere by diverging the scope. Although only a limited number of building blocks are developed, the combinations of building blocks help to diverge the scope even further.

6.1. Barrier: Lack of Standardization

This paragraph deals with solving the first main barrier, standardization. Two alternative building blocks for this barrier have been developed. For the definition and the nature of the building blocks see paragraph 2.5. The first alternative building block developed for the standardization barrier is based upon mass customization. Mass customization is chosen because it enables both further cost reductions and the necessary options for customizing a product to meet the customers' requirements.

For the second building block the solution is based on variety as a scientific theory. This theory resembles mostly what currently is happening in the PV industry.

6.1.1. Use of the concept of 'component' and 'building block'

Before heading deeper into the literature on mass customization it is important to define the different concepts used in the theory. The theory of mass customization and to a lesser degree variety refer to the concept of building blocks as well. This poses a problem because the definition of a building blocks used in this study is different from the definition of a building block used in the mass customization literature. The theory of mass customization refers to a building block as one of

the components in a mass customized product. So, in order to avoid confusion I will reserve the term component in the context of mass customization. Figure 18 shows the definition in use to describe mass customization, this figure is used as an example, nothing else intended:

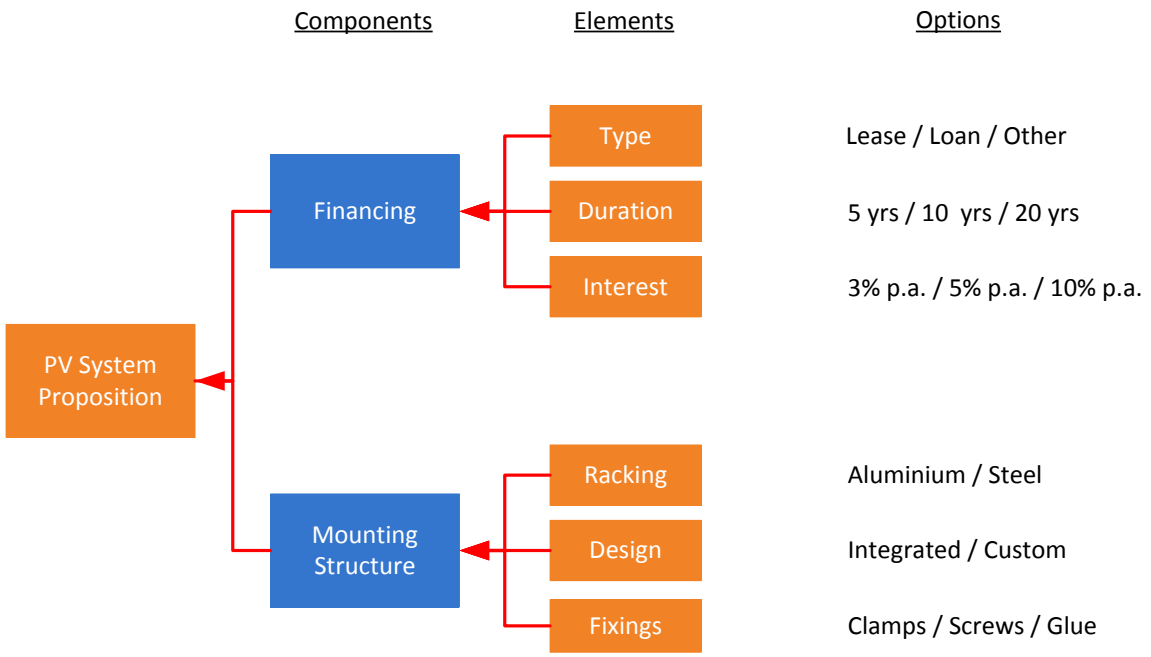


Figure 18: Terms definition of mass customization

The concept of the building block in my thesis is defined as a functional viable solution, although validation is still needed, for an identified barrier as explained in paragraph 2.5 and used in the context of CSA.

A mass customized PV system can consist of a number of modular (loosely coupled) functional building blocks. These building blocks are designed to mitigate the issues presented by the barriers. The building blocks themselves can be built from a number of different components and elements. These components and elements can have a number of different (configuration) options to choose from.

6.1.2. The Mass Customization Morphological Chart

Here the morphological chart is used to show the different, components, elements and options of a mass customized proposition. The lay out of the morphological chart is slightly different the morphological chart presented in chapter 2.4.5. The morphological chart used in this chapter is applied for a different purpose than the morphological chart in chapter 2.5. In this case is the morphological chart is used to display the different options within the scope of the building block.

The morphological chart is displayed in Table 13. To keep the morphological chart readable the components and elements are placed on the left. In the element/component column no distinction is made between components and elements to keep the chart simple. This should not pose a problem, because the main purpose of this morphological chart is to display the different options. The options are shown horizontally in the rows, the components and elements are displayed vertically in the columns. The options are marked white to show the chosen options for a certain building block. It is important to note that multiple options can be used for an element or component. This increases the

number of choices. Multiple options are possible in a proposition in order to provide multiple choices to the customer.

	Options		
Elements / Components	**I**	**II**	**III**
Component A	Option A.I	Option A.II	Option A.III
Component B	Option B.I	Option B.II	
Component C	Option C.I	Option C.II	Option C.III
Component D	Option D.I	Option D.II	

Table 13: Morphological Chart for Mass Customization

6.2 Theory of Mass Customization

Lack of standardization is one of the important barriers concerning the large scale roll-out of PV. From the interviews it becomes clear that there is a large demand for standardisation. The solution cannot simply be blunt standardisation. When offering PV systems the consumer needs to be kept in mind. Every customer or consumer has different requirements and preferences, which may create a need for customization. Pure customization is not an option. The PV system costs would be just too high to be competitive with retail electricity sold to consumers. Below a literature review is given on ways to solve the problem of standardization: mass customization and variety described later. This should enable the development of building blocks solving the barrier of standardization.

One of the barriers facing PV is the different cost structure from classical energy generation. The transaction costs of PV and other forms of distributed energy generation technologies are higher than fossil fuelled generators that often benefit from economies of scale and scope (REPP, 1998). One of the reasons why transaction costs for PV projects are higher is due to the distributed nature of renewable energy projects itself. The projects are highly repetitive and are applied many times but under different conditions. It is often argued that PV roll-out should take a product path, where it becomes a highly standardized product, rather than the customized centralized power plant path of the incumbent fossil fuelled generator (Shum & Watanabe, 2007).

There are three specificities to PV projects:

- PV projects are by nature customization oriented because system integration and installation remain site and application driven (Shum & Watanabe, 2008). This inhibits the use of a standard product strategy like mass production based on standardizing components. Each individual site requires a certain level of customization, but if this can be done at the level of a building block flexibility increases enormously with regard to other components making up the total proposition. For example, each roof is different, but if smaller repetitive designs are

created, the need of customization is decreased and other standardised components can be integrated.

- Consumer PV projects are often applied at the smaller kW scale than the MW scale fossil fuelled centralized power pants. The scale based advantages arising from construction, product administration etc. are much smaller for the size of a PV project than for a conventional project for PV (Shum & Watanabe, 2008).
- PV projects require an upfront investment by the customer while the traditional energy delivery model is based on a 'pay as you go' model for the consumer.

In short, the economies of scale resulting from large production systems are not applicable to the small consumer scaled grid-tied PV systems. Thus the challenge is that PV deployment needs to utilize the economies of scale[20] from highly standard, modular and cost efficient components that make-up a total PV system solving at the same time any potential financial barrier.

A typical grid-tied PV system with a generation capacity of a few kW's consist of a number of technical system components: PV modules, an inverter and installation components such as framing. The components themselves experience the benefits of standardization while the entire system needs a degree of customization before installation. The economy of such a system is an intermediate between standardization, due to the use of standardized components, and customization due to the need to adapt a PV system to site-specific conditions (Pine, 1993).

In scientific literature this is referred to as mass customization. It describes the situation where a mass produced product is made to specific customer needs or requirements based on list of predefined options where customers can choose from to order a 'tailor made' product. It does not fit with the conventional product manufacturing paradigm of companies that produce either completely customized products or standardized mass-produced products (Duray, Ward, Milligan, & Berry, 2000; DaSilveira, Borenstein, & Fogliatto, 2001; Davies & Joglekar, 2010). Customized products are mostly manufactured in very low volumes meeting individual requirements. In contrast mass produced products are manufactured as standard goods in high volumes in highly efficient production processes tailored to the requirements of the product. The attention here is not on consumer requirements but on maximizing economies of scale and low costs.

Davies (1987) argues that one-of-a-kind products can be manufactured to customer specifications without sacrificing economies of scale based on the concept of mass customization. This enables consumers to purchase a customized product at the costs of mass produced item. Pine (1993) complements this idea by mentioning that mass customization provides enough variety in products and services to allow consumers to find exactly what they need at a reasonable price. It should be mentioned that mass customization does not only apply to the 'physical' products but to services as well.

6.2.1 Modularity

According to Pine (1993) the basis of mass customization is modularity. Modularity provides the means to produce modular components using economies of scale. Product customization is achieved

[20] Economies of Scale are the increase in efficiency of production as the number of goods being produced increases. Typically, a company that achieves economies of scale lowers the average costs per unit through increased production since the fixed costs are shared over an increased number of products (www.investopedia.com/terms/e/economiesofscale.asp, queried 18-08-2010).

by combining and modifying the lay-out for composing the components. Components or the constituent elements that are used in a customized product can be manufactured by mass production system through standardisation. The mass production allows components to be produced cheaply and with consistent high quality, lowering the costs of the components of a PV system. However, optimal modularity is critical to achieve the mass needed for mass customization.

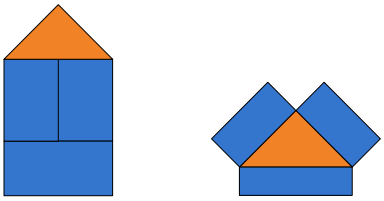
This raises questions with regard to what is the definition of modularity in order to check whether a PV system can comply with the requirements put forward by mass customization i.e. modularity. This definition for modularity is provided by Wolters (2002) as:

> *"A system is modular when it consists of distinct, (autonomous) components, which are loosely coupled with each other, with a clear relationship between each component and its function(s) and well-defined, standardized interfaces connecting the components, which require low levels of coordination"*

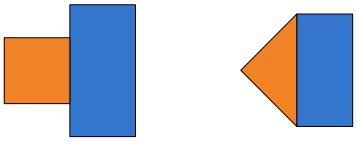
(Wolters, 2002) p. 263).

Applying this definition to a PV system we can distinguish: loosely coupled technical components, namely the inverters, PV panels and mounting components. Sometimes additional services components are offered, such as installation or a roof check. These components however are not integrated into one system, so they could be changed independently. The interfaces between these three technical components are standardized (PV Resources, 2011). Finally the relationships between components and the function of each component is well-understood and well-defined. This being the case it can be concluded that a PV system has a modular character and is suitable for mass customization.

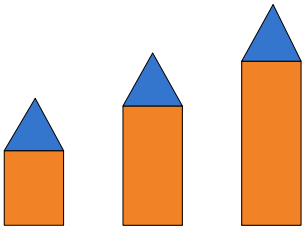
There are six types of modularity for the mass customization of both products and services (Tung & Ulrich, 1991; Duray, Ward, Milligan, & Berry, 2000). These six types of modularity – *'component-sharing', 'component swapping', 'cut-to-fit', 'mix-, bus- and sectional modularity'* – are presented in Figure 19. Each diagram presents a type of modularity. A short explanation is given on what this type of modularity encompasses.



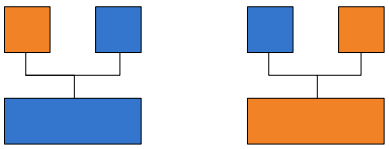
Component -sharing modularity
Common components used in the design of a product. Products are uniquely desinged around a base unit of components.
Example: *Elevators*



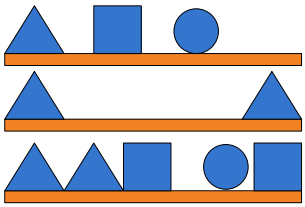
Component -swapping Modularity
Ability to switch optinions on a standard produtct. Modules are selected from a list of options to be added to a base product.
Example: *Personal Computers*



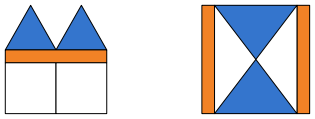
Cut-to-Fit Modularity
Alters the dimensions of a module before combining it with other modules. Used where products have unique dimensions such as length, width or height.
Example: *Eyeglasses*



Mix Modularity
Also similar to component swapping, but is distinguished by the fact that when combined, the modules lose their unique identity.
Example: House paint



Bus Modularity
Ability to a module to an existing series when one or more modules are added to an existing base.
Example: *Track Lighting*



Sectional Modularity
Similar to component swapping, but focuses on arranging standard modules in a unique pattern.
Example: *Legos*

Figure 19: Modularity types adapted from Ulrich and Tung (1991)

A more thorough explanation is provided on bus-modularity because it resembles a PV system the best. Bus modularity uses a standard structure that can attach different kind of components. Multiple modules can be added to the existing base, for example track lighting. The bus can be seen as the infrastructure. The components or modules that are essential to the customer or for the operation of the product, can be considered the bus, modularizing everything else into components that can be plugged into that standard structure. The common bus of the customized products allows for a high degree of standardization of the components based on a common bus interface. The specific factors that support the mass customization of a bus modular PV system are the following (Duray, Ward, Milligan, & Berry, 2000):

- Products have interchangeable features and options (Size, power, services).

- Options can be added to a standard product (the PV system).
- Components are shared across the developed products (the inverters, the PV modules).
- New products are designed around a standard base unit (the technical PV system).
- Products are designed around a common core technology (Photovoltaics).
- Bus-modularity allows for customized solution. In case one of the components does not fit the customers' requirement, then such a customer can choose another option for a small surcharge for the non-standard[21] module (roofing)

Therefore in the development of a mass customized alternative these are used as a basis of the alternative.

6.2.2 Advantages of mass customization

The main advantages of mass customization are:

- current PV propositions use variety rather than mass customization[22]. Such a fundamental difference makes the proposition harder to copy by competitors, because it takes more effort to set it up properly.
- Mass customization creates an innovative and sustainable proposition contributing to the goals of Eneco as well as to the requirements of customers.
- Mass customization offers flexibility to Eneco through changing components as new developments present themselves, increasing the agility of Eneco's strategy
- Customer satisfaction is likely to become higher: the final product is tailored to the needs of the customer. Becasue the components are designed to work together, instead of the lowest possible cost, which is the main driver of variety.
- Mass customization as proposed here would take a system view, rather than just looking at the physical components. A thorough look needs to be given on service components related to a PV system as well as the technical components. Taking such an integrated view increases the value for both Eneco and its customers.

6.2.3 PV system Components

Figure 20, shows the different components that make up a full service solar PV system. There is a differentiation between physical and service orientated components. However at times components are more interdependent than independent from each other. For example a more expensive inverter may provide better monitoring, maintenance and service opportunities and has for that reason a high interdependency with elements such as service or billing or the underlying aftersales service. Each of the components or underlying elements represent a number of options that can be chosen by the customer to meet his requirements. Each component fulfils a specific function in the PV system as outlined in the component's name.

[21] Standard here refers to the basic option provided to the customer from which he can upgrade.

[22] When looking at various internet sites of companies offering PV systems, either including or excluding additional services and installation, one can only discern a number of different packages. Meaning that they are marketing their products according to the variety approach. Often the installation is the responsibility of the consumer, although some provide installation as an extra option. This is not a care-free package for consumers. Mass customization however does provide the opportunity for a consumer to create a care-free package themselves.

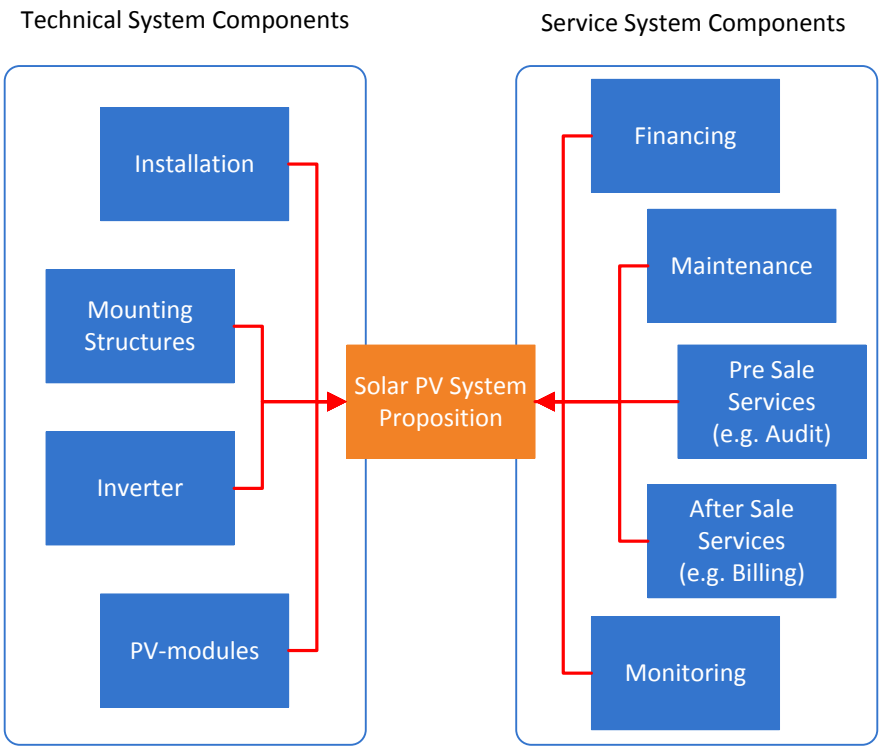


Figure 20: Modular components of a solar PV system

6.2.4 Requirements when applying Mass Customization

Finally in developing a mass customized product a number of requirements need to be kept in mind:

- A stable customer demand has to be created enabling the realization of economies of scale required for achieving appropriate cost levels (Newman, Doig, Hansen, & Lacy, 2010). The success of mass customization depends on the lower price that customers pay for mass customized products and the company's ability to produce and deliver individualized products within an acceptable time and cost frame (Hart, 1995).
- System design. The standardized components need to be interoperable with other components used by the PV system and match the customers' requirements as well. As became apparent in a discussion with Morren (2011), the system that is offered to consumers should be commensurable with both the power requirements of the consumer and at the same time preventing any over-engineering. For example a household consuming only 1500 kWh yr^{-1}, has no real need for a solar PV system generating 3000 kWh yr^{-1} (matching 3.5 kW_p a solar PV system). This means that a broader view needs to be taken, encompassing the entire system when developing alternatives ranging from technical and service compatibility with customer requirements.
- Market Conditions. The company's ability to transform the mass customization potential into and actual (competitive) advantage depends on the timing of this development. Being the first to introduce such a concept in a market may get the company entrenched and show consumers that the company is innovative and customer driven (Kotha, 1995).
- Value Chain. Mass customization is dependent on collaboration between multiple stakeholders in the value chain. The network of companies needs to be able to fulfil the system's demands (DaSilveira, Borenstein, & Fogliatto, 2001). Stable demand is necessary for the cooperation between component and service suppliers. When they think a certain

demand is present for a certain product then they are more inclined to lower their margins and cooperate in standardizing further. Standardization only works well if there is at least the expectation of a stable demand (Newman, Doig, Hansen, & Lacy, 2010)

- Customizable. Independent components, assembled into different configurations, compose a modular mass customized product. Successful mass customized products are versatile and constantly updated (Pine, 1993). A balance should be found allowing for the commercialized and cheap mass produced components of today like c-Si PV panels to achieve even greater economies of scale. Whilst leaving at the same time room for new innovative and breakthrough technologies, offering greater benefits like better quality, improved performance or cost reduction (Newman, Doig, Hansen, & Lacy, 2010).
- Knowledge sharing. Mass customization is a highly dynamic strategy depending on the ability to transform customer demands into a customized product. This requires that a company actively pursues knowledge creation and knowledge distribution across other stakeholders in the network to improve their current product or service offering (DaSilveira, Borenstein, & Fogliatto, 2001).

The solutions developed have to meet these requirements. In paragraphs 6.3 and 6.4 where the building blocks are developed these principles will be applied. Finally the developed building blocks are combined with the other building blocks, developed for the barrier lack of consumer knowledge. This will result in a partial PV strategy for Eneco.

6.2.5 Analogy

An example of a mass customization could be buying a new car. A car consists of technical and service related components. These components are often based upon a modular design. A number of large modular items in the car are: the engine, transmission, number of doors, wheels, paint and an extensive list of options. The service module components are for example: financing, insurance, guarantees and additional service options.

When a customer buys a new car either online or at the dealership he or she has a number of choices. What type of engine, an automatic or manual gearbox, colour, three or five doors, stock or alloy wheels, etc.. These are just a fraction of the choices a customer has. The customer can even decide whether he or she requires financing of the car: cash, lease or a loan. In this respect the customer buys a customized product, as the car is tailored, within limits, to his or her specific needs. While from the manufacturers point of view, he is still dealing with modular mass manufactured goods, such as the wheels, engine, transmission, colour and financing packages, that keep the costs down.All the dealer has to do is to manufacture or combine all the (modular) components together that the customer receives his customized car.

6.2.6 Variety

Variety is a term often confused with mass customization. Mass customization is not the same as variety. Variety offers more choice from which the consumer is able to choose his preferred product. If variety increases the supplier has a greater chance of success in meeting customer requirements (Desmeules, 2002). He can choose proposition A, B, or C , but he has not the ability to specify the product to his needs. When walking down the cereal aisle in the supermarket a lot of different brands and kinds of cereal can be found. However this is not mass customization. There is a lot of choice for the customer, but the customer is not integrated in the production process and he cannot

specify the content of the cereal boxes. There is a great deal of variety in the marketplace which could satisfy most customers, but is not a substitute for customization (Duray, Ward, Milligan, & Berry, 2000). “consumers do not want more choices, they want exactly what they want – when where and how they want it” (Pine, Peppers, & Rogers, 1995) A customized cereal box would be the option where the customer could choose and weigh his own mix of cereals, dried fruits, nuts and chocolate chips.

6.3 Building Block A.I – Mass Customized Full Service Proposition

The first alternative is providing a full service[23] proposition based on mass customization. Mass customization enables Eneco to approach a large share of the consumer market. The proposition fulfils more of the customers’ requirements than is the case today. At the same time it eliminates the identified underlying issues of the barrier of standardization. Mass customization can meet these requirements by providing more options to customers, keeping costs down by matching the characteristics of a mass produced product.

Alternative I is nonetheless divided into two sub-alternatives that have a lot in common and are both based upon mass customization. Alternative A.Ia is the full-service proposition, limiting the number of service options by including them in the proposition creating a carefree proposition if chosen. The second sub-alternative (alternative A.Ib) allows the customer to choose the service level matching his preferences, reducing the costs for a customer. Both alternatives should enable the option of a pre-specified technical PV system preventing a customer to become overloaded with information and options to choose from. The customer can change the configuration within boundaries to his wishes. These boundaries are set by the number of choices Eneco offers, if the pre-specified option is not in accordance with his needs (Huffman & Kahn, 1998; Herrman, et al., 2011).

Both sub-alternatives are developed as a solution for the standardisation barrier. Stakeholders expressed that cost reductions through standardization are necessary, while secondly, customers want to buy a PV system that is complete and does not need any additional work or effort on the customers part, thus a solution with ‘peace of mind’.

In both sub-alternatives a customer has to decide whether or not to invest in PV and if he or she wants more customization. If so, he can add or change components and services (in case of building block A.Ib). Once the decision is made, the consumer should not have to search the internet to find more information, such as finding a certified installer, looking for financing or otherwise (Huffman & Kahn, 1998; Morren, 2011; Verbeek, 2011). Ordering needs to be simple and straightforward, where everything from the customers’ perspective happens under one roof. This requires a significant level of coordination. These tasks, such as ordering, installing and billing have to be coordinated and organised by Eneco, or another stakeholder who markets the proposition to the customer. The implication is that Eneco needs good stakeholder connections to effectively coordinate the roles of the different stakeholders.

In short the full service, carefree or ‘*ontzorgings’* proposition is aimed at:

- First, not every consumer requires the same service level. Some want a basic service level while others prefer a more extensive model (Morren, 2011). The proposition should aim at

[23] In the interviews this is often referred to as “ontzorgen”.

providing only the services that are selected by the customer increasing customer satisfaction and avoiding over-engineering and complexity.

- Project management is an important part of the full service proposition. A consumer faces a high barrier if he has to manage all the stakeholders involved, such as: the connection with the distribution grid (DSO), financing (financial institutions), installation (PV installation companies), procurement of the PV system (PV system suppliers), billing etc. If Eneco wants to offer PV systems to customers, it has to contain these elements. An effective PV strategy should contain these elements.

The difference between alternatives A.Ia and A.Ib is that A.Ia only offers a choice between full service packages, as the aim is to offer a carefree system. A.Ib has a number of service options and different components increasing the perception of value and customization for the customer. Both building blocks A.Ia and A.Ib are pre-specified through the roof check. The roof check controls whether the roof of a potential customer is suitable for PV. Secondly it can estimate the maximum size of the PV system that can be installed on the roof as well as calculate the optimal size of the PV system taking into account the energy consumption profile of the customer (Herrman, et al., 2011). If the customer disapproves the suggested pre-specified system he can, through the technical options, customize or reconfigure the technical system.

Table 14 shows the morphological chart of the mass customization building block as explained in paragraphs 6.1. The components and elements of a PV system are shown vertically and the options provided are shown horizontally. The options that are marked white are provided to Eneco to offer in its proposition. These options can become more detailed at a later stage as a number of choices from which the customer can choose. The options provide also an important instrument for Eneco to quickly respond to changes in customer demand and technological and institutional change.

The choices provided to consumers create an open platform for PV-systems. Additional services can be plugged in or changed at the consumers convenience in case of building block A.Ib. The final product is thus developed in collaboration with the consumer. The customer can choose the product he or she wants from the options provided.

	Alternatives			
Physical solar PV-system				
Roof Suitability (Roof Check)	100%	90%+	80%+	60%+
System Size / Power	1 kW_p	1 – 2 kW_p	1 – 3 kW_p	1 – 10 kW_p
Design	Standard Lay-Out	Standard + Alterations	Standard Components / Customized	Fully Customized
PV module Technology	m-Si	c-Si	a-Si (thin film)	Other
Inverter	State-of-the-art + Wi-Fi / GPRS	Standardized Inverter	1 – off	Panel integrated
Mounting Structure	Panel integrated	Roof integrated	Standard Customized	
Component Quality	Highest industry standard	High	Mediocre	Low
Solar PV system related services				
Service	Full	Billing service only	Pick & Use	
Installation	Self Service	Self + Instructions	Full Service	
Monitoring	None (Self)	Monitoring by Eneco	Interactive Monitoring Application	
Maintenance	None	Included	Additionally	
Insurance	None (Self)	Included		
Financing	Up-front	½ down – ½ lease	full financial lease	Full operational lease
Contracting Type	Power Purchase Agreement	Service Fee	Service Fee + Lump Sum	Energy Contract Integration

Table 14: Morphological Chart Mass-Customized Full-Service Proposition

6.3.1 Mass Customization Proposition

Below the different components of the PV system are explained. The presale service and the roof check has been included under the technical system components because it influences the rest of the process and choices.

Technical PV system components

A PV system is built from the technical components, that were shown in Figure 20. A number of these components have been split into a number of smaller elements, displaying different options. The options that are marked white need to be specified into choices for customers later on, if Eneco chooses to implement this building block in their PV strategy.

Roof Check

The first step in the process for a customer who is interested to buy a PV system is to execute the compulsory "Roof Check"[24]. A roof check is already commonplace and executed by companies that offer PV installations. The roof check will present a value for the performance of PV system on a particular roof based on the attributes and the location of that roof. It can be used to advice the customer on a PV pre-specification if the customers' consumption information is taken into account.

Eneco should only market PV systems to potential customers who carried out a roof check and obtained a high value for feasibility. These customers can obtain the highest benefits of investing in a PV system. They are more willing to invest and customer satisfaction will probably be higher. If the roof check yields a low value the customer is advised not to invest by Eneco because this only results in customer dissatisfaction in the long run.

The size of a PV system in this concept is limited to a capacity between 1 and 3 kW_p. It prevents consumers from buying an oversized PV system (de Graaff, 2011; Morren, 2011; Samsom D. , 2011; Schootstra , Holland Solar, 2011). This has the following two benefits:

- It reduces the previous identified investment cost barrier. The overall system costs are lower when a PV system is smaller.
- The modular nature of the system leaves the option for a consumer to expand or upgrade their PV system at a later date. PV systems are easily upgradeable or expendable (Morren, 2011). Additionally the average electricity consumption of a household is 3500 kWh, a 3 kW_p solar PV system generates approximately 3 * 850 full load hr. yr^{-1} = 2550 kWh per year (ECN, 2010). Such a system enables a household to generate more than two-thirds of the electricity consumption themselves. The range chosen allows for smaller systems to be chosen by the customer. If their situation and or preference are more compatible with a smaller system.

Design

When looking at the design the following issues have to be kept in mind:

- Inverters, mounting fixtures and solar panels need to be standardized components. Using a single or at most two interchangeable products allows the use of economies of scale and thus standardization but also gives flexibility and reduces dependency from one supplier.
- The final design needs potentially a degree of customization to ensure that the system fits aesthetically on the roof and making optimal use of the roof surface area (Bryan, Fases , Rallapalli, & Jo, 2010). The barrier of aesthetics was explicitly mentioned by AgentschapNL and ECN (Janson, 2011; Sinke, 2011).
- To reduce costs for the design a number of templates could be used describing various situations. These templates can be used as starting points for the installers or sellers of a PV system (Bryan, Fases , Rallapalli, & Jo, 2010) . A large number of interviewees mentioned this

[24] A roof checks the orientation towards the sun, a certain orientation (inclination, facing) is scored a percentage of the most optimal orientation possible in the Netherlands. Furthermore during the roof check, the roof is checked for obstacles and suitability for a solar system. The roof check calculates the maximum size of a solar PV system. This should be compared to the consumption of the household. For an example of a simplified roof check see: www.vergelijkzonnepanel.eu/prijs-zonnepanelen/stap1. This Roof Check does not take into account shading or roof obstacles. The roof check presents a score for the feasibility of solar panels for a given location.

aspect (Buddenbaum & Vrijmoed, 2011; Janson, 2011; Morren, 2011; Schootstra , Holland Solar, 2011).

Panels

There are important choices to be made with regard to the PV panel type, more details are provided in Appendix D. The choice of the type of PV panels should be based upon the customers' requirements and situation. Thin-film solar panels have lower efficiencies and require more surface area, but are cheaper W_p^{-1} and considered as more aesthetically due to its dark uniform colour. If sufficient surface area is available, thin film panels would be more advantageous over c-Si solar panels that are slightly more expansive but more efficient. The selection of the right panel could be a software supported application.

Inverter

The selection of the inverter depends on the service components chosen by the customer and the capacity of the PV system. The inverter converts the direct current produced by the solar panel into alternating current which is used at home. A cheaper inverter can be chosen if the consumer opts for less service, while the more expensive inverter is necessary for a higher service level and is compulsory in a more carefree system proposition because the more expensive inverter have built-in service options. Providing two categories of inverters enables customers to select a system that fits their needs or their financial requirements.

Quality

Finally the quality level of the provided system has to be chosen. From information provided by the stakeholder interviews the general consensus is that the system should be of very high quality. When a system breaks down or a malfunction is detected, it will cost a lot of money to repair the system. A call from a dissatisfied consumer costs approximately €30,- per call and bad publicity (Morren, 2011; Roesink, 2011; Verbeek, 2011; Weeda, 2011). It is not advised to market cheaper solutions because these will require higher maintenance efforts and costs. It also carries the risk of reputational damage when after a couple years it becomes clear that the PV system is less reliable than could be expected.

Service PV system components

A 'pick & choose' proposition requires the customer to pick and choose which services he likes. This strengthens the perception of the customer that he will receive value for money. First, he does not pay for anything he does not want, but he also can opt for a hassle free solution that will save him a lot of time when all the service options are included.

Installation Service

The customer should not have the option to install the system himself. Some potential customers might be willing and capable to install a system themselves (de Graaff, 2011), but from a service standpoint it is advisable to install the system by an certified installer because it prevents warranty- and service compatibility issues; e.g. would a customer be eligible for the same terms of insurance if he installed the system himself? On the other hand the Eneco proposition would compete directly with the offerings of supplier who deliver PV packages as a 'do it yourself package'.

Monitoring Service

If an inverter is chosen with a monitoring option a customer can opt for a monitoring service. Otherwise he has to check the system status himself. The monitoring service of Eneco would provide him with an interactive application providing service options that shows him his current electricity consumption and generation in real time including features as monthly reports etc. These options should increase the energy awareness of consumers as well as the possibility to generate additional revenue (Morren, 2011).

Maintenance

PV systems have very low maintenance costs. In principle a consumer can deal with maintenance himself (Zweibel, 2010; Zeman, 2010). If the consumer is uncertain or the roof is not directly accessible he could choose for a long term maintenance and cleaning contract in case the system malfunctions. In that case Eneco will dispatch a maintenance crew for the consumer to service the solar PV system.

Financing

Financing a PV system is an important feature because consumers are not used to invest in electricity generation. With regard to financing a PV system three consumer groups can be distinguished who are important for the large scale roll-out of PV in the Netherlands:

- Consumers who have the financial means to pay the system upfront and taking direct ownership of the PV system.
- Consumers who do have the financial means to pay the system upfront, but do regard the high investment costs as a barrier and feel that financing the system is more beneficial for them.
- Consumers who do not have the financial means available, but are genuinely interested in investing in a PV system. This group will require financing if they are to invest in a PV system.

It is unclear how many consumers each group represents. This would require additional research. What has become clear from the interviews is that obtaining financing is a problem for most consumers. For the mass customization proposition it is recommended that Eneco looks at the financing options offered by SolarCity[25] in the United States:

- An upfront option where the customer pays the entire system upfront.
- A full lease option where the customer does not pay anything upfront but pays a monthly fee for the system over a fixed period, paying off the system at the last term.
- A combination, where the customer pays a certain percentage upfront, for example 50% and the other 50% is leased from the financing company.

SolarCity also offers a financing option where the customer prepays the system and benefits from the lease associated services, such as maintenance and monitoring services. With regard to financing it is recommended that Eneco does not provide a wide range of financing options. However it is up to Eneco to decide if they want to couple ancillary services, like insurance, to their leasing product. This requires more market research after the preferences of the customers before taking this decision.

[25] SolarCity is an American based PV company, it provides full service PV products to its customers, the financing website can be found at: http://solarcity.com/residential/purchase-options.aspx, queried: 02-10-2011

The customer pays the monthly service fee[26] through their utility bill, making use of an existing customer relationship, reducing transactions costs in the process (Roesink, 2011).

One of the advantages of offering a financing or leasing product other than reducing the high investment costs barrier, is that it creates a long term customer relationship. The customer is bounded by the lease payments over a period of approximately 5, 10 or 20 years, creating a greater customer lock-in with the energy supply company Eneco (Verbeek, 2011; Weeda, 2011).

Greenchoice already has a proposition in the marketplace providing a PV system at no investment cost to the customer. However this proposition is limited to Greenchoice customers and to a maximum of 500 PV systems. The customer signs an electricity purchasing contract with Greenchoice and agrees to purchase the generated electricity by the PV system for 20 years. Such a financing construction has not been proposed, though attractive, mainly because it creates transparency issues and additional problems. One of these other problems according to Wijgerse (2011) is an administrative issue that two electricity suppliers could become active on one EAN connection, which is the connection of the house to the electricity grid. This creates a situation that one energy company supplies the electricity when the PV system has insufficient capacity and Greenchoice supplying the electricity generated by the PV system. This situation creates administrative problems for the distribution system supplier.

For the same reason it is not possible for Eneco to integrate the electricity supply contract to the lease of a PV system and according to the Electricity Act both products may not be coupled. The customer is free to select his electricity supplier and this is not possible if the regular electricity supply contract is locked into the PV system contract. Financing should be offered as a solution to lower the barrier for the last two mentioned customer groups who do not want to or cannot finance the PV investment themselves.

Considerations

A number of important considerations have to be made in the concept provided above. These considerations form important choices which Eneco has to make with regard to developing a PV proposition, based upon the building block mass customization detailed here. The considerations were obtained during the development of this building block and through the stakeholder interviews. These considerations are made explicit in the summary provided below.

1. **Financing** is an important issue. One of the issues regarding financing is that most consumers do not have the money directly available to buy a solar PV system. This provides a significant barrier for the penetration of solar PV in the Netherlands. Alternatively financing services can be provided implying that Eneco or a financier pre-finances the project. This leads to the following calculation of the capital required to fund the project:
   The average price of an installed PV system is approximately € 4 W_p^{-1}[27] although prices are declining quickly. If we take an estimate that an average system is 1500 W_p. the total cost of

[26] Service fee = Financial Lease Payment + Service Fee.

[27] At the website of the Eneco installation companies a package of 2.1 kW_p is offered at € 7084,- - € 7436,- (Tempus, 2011). Including installation, the former price is including VAT and installation on a sloped roof, the latter price includes VAT and installation on a flat roof. Corresponding to a price of € 3,35 W_p^{-1} - € 3,51 W_p^{-1}. However taking into account the preference of the market parties to use high quality products and the fact that

an installed would be € 6.000 per system. If Eneco installs 10.000 of these PV systems a year (15 MW_p) Eneco would have to finance € 60 M yr^{-1} (In 2010 Eneco's profit was €141 M) According to the financial director of Eneco, Duisenberg (2011), such an investment cannot be financed easily by Eneco. Therefore project financing needs to be secured. The required financing could be obtained by combining a large number of financing contracts and selling them to a financial institution. During the interviews the ASN Bank said they would be interested in buying such a package of consumer financing (Roesink, 2011). Not only ASN Bank could be interested in providing financing for such a project, Rabobank, Triodos, or Leaseplan could be interested as well.

2. **Customer Base** might be too small for a viable business case and to interest sufficient stakeholders. The potential customers need to be a homeowner as well as having a home with a favourable roof orientation. The favourable roof orientation is needed to keep the electricity savings in line with the costs of the system. This could mean that the potential customer base for a PV proposition is too small. More research has to be done to investigate this matter.
3. **PV System Prices** remain high to comfortably finance a full service solution. It is expected that it will take a number of years for PV system prices to decline to a level that they are truly competitive with retail electricity prices and enable a greater degree of service provision (Samsom, 2011). Although not every consumer benefits from having all the associated services, there is an opportunity to deliver customized services. More research is needed to investigate if customers are prepared to pay more for increased service levels and consumer choice
4. **Stakeholder Cooperation** needs to be good in order to get the system operational. The stakeholders that need to be involved have been discussed in chapter 4. The cooperation of the PV system suppliers, installers, DSO's and financial institutions is needed to successfully launch any proposition. The PV system supplier has a long term relation as they have to coordinate the installation of the PV system, monitoring it over the lifetime of the system and to provide maintenance. If any of the stakeholders underperforms or cooperation is bad, then the proposition will fail.
5. **Moving service,** when a customer decides to move home the change of ownership of the PV system has to be dealt with. Especially in the case if he financed the PV system through Eneco or another party. At least one possibility has to be included that transfers ownership of the customer to another customer. This can be done by offering the options of paying off the system by the customer who is selling the home and including it in the price of the house or by providing an option that the new homeowner can acquire the lease contract of the previous homeowner. More research should be done to investigate all the possible options and which options are most appealing to the customer.

6.4 Building Block A.II: Variety

The PV concept, presented in this paragraph is a very lean, standardized product, compared to the comprehensive mass customization building block. The building block Variety aims to reduce the costs of customization as much as possible and eliminate customization where possible. The amount of choices that consumers have are reduced significantly and the risk of confusion and complexity

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smaller systems are relatively more expensive. The installed cost of PV is taken as approximately € 4,- W_p^{-1} (at 01-08-2011). Although at the time of this project being published prices may have dropped considerably.

during the selection process is reduced (Huffman & Kahn, 1998). One of the main differences is that financing is not an option here. To catch this shortfall Eneco could point the customer towards a financial institution where he can obtain financing at reasonable terms. The choice to leave out financing is motivated by the fact that it creates a significant level of complexity and thus costs in the proposition. Detailed contracts and arrangement between the stakeholders have to made.

Table 15 shows the standardized PV concept for Eneco. The options marked in white are the choices offered in this building block variety. Within each option, more specific choices can be provided to the consumer if applicable. It resembles to a large degree the concept that Eneco and other energy companies have marketed through their respective websites[28]. Most of these concepts except for Greenchoice's ZonVast[29] proposition are setup in a similar minimalistic way. Resembling variety rather than customization as explained in paragraph 6.1.

Physical PV system components

System sizes for the Variety building block are offered in the 1 to 3 kW_p range, preferably in 3 packaged PV system offerings to the customer. The packages should be built with a specific lay-out in mind, for instance in 2 rows of 5 panels or arrays constituting 3 to 4 solar panels. Such a setup minimizes the amount of customization that needs to take place reducing costs further. However, it does limit the number of potential roofs on which the marketed product can be installed, because such conditions require large surface areas without obstacles on roofs.

The roof check remains an important part of the proposition determining whether a roof is suitable for a packaged PV system. Because the total cost of the packaged PV system is cheaper, it can be installed on a broader range of roofs with less optimal solar orientations without sacrificing the financial performance of the product.

The packaged solution is designed to keep the potential customer base as large as possible at a low cost. In this case c-Si solar panels are used. These have the advantage of being smaller that thin film solar panels and are attractive to consumers with smaller roof surfaces. Because of only one type of PV panel is chosen, costs are kept minimal. For this alternative costs are as important as quality, so a trade-off has to be made. To maintain customer satisfaction high and costs low, the quality level of the installation and of the components should be kept high. Especially because if a large share of the systems fail, it will be detrimental to the reputation of Eneco.

[28] Nuon: www.nuon.nl/energie-besparen/zonne-energie/zonnepanelen/ queried 23-08-11
Eneco: www.gsu.nl/producten/zonnepanelen/pages/producten-prijzen-zonnepanelen.aspx queried 23-08-11
[29] Greenchoice ZonVast: www.greenchoice.nl/thuis/zelf-opwekken/met-zon/zonVast queried 23-08-11

	Alternatives			
Physical solar PV-system				
Roof Suitability (Roof Check)	100%	90%+	80%+	60%+
System Size/ Power	1 kWp	1 – 2 kWp	1 – 3 kWp	1 – 10 kWp
Design	Standard Lay-Out	Standard + Alterations	Standard Components / Customized	Fully Customized
PV module Technology	m-Si	c-Si	a-Si (thin film)	Other
Inverter	State-of-the-art + Wi-Fi / GPRS	Standardized Inverter	1 – off	Panel integrated
Mounting Structure	Panel integrated	Roof integrated	Standard Customized	
Component Quality	Highest industry standard	High	Mediocre	Low
Solar PV system related services				
Service	Full	Billing service and customer support	Pick & Use	
Monitoring	None (Self)	Monitoring by Eneco	Interactive Monitoring Application	
Installation	Self Service	Self + Instructions	Full Service	
Maintenance	None	Included	Additionally	
Financing	Up-front	½ down – ½ lease	full lease	
Insurance	None (Self)	Included		
Package Pricing	Per component	Integrated	Packaged	
Contracting Type	Power Purchase Agreement	Service Fee	Service Fee + Lump Sum	Energy Contract Integration

Table 15: Standardize solar PV system concept

Service PV system Components

The provisioning of services for this alternative is limited. To provide customers with support there has to be a support desk that can redirect customers with questions to the parties that can solve their issues. To generate additional revenues there is the possibility for consumers (as exists today) to opt for a maintenance contract with one of the Eneco Installation Companies (GSU, Tempus and Metapart). Financing can best be done by an up-front payment. This reduces the investment requirements for Eneco. If the consumer wishes to finance the product he has to arrange financing at his local bank. The system will be installed for the customer, generating business for Eneco's installation companies as well as reducing the investment barrier for consumer. Many customers are hesitant to install such a system themselves and are hesitant to ask a local company to install the package for them, mainly because they have no experience with these installations companies and no information on the quality of their work.

Considerations

The trade-offs made for Building Block A II Variety are:

1. **Costs versus Service.** In order to remain competitive with other propositions in the solar PV market in the Netherlands the costs have to be kept at a minimum as long as the competition is based on price. However it should be investigated if competition on price is more dominant than offering a customizable care free package. If costs are dominant then the options need to be reduced and the system has to be made as cheap as possible. Although in this proposition there is the possibility for consumers to buy the requested services at affiliated business partners.
2. **Customer Base.** Because the system is a lot cheaper it can be installed on less favourable locations and still have a favourable financial performance, however this will be at the cost of quality and service. Before deciding on using this building block Eneco should investigate what the size of the customer base is for considering the packaged solutions. A smaller or larger customer base has a significant impact on the potential profitability and performance of this building block and on the entire strategy.

6.5 Barrier: Lack of Consumer Knowledge

The second main barrier identified in chapter 5 is lack of consumer knowledge. Many surveys show that homeowners have a positive attitude towards investing in energy efficiency or sustainable innovations (DeCanio, 1993; Sansted & Howarth, 1994). A study executed by USP Market Consultancy (2011) on solar heating and electricity shows that 80% of the homeowners is willing to invest in a PV system in the Netherlands. This raises the question why the number of installations is not more in line with the research outcomes. So far only 67,9 MW of solar PV has been installed in the Netherlands (IEA, 2010). Another question is why consumers overlook energy efficiency investments that will save money in the long run (Allen Consulting Group, 2004).

As explained in paragraph 5.5 the number and variety of PV products and ancillary services available to customers are overwhelming. Numerous firms offer PV systems in the Netherlands[30], causing an information overload to consumers who are unable to make a detailed assessment of the different offerings due to the differences in the product package and by conflicting information (Bettman, Luce, & Payne, 1998). Also the large number of different parties involved in installing PV is a headache for most consumers.

6.5.1 Energy Efficiency Gap

Consumers have a positive attitude towards investing in PV, but this has not been translated into a large number of PV system installations. In scientific literature this phenomenon is described as the *energy efficiency gap*. In market studies, several authors state there is a difference between the observed behaviour and what economic theory on *utility maximization* would suggest, when a customer makes an energy efficiency investment decision (DeCanio, 1993; Sansted & Howarth, 1994). One of the explanations for this behaviour is that consumers experience an internal hurdle rate[31], that exceeds the internal rate of return of the proposed investment. The energy efficiency gap can provide a starting point in developing building blocks for the consumer knowledge barrier.

This hurdle rate or the energy efficiency gap discounts the benefits of the investment at higher rates than normal market discounting practices or capital interest rates would do. Sometimes consumers use hurdle rates as high as 800% per year (Sansted & Howarth, 1994). Meaning that an investment would have to pay itself back within 6 weeks to be profitable in the eyes of the customer, creating the problem of over-emphasizing the investment costs, and virtually ignoring the lifetime achieved savings. DeCanio (1993) and Sansted & Howarth (1994) state as a probable cause that consumers do not act rationally when making such a decision by attributing a significant weight on the investment costs in their decision. They are prone to calculation mistakes, discarding relevant information instead of looking at their information and calculations and actually making the correct decision.

A second explanation for the energy efficiency gap comes from Simon (1957). He argues that the lack of investment can be caused by the use of rules-of-thumb or by decision heuristics in making complex decisions. The hurdle rate in solar PV is then just a heuristic rule of thumb rule for a customer enabling him to make only the most profitable investments.

[30] Holland Solar is a trade organisation for among other the solar PV industry. A majority about 2/3rd of all the firms affiliated with solar PV are members of Holland Solar (Schootstra , Holland Solar, 2011).
[31] "Hurdle Rate" this refers to the minimal acceptable rate of return implicitly stated by the individual before taking a positive investment decision.

I personally think that many consumers are not used to make these type of investment decisions. For most consumers it is a huge drain on their cash position and the money flows back over a long period in small tranches. It is a clear example of a high valuation of current cash over a long period of small cash flows (Berck & DeMarzo, 2007).

The theory on the energy efficiency gap provides a possible direction towards finding alternatives to deal with the barrier of lack of consumer knowledge for Eneco.

6.6 Bounded Rationality

Herbert Simon approached decision making from a machine-learning perspective in his work *Models of Man* (Simon H. , 1957). Simon looked how the concepts of uncertainty and complexity affected human decision making. He was one of the first to create awareness on human decision making under uncertainty which creates a barrier for investment. Simon argues that it is impossible for human beings to have a complete and perfect information about any given subject at any given time (Simon, 1957). He coined the term *bounded rationality* to describe that people have limits in their knowledge and cognitive processes. Men developed cognitive and behavioural short-cuts, or "rules-of-thumb" to save on mental effort and to avoid inconsistencies (Christie, 2010). Simon described bounded rationality as follows:

> *"The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behaviour in the real world. Or even for a reasonable approximation to such objective reality"*

(Simon, 1957 p.198).

Bounded rationality is one of the founding concepts in behavioural economics. Behavioural economics emerged from dissatisfaction with the neoclassical assumptions of individuals taking fully rational economic decisions, the *homo economicus*. The *homo economicus* makes decisions from the view of maximizing his or her utility.

- The first neoclassical assumption is that the individual that makes the decisions has perfect information, perfect knowledge and stable preference functions (Kahneman, 2003).
- The second assumption is that consumers conduct a rational evaluation of all the costs and benefits of an investment.

However, studies on investments in energy efficient appliances show that individuals can act irrationally when faced with a complex or difficult problem. This often results in less optimal decisions (DeCanio, 1993; Sansted & Howarth, 1994). Either because they do not have the information required or because he is overloaded with information and is unable to discern the relevant information from the rest. According to behavioural economists individuals rarely have all information available, perfect information or stable preferences. Many economists and researchers found that the neoclassical assumptions were thus unrealistic. The neoclassical assumption often create anomalies in their research.

Bounded rationality provides to be a more realistic model of behaviour. It explains why optimal decision-making under neoclassical economic principles is an unattainable goal, because of the

cognitive and information-processing constraints of human-decision making in complex environments (Kahneman, 2003).

As Christie (2010) wrote in her dissertation, a homeowner may fail to weigh relevant variables properly when he or she considers during the summer how large their utility bill will be in winter. They could fail to take into account rising fuel costs or over- or underestimate the cost benefit analysis of an investment in an energy-efficiency investment. These examples are applicable to investments in PV systems by consumers as well. A vast majority of the consumers does not know how much they pay for energy or how they can influence consumption and what the impact of PV on usage might be.

Because bounded rationality impacts human decision making, Simon proposed that human or consumer decisions are based upon *satisficing*. Satisficing is a merger of two words, to satisfy and to suffice (Simon H. , 2003). This term explains the behaviour, people do not simply maximize or optimize as prescribed in neoclassical economics. They simply make a decision based on the premise that the outcome of the decision is adequate for them.

These concepts of Simon: *bounded rationality* and *satisficing* laid the foundation for many other researchers on decision making by consumers. Two Nobel laureates who have done extensive research on this are Kahneman and Tversky. They have investigated specific applications of decision making; why human decisions often display bounded rationality and satisficing behaviour. Their work is used developing building block B for the second barrier.

As said in paragraph 5.5., the most significant problem why consumers fail to invest in PV is because of complexity. The theory of bounded rationality helps to deal with this complexity by using its premises and proposed solutions to develop building blocks applicable to PV systems. These developed building blocks should support consumers to make the right decisions for their energy supply with regard to costs but also to the use of renewable sources of energy, as well as for Eneco.

6.7 Building Block B.I - Interactive Information Management Approach

Two alternative building blocks B are developed based upon bounded rationality and the energy efficiency gap. The first building block 'Interactive Information Management Approach' is explained here and describes a structured information provision process. This is an interactive environment guiding a customer through a decision making process. The alternative building block B developed in paragraph 6.8 shows how simply phrasing, framing and presenting information can change the perception and behaviour of a customer when taking bounded rationality into account. By changing his perception his decisions are influenced. The result is that a consumer will take a more positive attitude towards PV than he would have if he was provided regular information, see paragraph 6.5 and 6.6.

The building block B.I provides a comprehensive and interactive information package for customers to convince them but also to solve the problem of lack of consumer knowledge and complexity by using the theory of bounded rationality. However, simply providing information does not solve the problem of complexity and lack of knowledge as noted by Stern:

"… the cost of searching does not seem to be the main reason people are ill informed. The effectiveness of information depends on more than its availability and content."

(Stern, 2000)p.621)

In scientific literature searching for information is often associated with cost. Some argue that the cost of searching for information is the reason people use decision heuristics to take a decision, rather than invest time and effort in finding all the necessary information. Stern argues that the content and availability of knowledge are important factors as well. It is therefore not only important that all information is provided, it is also the form in which the information is provided. Sorell et al. (2000) provide five elements of information that are of particular importance when transmitting information concerning investment in energy efficiency, see Table 16.

Information Requirements	Explanation
Specific and Personalized	Information should be specific and personalised. Individual advice on investment in solar PV systems is more effective than general information on the costs, benefits and saving opportunities of such a solar PV system.
Vivid	Information should be presented vividly. People who view an interactive medium or video about energy saving and efficiency measures are significantly more likely to cut energy use than those who get the information in writing. Similarly, demonstration of tangible success with a technology is more persuasive than a sales pitch. An extension can be made here to include social network advertising, where people share their experiences with an Eneco solar PV system.
Clear and Simple	Information has to be clear and simple. It should take as little effort as possible to understand. If the material is too complex, it will deter people to take further action.
Timing	The information needs to be provided as close in time as possible before a relevant decision is taken. This will ensure that the individual remembers the advantages and disadvantages when making his decision
Feedback	Feedback should be given on the beneficial consequences of previous energy decisions if subsequent efficiency measures, or business is to be encouraged. For example, if a consumer receives (positive) feedback on his decision to insulate his home, he is likely to take additional measures to make his home more energy efficient

Table 16: Requirements on Information (Source: (Sorell, et al., 2000))

The requirements presented in Table 16 are related to the theory of bounded rationality ensuring that the information provided to a customer is easily understandable facing a decision. Poorly presented, or difficult accessible information requires more effort form the part of the customers to assimilate and process. Information that is hard to process is easily discarded by the consumer, which results into a satisficed decision making based on decision heuristics.

6.7.1 Trustworthiness of the Information

A second important issue with regard to providing information is the credibility of the information and the trustworthiness of its source. If Eneco would provide customers with all the information

needed to make a well thought through decision, but the customer does not trust the source or the information is not credible, then he is likely to discard the information.

In a study by Craig & McCann (1978), 1000 households were sent an information brochure describing how energy could be saved. Half of the households received the brochure from their local electricity supplier while the other half from the regulatory agency. The following month households that received the brochure from the agency consumed 8% less electricity than the household who received the brochure from their local electricity supplier (Craig & McCann, 1978).

This is partly due to credibility of the source. Sorell et al, (2000) argue the following factors are important: the nature of the source (private company, charity or interest group), past experiences with the source, the nature of interactions with the source or recommendations from peers or a wider group in their social or professional networks. These interpersonal contact and recommendations carry a far greater weight than other sources of information such as pamphlets and brochures (Rogers, 1995; Kaplan', 1999; Weeda, 2011; Verbeek, 2011).

Stern (2000) who has done extensive research on credibility and trust of information sources gives a number of explanations why opinions and experiences of peers are important:

- Uncertainty. Lack of knowledge and lack of trust in information enhance the value of personal recommendations from individuals.
- Direct exposure to the adoption of an innovation or new technology by another individual or firm acts as a “vicarious experiment” or trial.
- Information from close associates is salient, it stands out from the mass of available information provided to a consumer and attracts far more attention.

Extrapolating this to the case of Eneco for the provision of information to consumers has the following consequences. It increases the need for the involvement of additional stakeholders. Stakeholders that can be approached to provide and carry the information across are: ASN Bank, Environmental Organisations, and Consumer Associations. These stakeholders can add to the credibility of information provided by Eneco to influence the investment decision, even though Eneco is often seen as a trustworthy and reliable company.

One important note in Stern’s work is that the provision of information to the consumer does not necessarily have to be very accurate or complete. What is most important is that the information is able to capture the targeted consumer. Information has to gain the attention, has to create involvement and has to overcome scepticism about the credibility and usefulness of the investment for the specific situation of the consumer (Stern, 2000).

6.7.2 The information provision model

Building block B.I is developed using the theory of bounded rationality and how information should be provided. Figure 21 shows the model of this building block. The first step is to provide existing satisfied customers of Eneco with a directed letter. These customers perceive Eneco as a trustworthy and credible party and are more likely to participate in the proposition. In an interview Eneco stated they have a fair degree of consumer knowledge and can distinguish between these customer through a client relationship management tool. Selecting and approaching the right consumers therefore should not be a problem (Verbeek, 2011).

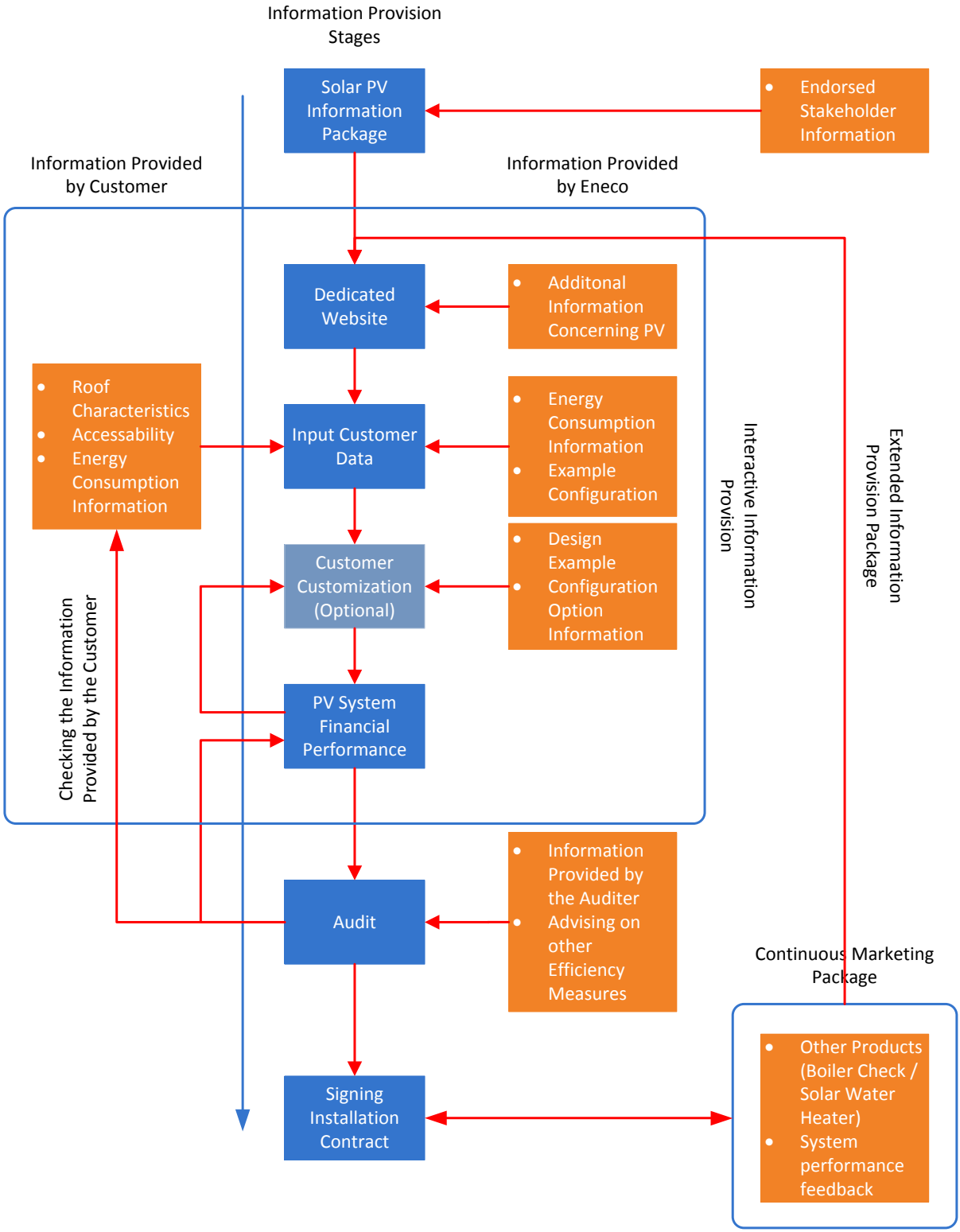


Figure 21: Interactive Information Management Approach Diagram

Taking into account the previous notes on the credibility and trustworthiness of information, the first information package should be endorsed by other stakeholders as well. If the ASN Bank, Environmental Organisations and Consumer Associations would also propose the same product to their members, the information and proposition would directly gain credibility (Roesink, 2011). The information package should contain information regarding financial performance, environmental

performance, ease of installation by certified installers, additional benefits, as well as disproving counter arguments.

The second step is to set up an interactive website making the information package interactive by providing more extensive information without overloading the customer with information causing bounded rationality-like problems. Information should include Eneco reference projects and information from other stakeholders.

In the interactive environment the customer can start configuring his solar PV system. Two inputs are necessary to start the configuration process:

- Historical information on electricity consumption of the consumer. If the customer is already a customer of Eneco the energy information can be imported easily from Eneco's databases, otherwise the customer can fill in the information himself. The electricity consumption profile determines the size of the PV system. A large electricity consumption profile leads towards a larger system.
- Determination of roof characteristics. The roof has a significant influence on the performance of a PV system (Bryan, 2010). Factors such as orientation, sloped or flat roof, obstacles etc. have to be filled in. These factors determine the available surface area for a PV system[32] demarcating the maximum power of the PV system when installed at the customer's roof, as well as the costs of the system including additional installation elements required.

The next step is optional depending on the choice made for building block A.I or A.II. In the case of building block A.I, the customer can proceed to configure a proposition based on mass customization or he may opt for the carefree proposition. Service, financing and other options can be selected by the customer. The impacts of these upgrades need to be presented clearly.

The system configuration step is similar to ordering a personal computer from Dell[33]. When ordering a computer from Dell a customer chooses a basic model and through a structured process other components can be added. When a component is added the customer is informed with an updated price. Throughout the PV customization process, a picture will be shown plotting the selected PV system on the customer's roof, as based on the input parameters of the roof. This is important because an investment barrier may be that the investment looks bad (McGee et al. 2006). In the case of building block A.I and A.II, a number of options of the current configuration can be presented giving the customer an option to choose the most appropriate one (McGee, Partridge, & Lewis, 2006).

Once the system is configured, the financial and energy performance of the system is presented to the customer including contribution to CO_2 reduction. This model incorporates roof characteristics, sun irradiance data, financing methods, energy production and savings of fossil energy sources. A service contracts determines the financial performance of the system over the lifetime of the system. Also the savings in relation to the status-quo decision are shown as well as the monthly payments financing is chosen.

[32] Website plugin with calculating surface are and orientation tool.
[33] Dell is computer retail company using mass customization to market computers, their website can be found at www.Dell.com last queried 22-09-2011.

When the customer is satisfied with the system configuration and the performance (financial and energy) he can proceed to the next step. If the customer is not satisfied or he wants to change a number of parameters he can create another configuration. The programme offers iterative loops. It is likely that a consumer runs through a number of iterations before arriving at his preferred configuration.

The next step is making an appointment for an inspection at the customer's location. In the case of the Eneco proposition it is likely that Eneco uses their own installation companies for this inspection (Weeda, 2011). A qualified installer is dispatched to the home of the customer to advise on the following steps:

- Verifying the information provided by the customer and the configuration chosen by the customer.
- Checking if additional measures need to be taken during the installation and making the final roof design for the customer. Additional costs for measures that need to be taken to ensure safe installation such as scaffolding are incorporated in the final financial and performance proposals on which the customer can base his or her final decision.
- Advising and pointing the customer to other energy efficiency upgrades at the same time like investing in buying a solar water heating unit.

When the roof check is completed and the customer agrees with the finalized design proposal based on his input, the customer signs the installation and service contracts. The system installer plans the installation in consultation with the customer. The roof check is free of charge when the customer takes a positive investment decision and signs the contracts. In the case the customer takes a negative investment decision he may be charged a small compensatory fee.

As part of building block B.I and information provision, it is important to provide the customer with feedback. Feedback on the energy investment decision lowers the barrier for taking new investment decisions and maintain customer participation and involvement (Stern, 2000). The feedback provides an excellent opportunity for Eneco to sell additional energy conservation products and services. The same programme can be used to configure a number of these products as well, for example solar water heating units, insulation, etc. The red arrow in Figure 21 connects the interactive information provision package with the continuous marketing package.

Building Block B.I ensures consumer participation as highlighted in the mass customizations section of paragraphs 6.1 and 6.2. and it will guide a consumer through a structured decision process. His interest is being sparked and at the same time he is made aware of the innovation and advantages and guided towards an decision (Kaplan', 1999). This structured decision process reduces the bounded rational behaviour of the consumers through displaying collected information to the consumer. He can make a well informed decision based on the information provided by himself and general information from Eneco and associated stakeholders. The financial performance section clearly shows what the financial implications of his choices are. The energy performance will show him the effect on the use or renewable energy source over traditional fossil sources. The designed system is personalized, creating greater credibility and trust from the customer (Stern, 2000). Stakeholders supporting the effort, are there to create even more credibility to the proposition stimulating the large scale penetration or adoption of solar PV even further.

6.8 Building Block B.II – Information Framing

Building Block B.II steps away from the provision of information to customers, but focuses on how to transfer and phrase the information to consumers. Consumers are often more susceptible if information is phrased in a certain way, instead of merely relying on the information objectively given to him. This building block B.II 'Information Framing' extends the notion of bounded rationality, to include also the cognitive limitation of men to value two different statements containing the same information on an equal basis (Kahneman, 2003).

In building block B.II Information Framing the following issues are dealt with:

- Framing of the benefits and costs of the system
- Dealing with immediate costs & benefits of the system
- Preference of consumers with the status quo and risk perception.

Framing of the costs & benefits

Kahneman and Tversky investigated the influence of cost and benefit perception on human behaviour. This is known as prospect theory (Kahneman, 2003). Prospect theory can be seen as an extension of bounded rationality attempting to explain why customers at time display 'irrational behaviour'. Below two examples are given on framing the proposition in such a way that it deals with the bounded rational behaviour of men and encouraging him to make an investment decision.

The first part of this alternative deals with the perception of costs and benefits. Tversky and Kahneman argue that humans perceive gains and losses differently. This perception difference between gains and losses influences investment decisions. Christie (2010) explains this behaviour as follows. Customers are far more risk averse when they perceive a gain and they become reluctant to accept any risk in order to obtain that gain (Kahneman, 2003). On the other hand customers are far more risk susceptible when they are faced with a loss. Therefore a consumer is more likely to invest in a solar PV system facing a loss of a saving of €20,- per month than saving €20,- per month. Typical marketing campaigns however stress savings more than losses, thereby indirectly discouraging people from investing in solar PV. Therefore Eneco should market the proposition as means to prevent a monthly potential loss of a potential saving, rather than saving.

A second example shows the difference in perception by men in an example given by Thaler (1980). Credit card companies in the past banned affiliated stores to charge higher prices for the use of credit cards. A bill to outlaw these practices was brought forward to the American Congress. When it appeared likely that the bill would pass, the credit card lobby turned its attention to the layout of the bill or the payment slip. It stated that any difference between cash and credit payments should be in the form of a discount instead of a surcharge when a credit card is used. This makes sense because any surcharge would be perceived as a penalty for the use of a credit card (Thaler, 1980). A possible solution is framing desirable actions from the view of Eneco as discounts and choices which are less attractive to Eneco as surcharges or incorporate these in a slightly higher price.

Addressing issues of implicit discounting

Sansted and Howarth (1994) argue that the high upfront costs are a large barrier for investment in energy efficiency. The issue of investment costs has been mentioned during the interviews as a significant barrier (Buddenbaum & Vrijmoed, 2011; Morren, 2011; Schootstra , Holland Solar, 2011; Sinke, 2011; Weeda, 2011; Zwang, 2011). These high upfront costs provoke consumers to use a high

discount rate when calculating an investment opportunity ensuring that the investment pays itself back. The discount rate is a heuristic rule of thumb to deal with perceived risks and uncertainty regarding the investment (as can be seen in paragraph 6.5 and 6.6).

The perception of risk related to the high costs and the reluctance of consumers to invest in a solar PV system can be overcome. High investment costs encourage consumers to demand very short payback times (Thaler, 1980; Sansted & Howarth, 1994; Christie, 2010), which are impossible to deal with because a solar PV system is only profitable over a long period of time. This can be mitigated by providing consumers with a leasing product or financial products that flattens the upfront investment through converting it into a much lower monthly fee. This fee will not been perceived as excessive or as a high risk investment. The payment of the system is spread into monthly payments over time offset by the benefits of the solar system. The high investment is eliminated and the implicit discount rate is lowered encouraging more positive investment decisions. .

The monthly payments lowers the perceived benefits of the system as long as the monthly payments towards the system are lower than the revenues generated by the system (value of the generated electricity). Otherwise it lowers the perceived benefits by the consumer (Oxera, 2006). When looking at the proposition of Solar City it is clear that whatever financing method is chosen the monthly payments are lower than the revenues leading to a positive net benefit and a saving for the consumer (SolarCity, 2011) This provides a solution for an important investment barrier. These net benefits are immediate rather than long term benefits, because the system starts making money for the consumer right from the start.

Breaking through the status quo

A final issue is that consumers are inclined to preservation of the status quo. The status quo is often preferred even in the case when the current situation is detrimental to their utility[34]. Consumers do not like change and prefer the status quo over exposure to limited uncertainty and risk. The only way to overcome this bounded rational behaviour is to provide an incentive that is compelling (Stern, 2000; Christie, 2010).

A possible solution is stressing the non-monetary benefits of a solar PV system, sustainability, self-sufficiency, stable electricity prices, etc. These benefits however are already being stressed by solar PV companies. What not has been done so far is providing a performance guarantee on the installed system by a solar PV company. Such a guarantee reduces uncertainty about the costs and benefits of the system and reduces the risks for the consumer of system malfunctions or underperformance. A performance guarantee will make the system more expensive, Eneco and its partners have to assume more risks, but it reduces barriers related to uncertainty and risk.

Of course it will increase the risks for Eneco, but Eneco could offer such a guarantee because the installation of the system (Eneco Installation Companies) as well as the service provider (Eneco) are both the same company. The technical components create an external risk factor to Eneco. This issues could probably be partially been mitigated by the component supplier when the installation is done by a certified installer.

[34] The concept of utility has already been described briefly in paragraph 6.6.

A possible performance guarantee could look as follows. Eneco guarantees a buyer of a solar PV system that he will generate at least a certain production volume of electricity during for example for 15 years. Eneco should not guarantee savings. Savings are uncertain because it is difficult to predict the electricity prices that far in the future.

A second solution to breaking through the status quo, is dealing with sunk costs (Kahneman, 2003). An investment in a PV system is a long term investment or commitment. The time horizon is often longer than the time a consumer expects to live in a given house. It is important that changes in ownership or moving is dealt with in a transparent way. This applies to the lease of solar panels, because there is a long term commitment with Eneco. In the case the consumer has full ownership he can include the system in the price of his house, or remove the system and reinstall it in his new home. Changing ownership in a lease construction is a complex issue for a consumer. They do not want to end up with a PV system or house that cannot be sold, or a financial lease contract that cannot been transferred, or from which they cannot reap the benefits due to the Electricity Law on net metering, see Appendix B. In case the customer keeps the ownership of the PV installation, he would be generating electricity in front of the meter, rather than behind the meter due to the fact there is physical distance between his old and new home address. The investment poses for the consumer a sunk cost, of which he is unsure how to recoup his investment in the case he moves.

It is important to mention that the alternatives available to transfer ownership are dependent on the financial construction as well. In the case of lease, Eneco could assume ownership, transfer the lease to the new homeowner, or the customer can buy off the lease. The lease contract needs proper exit clauses well documented and well communicated to the consumers. At the moment Eneco has exit clauses with regard to the Zonnestroom[35] proposition, including high penalties. It would be a good idea to see if the penalties on transfer of ownership can be reduced to create ease of mind with the consumer, lowering the investment barrier.

Kaplan (1998) as well as Kahneman (2003) provide a final example which can overcome the bias towards maintaining the status quo. They argue that from a standpoint of adopting an innovation such as PV it is important that the consumer likes the technology or product. Customer adoption is higher when he is confronted on a daily basis with the benefits of having a well operating solar PV system.

However people are only confronted on a daily basis with solar PV if its adoption is already high in their neighbourhood, which is often not the case. More exposure could be created by sharing positive experiences of PV system owners. This could either be done by social media, or information brochures or general advertising. Over time the consumer will become more enthusiastic and he will perceive less barriers than are present today. Ultimately this will lead to a more rational investment decision, either a positive or a negative.

Final Notes

Building Block B.II reduces bounded rationality issues by framing and presenting information in such a way that it addresses the heuristics used by consumers in their decision-making process. These heuristics are at the core of decision making by consumers. Communication with consumers have to

[35] http://thuis.eneco.nl/~/media/EOL/PDF/Voorwaarden%20en%20brochures/Voorwaarden%20overig/-productvoorwaardenenecozonnestroom.ashx last queried: 25-10-2011

take into account their heuristics. According to the scientific literature this should lead to a higher adoption rate of solar PV with the consumer.

Information Framing however does not provide a structured way for a consumer to make a decision but it does aim at solving barriers specific for constraints set by bounded rational behaviour. It becomes apparent through this alternative that using a financial lease structure is preferable to solve a large number of issues. A well thought communication strategy can help to overcome the barriers of bounded rationality. Nevertheless, it is the opinion of the author that Eneco should not only focus on leasing the system but on regular payment as well. Because lending money is associated with risks as well, such as the customer defaulting on his lease.

6.9 Interdependencies

Large assortment or selection strategies such as mass customization can backfire. They may invoke complexity which in turn can create information overload at the customer. The customer can become dissatisfied with the experience and either take a negative investment decision or not make a decision at all, which is equally bad from the perspective of Eneco.

The key to ensure customer satisfaction in a mass customization process is to provide the tools to a customer to handle the complexity and options presented. This can be done by obtaining information from the customer and thereby structuring the decision process and limit the number of options for a customer.

Here a connection between building blocks B.I and B.II can be made. When a mass customization approach is chosen, it would be in the best interest of the customer and Eneco to opt for building block B.I. This will structure the information and will reduce complexity and customer information overload. This in turn will improve customer satisfaction and increase the chance a customer taking a positive investment decision.

The opposite choice could be made as well where the variety approach is connected with building block B.II. Because of the limited choice, the customer has to be convinced that a PV system is in his best interest which is more easily done by using this building block. Elements of Building block B.II can also be used to enhance the option based on mass customization.

6.10 Conclusion

6.10.1 Conclusion Regarding Lack of Standardization

The Building blocks Variety and Mass Customization seem to provide two interesting answers in both serving a larger share of the market as well as keeping the costs of a PV system low. The mass customization approach and its alternatives provide a more comprehensive approach, which is unique to the PV market in the Netherlands at least. Mass customization is the better approach because it combines standardization of the components, reducing the costs of a PV system significantly and addressing the need for customization because every customer and roof is different.

Mass customization offers a lot of advantages regarding flexibility as well. Flexibility not in terms of a sheer number of different products that can be offered to the customer, but flexibility in terms of adapting the proposition to reflect changes in the environment like technological and institutional change.

Mass customization does however increase the complexity on the organisational side for Eneco as well as it has slightly higher costs compared to variety due to the customization. The benefits of flexibility and the ability to customize the product, should be able to offset the negatives, because the mass customization approach can easily be changed if external developments change.

A final issue distinguishing mass customization and variety is financing. Financing needs to be included with the mass customization proposition, however it creates some significant problems. It is likely that once Eneco offers financial lease products on a large scale, the Dutch financial regulatory authority, the AFM, will require a banking permit or will require that Eneco selects a partner, being a financial institution or a bank. ASN Bank has said during the interviews that they would be very interested in helping with financing such a project. They however do not want to finance on an individual level (Roesink, 2011). The financing arrangements will increase the number of stakeholders and the complexity of contracting.

So although financing will open up a larger market, it presents also some significant obstacles. This consideration needs to be taken into account when choosing the PV strategy in chapters 7 and 8.

6.10.2 Conclusion regarding Lack of Consumer Knowledge

A number of important points can be made with regard to the building blocks developed in dealing with the barrier 'Lack of consumer knowledge':

- Information can do little to open up the market , when there are other important barriers to cope with, such as regulatory issues, significant financial barriers or policy barriers. Information provision can only facilitate the decision making.
- Endorsement by other stakeholders increases the requirements for the PV propositions. The new proposition has to be in conformity with the other organization's values and has something to offer for the participating stakeholders.
- The incentives given by Eneco to invest in the system need to be large enough for consumers to be taken seriously. Large enough to convey unambiguously that there is a personal benefit to be gained from investing in PV systems. If it shows that the financial incentives have diminishing returns, it can be more effective to invest in improved information provision. The information provided by either Building Block B enhances the incentive as the interest of the consumer is sparked by the financial incentive. There has to be a financial incentive that appeals to a customer (Stern, 2000).
- The provision of structured information makes the decision making easier to understand for the customer in order to overcome the decision heuristics laying at the core of the energy efficiency gap and bounded rationality.

6.10.3 General remarks

Information and standardization are not the only barriers that have to be removed. In the process of attracting customers and motivating them to invest a number of other requirements are critical as well. These should be integrated in the provisioning of information to the potential customer. The requirements have been obtained during the interviews (Morren, 2011; Roesink, 2011; Verbeek, 2011; Weeda, 2011). These can be split up into two categories of requirements:

Reliability

- The PV systems should be installed on time! This means that if an installation contract is signed, the date agreed upon has to be the date that the system is installed. A dissatisfied customer is bad/negative advertising.
- The system design agreed upon between the auditor or installer and the customer has to be installed according to those specs. Last-minute changes are detrimental to the customers confidence and satisfaction with regard to Eneco, reducing the likelihood of a customer returning or a high level of customer satisfaction.
- The information provided to the customer has to be reliable, trustworthy and transparent. If a customer has designed a system and it is installed, the customer should not be confronted with a list of additional costs or specifications that are not met during operation.

Communication

- Communication to the customer has to be unambiguous and clear.
- The customer preferably should have one point of contact in communication. An example of this could be the "green desk" of Eneco or a special assigned account manager for the client. This will Increase customer satisfaction because of the personalised approach given to the customer.
- Communication towards the customer should be friendly and non-threatening. An issue here is that building block B.II may come across as somewhat threatening due to the more aggressive way of marketing the PV proposition.

These requirements have not been integrated in depth, keeping the alternatives readable and easy to understand. When these requirements are taken into account for the final PV proposition it can contribute to recurring business for other investments in energy efficiency. Increasing the share of stable revenues for Eneco, being one of the main motivators for Eneco, see paragraph 1.1.1.

6.10.4 Potential Project Partners

The stakeholders below have been mentioned during the development of the alternatives and should thus be included during the further development of the PV strategy as well as its implementation. These stakeholders increase the feasibility and viability of the PV strategy, its robustness, credibility and they will deliver to results of the selected proposition (Miller & Lessard, 2000; De Bruijn & Ten Heuvelhof, 2008; Enserink, Hermans, Kwakkel, Thissen, Koppenjan, & Bots, 2010). Stakeholders such as the (environmental) organisations and financial institutions are especially important. These do not only have specific resources such as knowledge, permits or money, or can help to frame the information on PV system to the market. Their members or customers represents also future users of PV systems that can be targeted by Eneco's proposition.

- Eneco
- A financial Institution
- A PV Installation Company
- PV system supplier
- (Environmental) Organisations
- (ICT) developers

PART IV – Underpinning a Strategy

"Countries on every corner of this Earth now recognize that energy supplies are growing scarcer, energy demands are growing larger, and rising energy use imperils the planet we will leave to future generations. And that's why the world is now engaged in a peaceful competition to determine the technologies that will power the 21st century. From China to India, from Japan to Germany, nations everywhere are racing to develop new ways to producing and use energy. The nation that wins this competition will be the nation that leads the global economy. I am convinced of that. And I want America to be that nation. It's that simple."

President Barack H. Obama, 23rd of October, 2009, Massachusetts Institute of Technology, Boston

Chapter 7

7. Creation of a Morphological Chart

Chapter 7 is the penultimate chapter of this thesis. In the previous chapter the building blocks have been developed to build the (partial) PV strategy for Eneco. This chapter aims to answer the last sub question of this thesis:

8. *What is the best partial PV strategy for Eneco based on a morphological chart representing the barriers and the different building blocks*

By combining the building blocks developed in the previous chapter partial PV strategies can be build. Because multiple combinations of the different building blocks are possible each resulting in a 'unique' partial strategy. Combining the building blocks is done by using a morphological chart. The method of using a morphological chart has already been discussed in paragraph 2.4.4. The morphological chart in this chapter differs from the morphological chart used to describe the mass customization building blocks in paragraphs 6.2 through 6.4.

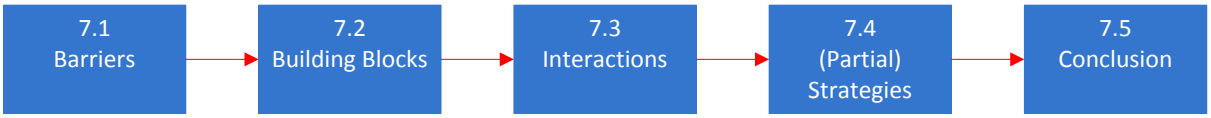


Figure 22: Chapter 7 Outline

shows the structure of this chapter. Paragraph 7.1 explains the variables of the morphological chart. Paragraph 7.2 presents the building blocks of chapter 6 in the morphological chart. Next in paragraph 7.3 any contradictory building block combinations are clarified. Paragraph 7.4 presents two possible partial strategies for Eneco. The word partial is used here because not all the elements of a complete strategy have been incorporated in the morphological chart. Paragraph 7.5 presents the conclusions and concludes this chapter.

7.1 Barriers

The morphological chart in this chapter is constructed from two categories: barriers and building blocks. The barriers identified in chapter 5 form the columns of the morphological chart, while the different building blocks of chapter 6 to solve a given barrier are presented horizontally .

Only two barriers have been researched for this research project due to time constraints. This results in a limited number of strategies that can be created from this morphological chart. A morphological chart is a tool to create insight in the trade-offs and options of multiple variables. If Eneco would like to continue this research it is necessary to further enhance or complete the morphological chart. This of course will further improve the quality of the strategy.

The two barriers used in the morphological chart have been rephrased from the name given earlier to them based on the interviews held and during the subsequent analysis steps. The labels used are "degree of standardization" and "consumer information provision".

Other barriers that could be researched, which were given high barrier scores during the analysis in Chapter 5 (see Table 11) complementing the morphological chart are:

- Cost / Benefit Allocation, presented
- Level of Cooperation between stakeholders
- Quality Assurance
- Financing

These and other barriers not taken into account due to the limitations set for this thesis, should be researched. These barriers could yield valuable building blocks and could fulfil a valuable role in the strategy as well. Therefore to develop a more comprehensive strategy a number of additional barriers should be added. The selection process as explained in chapter 5 can assist.

7.2. Building Blocks

The number of building blocks can be extended as with the addition of the barriers described above,. The amount of effort put in the development of the building blocks in the table below does not have to be repeated for the development of new building blocks. The building blocks created for this thesis are thorough. If Eneco chooses to continue to the use the morphological chart this can be done less thorough, because they do not have to develop the building blocks adhering to the requirements of writing a thesis. However any building block added to the morphological chart needs a degree of substantiation and the interdependencies between blocks need to be known to ensure that conflicting building blocks are not combined into an operational strategy.

Table 17, presents the morphological chart (for explanation see chapter 2.4.3) including also the barrier *Cost Benefit Allocation* and *Level of Cooperation* and the building blocks C and D. These building blocks C and D have not been further developed at all and are only added to provide a good picture how the morphological chart would look like if Eneco would like to expand it further. In the table the two mass customization building blocks have been included as two separate ones: the carefree and the pick & choose option. Next to those the Variety building block has been included.

	Building Blocks		
Barriers	**1**	**2**	**3**
Degree of Standardisation	Mass Customization: Pick & Choose (Building Block A.Ia)	Limited Customization: Carefree (Building Block A.Ib)	Variety (Building Block A.II)
Consumer Information Provision	Interactive Information Provision (Building Block B.I)	Information Framing (Building Block B.II)	
Cost Benefit Allocation (Other Barrier I)	Building Block C.I	Building Block C.II	Building Block C.III
Level of Cooperation (Other Barrier II)	Building Block D.I	Building Block D.II	

Table 17: Building Blocks Morphological Chart

7.3 Interactions between Building Blocks

To use the morphological chart effectively contradictory building blocks have to be excluded. This may not be such an issue for the small morphological chart created here, but it can have a significant impact if more variables and building blocks are added (Ritchey, 2002; Ritchey, T., 2011). Looking at the building blocks in the table there are no contradicting building blocks yet. The choice for the building block Variety does not exclude the building block Interactive Information Provision dealing with the Customer Information Provision Barrier or another combination of building blocks. This does not imply that such a situation cannot occur when more building blocks and variables are added to the list.

What does occur (as described in paragraph 6.9) is that building blocks are interdependent and can influence each other's performance disproportionally. An example of this interdependency is the interaction of the Mass Customization Pick & Choose building block with the building block Interactive Information Provision. These two building blocks complement each other because mass customization requires a structured information approach to prevent potential customers becoming overwhelmed by an overload of options and information.

These interactions can be both beneficial as well as detrimental to a potential PV strategy and need to be given careful consideration. When the interaction between two building blocks is detrimental for one of the building blocks, it needs to be discarded and another building block has to be chosen.

7.4. Partial Strategies

From the possible number of combinations of specified building blocks six partial strategies can be developed which are listed below in Table 18. This is done by combining the building block for one barrier with the building block for another barrier and writing down all the possible combinations. As there are no conflicting building blocks all the configurations are valid (partial) PV strategies.

(Partial) Strategy	Combination	With
	Degree of Standardisation	Consumer Information Provision
Strategy I	Mass Customization: (Building Block A.Ib)	Interactive Information Provision (Building Block B.I)
Strategy II	Mass Customization: Building Block A.Ib)	Dealing with Bounded Rationality (Building Block B.II)
Strategy III	Limited Customization: Building Block A.Ia)	Interactive Information Provision (Building Block B.I)
Strategy IV	Limited Customization: Building Block A.Ia)	Dealing with Bounded Rationality (Building Block B.II)
Strategy V	Variety (Building Block A.II)	Interactive Information Provision (Building Block B.I)
Strategy VI	Variety (Building Block A.II)	Dealing with Bounded Rationality (Building Block B.II)

Table 18: Possible Partial Strategy Combinations

Two partial strategies have been selected for Eneco as the most plausible solutions to obtain its goals: strategy I and strategy IV. These strategies have been selected based on providing a solution for their respective barrier and removing other identified barriers, such as the investment costs barrier, lack of financing barrier and quality uncertainty. A final criterion is: can the strategy achieve the goals set by Eneco? Both strategies are described below in a storyboard related manner. The two strategies are selected because the building blocks complement each other and fulfil the requirements set by Eneco. Looking at these criteria, the Building Block A.Ib and Building Block B.I complement each other, while fulfilling Eneco's requirements such as the ability in principle to achieve sufficient scale, although this should be validated (see chapter 8) and to complement the main corporate strategy. In paragraph 7.4.1. and 7.4.2. the partial strategies will be analysed in much greater detail. Analogies are used to put the strategies into perspective and to clarify it further to the reader. For partial strategy I the Dell analogy is used, for partial strategy IV a Club Med analogy is used.

Partial strategies II, III, V and VI are dismissed. The combination of building blocks in these cases do not reinforce each other, or they are less ideal than the chosen partial strategies. Therefore these strategies are discarded. For example Building Block A.II and Building Block B.I are a less ideal combination. The variety approach already has a limited number of choices for a consumer to choose from, building an entire ICT system for structuring the investment process is sub-optimal, especially when considering that the argument for using variety is to keep the costs as low as possible.

7.4.1. Strategy I – Dell Model

The first strategy selected is partial strategy I. Which from now on is referred to as the Dell Model, which is described in greater detail below. Dell introduced a new concept of selling computers. Customers can buy computers which they configure themselves. For each functional component of a computer the customer is presented with multiple options. Finally when Dell sells a computer to its

customer Dell also offers to buy additional products, not only support services but also printers, cables, scanners and beamers as well. This is also a clear example of the interactive information provision concept where other energy efficiency solutions could be sold by Eneco and its installation companies (Magretta, 1998).

The Dell model is an example of mass customization where the customer is integrated into the production process. The customer can choose the configuration that suits his needs in the best way possible within the limits of the options presented to him.

The way in which the options are presented to the customer is very much in line with the building blocks developed in this strategy I for Eneco. When a customer is considering to invest in a PV system, he gets the option to select a basic system. This basic system is then configured on a step-by-step basis as has been proposed with the interactive information approach of building block B.I.

An important requirement for the strategy is to attract customers to the website of Eneco to customize and select their PV system and hopefully invest in a PV system. The larger the flow of customers, the more likely the number of investments in PV will rise. The Dell model is unique in the sense that it allows customers to configure or customize their own systems. This may also lead to the situation where potential customers will check propositions for a PV system from the competition at the Eneco website. Then the customers will experience the ease of both the mass customization as well as the interactive information provision. This will create a larger flow of prospective customers to the Eneco website for PV system comparison. Exactly the same behaviour is observed at the Dell website, where large flows of customers check competing offers and end up buying a Dell computer (Magretta, 1998).

In the following paragraph the required changes from the current situation to the new strategy are analysed as well as the perceived advantages and disadvantages of using the Dell strategy. Finally the relationships with the different stakeholders are described.

Required Change from the current situation

Five profound changes need to be made to execute the Dell strategy.

- Transparent and open communication between the stakeholders is necessary. The supply chain, from the components to the installation and service needs to be integrated in order to install the system on time, on budget and on a low cost. This requires information sharing between the stakeholders involved (Miller & Lessard, 2000; Meredith & Mantel, 2009).
- The mass customization system needs to be developed and coupled to the interactive information provision building block as well as to develop more options for the customer than presented in the mass customization building block. For reasons of readability not all the likely choices are presented. These options have to be developed in a modular way and have to be compatible with each other. A virtually infinite number of packages can be developed from the same basic modular and compatible components. This is different from variety where four or five system packages are developed.
- The interactive information provision system needs to be developed, preferably including other energy efficiency investments as well. As said before, generating feedback, to the customer is an important way in both generating more business as well as gaining more information from the customer to develop new and to adapt current offers.

- To manage the service related problems the customer needs one central point where he can go in case he has questions or problems with his system. Although multiple stakeholders are involved it is important that one of the stakeholders has to assume the responsibility of dealing with the customer care. This stakeholder in turn can relay the problems to the project stakeholders (Verbeek, 2011; Weeda, 2011; Morren, 2011).
- Clear arrangements with component suppliers have to be made. A mass customization strategy cannot rely on the current business practices including buying surplus inventories cheaply and reselling them as one time offers. For the Dell model to work properly long term relationships are needed based on strict quality measures in order to fulfil the promises of service, keep maintenance costs low and to offer of continuity and reliability which is important for Eneco as well as its customer (Magretta, 1998).

Advantages

By using this strategy a long term relationship is created between Eneco and the customer. The mass customization tool, as well as the interactive information provision tool, allow Eneco to obtain valuable consumer information and market information, by investigating the customer behaviour. This information can be used to develop specifically tailored products and services to customers.

A second advantage is that the strategy is difficult to copy by competitors. The close relationship needed for the execution of the strategy between Eneco and the other stakeholders like PV system suppliers, financial institutions and PV system installers, create a huge barrier for entry. It is difficult for a potential competitor to quickly develop these relationships with stakeholders. Good and strong business relationships are generally difficult to duplicate (Magretta, 1998). The same is true for the information gathered through the previous mentioned channels.

A carefree PV proposition can still be offered by selecting the additional services offered in the proposition. Opting for the carefree proposition could be made even easier if the customer could simply click on a 'carefree' button which automatically included all the necessary options.

As mentioned previously the advantage of the Dell strategy is that it allows Eneco to fulfil a majority of the customer's requirements. System, size and services can all be customized to fit the customer's needs.

Finally due to the interactive information provision and mass customization system, and the feedback gained from customers, through the inspections as well as the choices made by the customers, enables Eneco to develop new PV products and services. The bus concept (see paragraph 6.2 will enhance future flexibility. This also applies to the backside of the process as well when using the long term relationships with the other stakeholders identifying new technologies and incorporating them. These will keep Eneco innovative and up-to-date with their proposition for the delivery of PV systems.

Disadvantages

The aftersales services and service in general have to be outstanding. Service is one of the pillars where Eneco needs to differentiate itself. Eneco is perceived as a reliable company. An image Eneco wants to keep. Mediocre service provisioning, cost overruns and delays will damage this image. Emphasizing this service dependency is seen as a potential disadvantage or risk for Eneco.

The risk of customization in a market where there is little demand, might increase the system costs substantially. This will create more competitive pressure on the proposition, largely because a low demand may result in a situation where the benefits of economies of scale cannot be realized.

High investment costs have already been cited as a significant barrier and should therefore be prevented. To prevent high costs a significant turnover is required to keep costs low and the proposition successful. Although a large customer interest is present, the question remains whether sufficient actual installations can be achieved.

Stakeholder Roles

The following stakeholders have a specific role in executing the Dell-strategy:

A financial institution such as the ASN Bank can have a number of roles. First and foremost they have to provide the financing for the PV lease contracts. Eneco finances the individual consumer through a project financing agreement with ASN Bank. Secondly, the ASN Bank can help in promoting the strategy to its own customers creating a larger market (Roesink, 2011). Thirdly and lastly, the ASN Bank can act as a project partner helping to enhance the reliability and seriousness of the proposition by endorsing its name to the proposition and by convincing its own customers to buy their PV systems from Eneco.

The installation companies, possibly including others than Eneco's installation companies to obtain the necessary geographical coverage, have to execute the installation and service contracts. They execute the inspections, install the systems and service them. Their cooperation is very important. They need to deliver on time, fulfil their commitments and work securely and neatly, achieving customer satisfaction. This requires a close cooperation between the installation companies and Eneco for the planning of the various activities.

Relations with the component suppliers should be arranged from a central point. As mentioned in the stakeholder analysis Ecostream France has the knowledge to deal with the necessary arrangements. They have relations with market parties for the acquisition of complete PV systems. It is important that the relations are long term when these are to be included into the supply chain. This will create benefits such as shorter component delivery times, superior guarantees, and lower costs, keeping the components uniform at the same time.

Although the DSO's do not have to be involved intimately, their relations with Eneco and the PV proposition need to be standardized, like the process of connecting a PV system to the distribution grid. Also the installation companies need to be allowed by the DSO's to make adjustments to the meter or fuse box in order to avoid two or more visits to the customer's house.

Finally it is important to have as few as possible stakeholders involved in offering the proposition. Fewer partners have the advantage that trust between stakeholders is increased as well as that long lasting relationships are established. Fewer partners also reduce complexity because less contracts need to be signed and the communication lines between the stakeholders remain short and quick. Speed and short communication lines are necessary to create the flexibility to deal with other issues and or barriers (Magretta, 1998).

7.4.2. Strategy IV – Club Med Model

This strategy I have called the Club Med[36] model. Club Med offers exclusive all-inclusive holidays. The exclusivity and all-inclusiveness is a great distinguishing asset from the competition. Although Club Med offers all-inclusive holidays, they provide a number of options to customers like larger rooms, special excursions, use of high quality (sports) equipment. This applies to building block AI.a, where extra service options and system size can be increased depending on the customers need. What is most important is that the all-inclusiveness lets the customer know with certainty what he is going to pay and what he is getting in return.

Club Meds customer service is very good. Their *Gentile Organisations* (GO's) are very customer orientated and customer friendly. This contributes directly to a very good customer experience and satisfaction. Although Club Med holidays are more expensive than competing offers, customers are willing to pay for the higher service levels and the certainty that they will have a good experience.

Club Med structures their marketing process differently from the Dell Model. The Dell model is centred around buying a PC system. Club Med's approach is centred around the emotions of potential customers and offering experiences to convince them to book their holiday with Club Med. Not all options are offered but Club Med makes the selection that appeals to most of the customers in their target groups. They have different offerings for different target groups. This is very similar to the bounded rationality building block B.II. In this building block often clear choices are made with regard to offering a customer with a service or product just as Club Med, as well as in the way it is offered to the customer.

One discrepancy with the comparison between Club Med and buying a PV system is that buying a PV system cannot be seen as a life changing event but on the other hand a PV system is a long term investment and does not have to be based on economic factors only. Other factors play a role in investing in solar energy like sustainability and CO_2-reduction.

Required Change from the current situation

Four profound changes need to be made to execute the Club Med strategy.

- The different steps, starting from generating interest first through marketing, taking up the order, installing and servicing the PV system, need to be well coordinated between the different stakeholders involved in the propositions. Interruptions, delays and bad service due to lack of coordination, are unacceptable as the basis of the strategy is 'carefree' or 'peace of mind'.
- In order to have a carefree PV system product guarantees are necessary. Clear arrangements and responsibilities between the project partners need to be defined, otherwise a guarantee will be nothing more than an empty promise. The guarantee is very important as part of building block B.II.
- The customization tool needs to be developed where the customer can choose the PV system that best fits his needs. This includes the roof check where the customer can fill in the characteristics of his roof and his electricity consumption profile. This information will

[36] The club Med strategy and mission is further clarified at the company website: http://www.clubmed-corporate.com/?cat=200 last queried: 3-11-2011

determine the pre-specified technical PV system, comparable to a fully equipped standard package of the Club Med model.

- A marketing campaign needs to be developed in line with the proposition based on building block B.II. The campaign should aim to convince customers to actually invest rather than just showing interest in investing as has been explained in paragraph in 6.7 and 6.8. Increasing the adoption rate is the main objective here. Furthermore, it is necessary to attract a (large) number of customers through the website to gain a sufficiently high number of investments. In support of the marketing campaign endorsement from other stakeholders should be further explored.

Advantages

The first advantage of the Club Med model is that it requires a lower initial investment. The more complex information provision of the Dell Model can be kept much simpler. The development of a more elaborate ICT system is unnecessary. For the Club Med Model only existing information systems need to be modified like the current "Mijn Eneco" page and roof check. The main modification to the system is enabling a customer to customize the pre-specified package, and giving the website the right look and feel for supporting the concept of the carefree PV system solution. Therefore this strategy is easier to set up for execution.

A second advantage is that the customer can simply opt for the carefree product including a maintenance and service contract, installation, insurance and financing. He can still change elements. Customers are often daunted by paying for elements of a product which they do not use **Ongeldige bron opgegeven.**. At the same time the customer is able to upgrade to a desired service level such as an advanced monitoring tool.

In line with the principle of Club Med Eneco should emphasize a closeness between customers with a PV system. It should be fun and exclusive to belong to this group. It is important that social media should be used to promote the system. Word-to-mouth advertising is often more effective than marketing. Satisfied customers should be encouraged to be open about their experiences through the use of social media platforms (Kaplan, 1999).

Disadvantages

The approach for provisioning information and guiding the consumer through the process from start to finish is less structured. This may result in a lower rate of investment by consumers, because they remain uncertain about the benefits gained from the investment. Secondly marketing in this way may prove more costly if the rate of adoption of the customers remains low.

A second disadvantage is the odd balance between mass customization where the customer can pick & choose additional components or upgrades while at the same time pre-configured packages are offered. This may contribute to lower product costs but it can convey a confusing message to the customer due to the limited number of upgrades the customer can choose from (Huffman & Kahn, 1998).

A third disadvantage is the difficulty to integrate Strategy IV with other energy efficiency products (solar water heating, insulation service etc.) offered by Eneco and its subsidiaries, because there is no real integration. A customer has to be approached multiple times to offer a wide array of different products because the systems are not sophisticated enough to offer different options as well and do

not obtain the necessary information. This is in contrast to the Dell Model where the customer can be approached in a one-stop-shop experience. Having to approach the customer multiple times for multiple products does increase costs as well as customer dissatisfaction (Morren, 2011).

Fourth, the Club Med Model can easily be copied by Eneco's competitors. Mainly due to the limited focus and limited integration of the strategy. The product offer is relatively standard, largely a pre-specified product. The Dell strategy relies on other products as well, and more importantly the information gathered from the customers that use their system is difficult to duplicate. This will give Eneco a significant competitive advantage.

To be successful the Club Med approach has to provide immaculate services. The Club Med model as explained by the Club Med website as well as by Kotaabi (2008) relies on a high level of service to distinguish itself. If the level of service provided by Eneco only equals the level provided by the competition, than the competitive edge of Eneco is lost, resulting in a proposed PV strategy heading for failure.

Stakeholder Roles

The PV installation companies, either Eneco's installation company or any others included to obtain national coverage, are very important. They need to provide the promised high quality to the customer. Not only do they have to be friendly towards the customer they have to keep their promises as well. Promises including being on time, installing the system correctly in one visit and no additional hidden costs. To obtain the desired results requires, just as in the Dell model, a good relationship and coordination between the installation company and Eneco.

The PV system supplier is important to guarantee that the PV systems installed at the customer is of a high quality. Not only the installation itself contributes to the quality of the systems, the used components play a major part as well in achieving a high performance and a long service life. Delivery of the PV systems needs to be on time to the system installers, otherwise it will be difficult to fulfil the promise of an on-time installation.

Finally clear agreements need to be struck between the PV system installers, suppliers and Eneco; not only for coordination but also to clarify their respective responsibilities and rights. If these are unclear or lacking it is likely that the quality offered to the customer will deteriorate resulting ultimately in a failure of the PV strategy.

7.5. Conclusion

Chapter 7 has shown how the questions answered in the previous chapters can contribute to the development of the partial PV strategies developed here. Chapter 3 described the sociotechnical system of PV in the Netherlands, followed by chapter 4 with a stakeholder analysis Eneco of which a number of stakeholders can play an important role in the strategy. Chapter 5 dealt with the barriers for which the building blocks here have been identified. These barriers were solved in chapter 6 using scientific theory and finally chapter 7 where these building blocks are used to build two (partial) strategies.

The building blocks were brought together by using the morphological chart as described in chapter 2. Not all the steps for a complete morphological chart could be carried out. A limited number of building blocks have been developed due to time constraints. As has been demonstrated five

different building blocks resulted in the identification of six partial strategies. In this case there were no real contradicting building blocks, although a number of building blocks reinforce each other when combined. The reinforcing or complementary nature of the building blocks was an important factor for selecting which partial strategy suits the needs of Eneco the best.

From the six partial strategies, two were chosen as the most promising partial strategies: the Dell Model and the Club Med model. Both strategies aim to stimulate the large scale roll-out of PV in the Netherlands, but both aim to achieve this goal in distinctly different ways.

In conclusion: the Dell model is recommended as the best partial strategy of Eneco. This strategy provides a lot of flexibility allowing Eneco to offer other (energy efficiency) services through the proposition as well, but also provides the flexibility in adapting the strategy to future needs of customers, changing regulation or new technological developments . The mass customization aspect of the strategy makes the proposition difficult to copy by its competitors. The strategy requires a strong cooperation between the stakeholders. When this is in place it will be difficult to copy by competitors. The strategy also will provide Eneco with a lot of market data and data on potential prospects. Finally it contributes the most of both strategies to the corporate strategy of Eneco stated in chapter 3. Because it emphasizes the innovative image of Eneco while at the same time locking in customers, stimulating the deployment of renewable energy in the Netherlands as well as increasing business for Eneco. The largest drawback of the approach are the high investment costs required to get the system implemented due to the ICT system that needs to be developed.

I have developed these two different partial strategies for Eneco based on scientific literature, the barriers identified by the stakeholder interviews as well as the opportunities identified by the interviewees.

An important remark has to be made. These partial strategies have not yet been validated by any means. This is not because validation is regarded as unimportant, it is actually very important by any standards. However due to the time constraints of this research this step has been omitted. In chapter 8 a paragraph is dedicated to the validation of the chosen partial Dell Model strategy. A model is given of how this partial strategy can be validated, as well as what changes could be made to the partial strategy as a result of the validation.

Chapter 8

8. Building a Strategy: Conclusions & Recommendations

Chapter 8 is the final chapter of this research project. This Chapter summarizes the answers on the research questions, including my conclusions, limitations of the research, recommendations, suggestions for validation of my recommendations and my reflection on this project. The outline of the paragraph is shown in Figure 23



Figure 23: Chapter 8 Outline

8.1 Answers on the research questions

As written in chapter 2 the main research question in this research project is:

> *"How to build an effective strategy facilitating the large scale roll-out of PV for retail consumers in the Netherlands, for Eneco, using a concentric systems approach?"*

To answer this question I have formulated eight sub questions which are answered as follows:

1. *Is PV the most appropriate technology for Eneco to build a PV strategy, considering technological, institutional and process factors?*

This sub question is answered in chapter 3.

First: Eneco has a sustainable strategy '*Duurzaam, Decentraal en Samen*' (DDS). That strategy is based on three pillars: sustainable energy generation, decentralised local solutions and cooperation with stakeholders both external and internal.

Second: PV is the best technology for consumers to generate part of their electricity needs themselves and simultaneously contribute to their sustainability goals (comparative chart, Table 4, chapter 3)

Third: The installation of PV systems in The Netherlands is very low compared to Germany, but also in comparison to the United States and Italy (Graph 2, chapter 3). This means that there are opportunities for Eneco.

Fourth: A study by USP Market Consultancy (2011) on solar heating and electricity shows that 80% of the homeowners is willing to invest in a PV system in the Netherlands.

2. *Who are the main stakeholders involved in a PV proposition and, what is their role in the process of developing a PV strategy?.*

This sub question is answered in chapter 4.

By means of a stakeholder analysis the following main stakeholders are identified:

- Eneco
- Ministry ELI
- Consumers
- Distributed Grid Operators
- Financial Institutions
- PV Installation Companies
- PV system Suppliers

The roles these stakeholders will perform in the process of developing a PV proposition have to be further determined when Eneco makes a choice concerning the PV strategy (chapter 7)

Cooperation with some of the stakeholders, i.e. a financial institution, Distributed Grid Operators, PV installation Companies and PV system suppliers will be necessary to launch a PV strategy successfully.

3. *What are the main barriers according to the stakeholders deterring PV investment in the Netherlands, that can be influenced Eneco by looking at the following type of barriers?*
    a. Technical barriers
    b. Institutional barriers
    c. Process barriers

This sub question is answered in chapter 5.

By stakeholder interviews a list of barriers has been made (complete lists can be found in Appendix G). The most important barriers per category appeared to be the following: '*standardization*' and '*quality uncertainty*' (technical barrier), '*contracting cost/benefit allocation*' and '*policy (in)consistency'* (institutional barrier), '*level of knowledge'* and '*level of cooperation'* (process barrier).

4. *What are the most important or main barriers?*

This sub question is answered in chapter 5.

By scoring, see Table 11, the main barriers per category are found. Due to the limitations in time and in working capacity for the scope of this Master thesis two barriers for further research were selected: '*lack of standardization'* and '*lack of knowledge'*.

5. *What are the underlying issues of the most important identified main-barriers, providing starting points to search for scientific theory?*

This sub question is answered in chapter 5

Lack of standardization creates higher investment costs as elements need to be customized. Mismatching components create even higher (total) cost of an investment in PV as well as delays with installation and higher costs for maintenance. The end result is that an investment in PV looks less attractive to a customer.

The main of consequence of the lack of consumer knowledge is that it is difficult for customers to obtain the necessary information in order to get a clear picture of the investment decision. Also the mismatch and conflicting information given by the large number of stakeholders as well as the number of steps that is needed to install a PV system create a high level of complexity for the customer. Both by the mismatch as by the complexity customers are inclined to postpone the investment in PV or even taking a negative decision.

6. *Is the concentric systems approach suitable to build an effective strategy in a complex market as the PV market?*

This sub question is answered in chapters 2 and 6.

In this research project the Concentric Systems Approach (with morphological chart and Meta design model) is used to build a strategy for the PV market. A market that can be characterised as a complex market with many stakeholders and influenced by institutional, technical and process factors. The valuation of the chosen method is as follows:

First: The Concentric Systems Approach (CSA) helps to understand the broader scope of problems and interdependencies between building blocks and its impact. The method helps to develop solutions that are qualitatively better. The method is very useful in creating (problem) awareness by its users. This awareness is of great importance when developing, alternatives, problem solutions, products and or strategies.

Second: The use of the morphological chart in the CSA helps to cut a large problem like the *large scale roll-out of PV for retail consumers in the Netherlands* into smaller problems. Smaller problems can be solved more easily, the interdependencies have to be kept in mind. The solutions for the smaller problem can be developed as building blocks allowing for different solutions per building block. This increases the flexibility of the total solution proposed. Smaller building blocks are easier to develop than a comprehensive solution to an entire problem.

Third: The Meta-Design Model (MDM) structures the process of developing the building block by including other stakeholders that provide (implicit) requirements for the building blocks more robust building blocks and therefore a better strategy can be created.

Fourth: The building blocks can be combined in the morphological chart into multiple configurations. Also when one of the building blocks changes a change to only that block can be made were the model provides the insight of the interdependencies between the building blocks.

Fifth: the building blocks created for this thesis are thorough. If Eneco chooses to continue the use the morphological chart this can be done less thorough, because they do not have to develop the building blocks adhering to the requirements of writing a thesis. It is also possible for Eneco to work with more people at the same time on multiple building blocks.

Sixth: The method in itself has flexibility that fits markets with a lot of volatility. The building blocks constituting of the strategy can easily be changed when the environment or socio-technical system changes, either by technological changes or institutional and process changes. The ability to adapt a strategy rather than discarding it presents a lot of added value.

7. *Which scientific theories can be applied to solve the main barriers, resulting into building blocks?*

This sub question is answered in chapter 6.

For the barrier '*lack of standardization*', the theory of *mass customization* is considered to be most applicable to build an effective strategy in a complex market as the PV market with. Mass customization provides the flexibility needed to work in a complex market. Secondly mass customization is a combination of both using standardization as a way to reduce costs as well as a using customization to address the requirements of different groups of customers. It also allows for tailoring to the requirements of the individual customer, increasing overall customer satisfaction.

The most suited scientific theory for dealing with the barrier '*Lack of Knowledge*' as well as dealing with complexity in decision making is the theory on *bounded rationality*. This theory provides a great insight why customers are not investing in PV, while most of them do see it as a promising investment. By gaining a greater understanding of customer behaviour the development of building blocks supporting customers to make a decision whether or not to invest in PV, becomes possible.

8. *What is the best partial PV strategy for Eneco based on a morphological chart representing the barriers and the different building blocks?*

This sub question is answered in chapters 6 and 7.

8.1.1. Building Blocks

Based on the theory of mass customization two building blocks are developed for the barrier '*Lack of Standardization*': Mass Customization and Variety (chapter 6). For Mass Customization two different options are developed: a mass customized full service proposition and a limited version of mass customization (paragraph 6.3).

In accordance with the theory of bounded rationality supported by the theoretical concept of the energy efficiency gap two building blocks are developed for the barrier '*Lack of knowledge*': the 'Interactive Information Management Approach' (paragraph 6.7) and 'Information Framing' (paragraph 6.8).

The conclusions of chapter 6 are that both Building Blocks Mass Customization and Variety seem to provide interesting solutions for serving a larger share of the market as well as keeping the costs of a PV system low. Mass Customization is considered as the better approach because it combines the standardization of the components for reducing the costs of a PV system significantly and the need for customization because every customer and roof is different. The mass customization approach provides a more comprehensive approach, resulting in a strategy that distinguishes Eneco from its competitors in the PV market in the Netherlands.

The conclusions of chapter 6 about building blocks 'Interactive Information Management Approach' and 'Information Framing' are that information can do little to open up the market, when there are

other important barriers to cope with, such as regulatory issues and significant financial barriers. Information provision can only facilitate the decision making.

Endorsement by other stakeholders like financial institutions or environmental organisations will increase the acceptance of the PV propositions. The new proposition has to conform to the other organization's values and has something to offer for the participating stakeholders.

The incentives given by Eneco to invest in the system need to be large enough for consumers to be taken seriously. Large enough to convey unambiguously that there is a personal benefit to be gained from investing in PV systems. There has to be a financial incentive that appeals to a customer. If the financial incentives have diminishing returns, it can be more effective to invest in improved information techniques like addressing the loss of savings as explained in paragraph 6.8. When the interest of the consumer is sparked by the financial incentive, the information provision will enhance the incentive.

Finally, the provision of structured information makes the decision making easier to understand for the customer in order to overcome the decision heuristics laying at the core of the energy efficiency gap and bounded rationality.

8.1.2. Answer to the Main Research Question

Through the combination of the building blocks (see chapter 6) by using a morphological chart, partial PV strategies are built (chapter 7). In using a morphological chart it is important that mutually excluding building blocks are removed. From the possible number of combinations of specified building blocks in this research project six partial strategies are developed (7.4). Two partial strategies have been selected for Eneco as the most plausible solutions to obtain its goals: strategy I and strategy IV. Mass Customization and Interactive Information Approach (Strategy I) and Limited Customization, with Information Framing (Strategy IV). These two partial strategies have been selected based on the quality of the solution it provides for their respective barrier, whilst removing other identified barriers (those other barriers have not been investigated in depth), such as the investment costs barrier, lack of financing barrier and quality uncertainty. The selected building blocks complement each other and fulfil the requirements set by Eneco. Strategy I is called the *Dell strategy* and strategy IV the *Club Med strategy*. Both strategies require changes of the current situation at Eneco. These changes are described in paragraph 7.4, including the advantages and the disadvantages, and the roles of stakeholders. Both strategies aim to stimulate the large scale roll-out of PV in the Netherlands, but both aim to achieve this goal in distinctly different ways.

The final conclusion is that the Dell model is the best partial strategy for Eneco. This provides a lot of flexibility. It allows Eneco to offer other (energy efficiency) services through the proposition as well, but it also provides the flexibility in adapting the strategy to future needs of customers, changing regulation or new technological developments. The strategy will also provide Eneco with a lot of market data and data on prospects. The mass customization aspect of the strategy makes the proposition difficult to copy by its competitors. Finally it contributes the most of both strategies to the corporate strategy of Eneco stated in the chapter 3. It emphasizes the innovative image of Eneco while at the same time locking in customers, stimulating the deployment of renewable energy in the Netherlands as well as increasing business for Eneco. A condition is that the strategy requires a strong cooperation between the stakeholders.

The largest drawback of the approach is the high investment costs required to get the system implemented due to the ICT system that needs to be developed.

8.2 Limitations

The most important limitations are the ones that are set at the start of my research. A master thesis carried out by one student does not give enough capacity to develop a complete strategic study after the possibilities of a roll-out of PV in The Netherlands. As said before only a limited number of barriers and building blocks have been investigated.

Other important limitations of the conducted research study are:

- More research is needed to investigate to what extent customers are really prepared to pay more for increased levels and choice, with regard to investing in a PV system.
- The focus of this research is on individual consumers who are willing to install in a PV system. This group should represent a majority of homes and most suited roofs. Homeowners are the easiest group to focus on when rolling out PV in the Netherlands. The results of this study however cannot simply be transferred to other customer segments such as VvE's or consumer collectives.
- This research has been conducted with the demarcation on the Netherlands. Because of differences in renewable energy policy as well as other differences such as insolation, this research cannot simply be replicated in other countries. Before replication, policy, local conditions etc., have to be researched
- Despite the limitations in scope of this study I have collected quite some material that is important to Eneco, I have included these findings in the next paragraph 'Recommendations for Eneco'.

8.3 Recommendations

Recommendations result directly from the research carried out and the presented conclusions. The recommendations are divided into two different groups: practical recommendations for Eneco in paragraph 8.3.1. and scientific recommendations in 8.3.2

8.3.1 Recommendations for Eneco

The following recommendations are for Eneco to support them in developing their final strategy for the roll-out of PV in The Netherlands:

1. The proposed Dell partial strategy should form the basis of Eneco's new PV strategy. The Dell strategy aims at:
    a. low costs, high services levels, reducing complexity for the consumer and increasing customer satisfaction.
    b. providing an open platform to incorporate other sustainability products
    c. offering the flexibility to incorporate future changes like technology or regulatory
    d. creating a barrier for entry for Eneco's competitors
    e. creating a greater customer lock-in
    f. contributes to the innovative appearance to the image of Eneco.
2. Eneco should develop (software) systems to support the investment decision making of the customer including customization tools, like the roof check, planning and scheduling as well as the opportunity to offer additional energy efficiency investments.

3. Eneco should consider to incorporate the methodology used for this research into their strategy and product development process. The methodology supports the development of different scenario's. Secondly the framework provides Eneco with a better understanding of the barriers, building blocks and their interconnectedness. The methodology strongly supports the cooperation with other stakeholders which is mandatory to become successful in the PV market. The methodology gives Eneco the flexibility to quickly respond and adapt its strategy to external developments such as technological and institutional change.

With regard to the Dell strategy additional recommendations can be made:

- Stakeholder relations are important to deliver a high quality proposition. Not only with the PV system suppliers and installers, but also financial institutions, environmental and consumer organisations. Financial institutions have the ability to help finance the strategy but they can also endorse the strategy to their customers. The environmental organisations can do the same by providing (unbiased) information to potential customers.
  Secondly, the arrangements between the stakeholders are important. Eneco should investigate how groups of stakeholders can be best included in the proposition, offering them the opportunity to contribute as well as realize their own goals. Stakeholders have valuable resources which could be shared by a fair allocation of costs, benefits and risks. For a successful strategy trust and shared values between stakeholders are important. These aspects must be tested in the selection of stakeholders.
- Whether Eneco embarks on the Dell partial strategy or not, Eneco should stick to its strategy for a long period. Continuity is important for the prospective customer. Today proposals are discontinued within months after their launch. This does not improve the image of PV. The Dell proposition offers strategic flexibility because the building block structure of the strategy facilitates its adaptability to changes in regulations, technology or customer preferences.
- The weakness of the Dell approach is having too many choices available to the customer, resulting once again a layer of complexity and bounded rationality: keeping PV simple should be the overarching principle in presenting solutions to the market place. This step should be included in the validation of the Dell strategy proposed in paragraph 8.4.

The following recommendations are directly related to the barriers I did not investigated any further:

Recommendations on Customer Preferences

- Eneco should research what the customer preferences exactly are, especially with regard to finance, insurance and a guarantee for future returns. This should guide the options that should be developed to serve these customers.
- It is unclear how customers are distributed over different customer groups with similar characteristics. More information has to be gathered regarding the customer's profile, helping Eneco to better target their services proposition.
- Care should be given to the promotion of investment in PV systems: if it is an investment in PV the customer will compare it with decisions like investing in a new kitchen, redecorating the home or buying a car. If the proposition is spreading future payments in line with the benefits PV becomes similar to electricity as a utility.
- The financial incentives given by Eneco need to be large enough for consumers to be taken seriously. There is a fine line when the effectiveness of a large incentive diminishes in favour

of better information provision (see paragraph 6.6). Eneco could save money by providing better information when considering financial incentives.

Recommendation with regard to Financing

- The option of financing of PV systems requires further research. Not only is large amount of cash required from Eneco for a large roll-out of PV systems, it is questionable whether Eneco is allowed to take up the role of a financing institution. At the moment Eneco does not have a banking permit. Eneco should investigate under which conditions financing is allowed and can be added to PV proposition.
- Eneco should investigate whether for leasing a PV systems a permit of the Dutch Autoriteit Financiele Markten (AFM) is required. Eneco should further investigate if a financial partner should become involved. From the interviews it has become apparent that the money required for financing is substantial. A number of financial institutions could be interested in providing financing on a large scale. ASN bank has expressed explicitly that they are very interested. Other interested parties might be Triodos Bank, Rabobank and LeasePlan for their large experience with leasing.
- Eneco should investigate in what way it will deal with a transfer of ownership of a home with a PV system installed and financed. If transfer of ownership is not possible, then this will form an additional barrier.
- Eneco should investigate how big the potential market for PV for retail consumers is. The potential market is a condition for the possible investment sum.

Recommendation on Future Developments in the Socio-technical System

- Eneco needs closely to observe the developments in the field of renewable energy and of PV specifically. Technological improvements are fast paced in the PV industry. Eneco can further distinguish itself from the competition by offering state-of-the-art innovation and components. Fast declining prices of PV panels makes it necessary the proposition is updated frequently to prevent losing the cost advantage and letting the door open for competitors to increase their market share. A second observation is that technological and institutional developments may provide pressing reasons for changing or altering the PV strategy.
- This thesis is aimed at the homeowner with a roof that is suitable for PV. Eneco should investigate how other market groups can be served by this proposition as well, like customers such as SME's, collectives, housing corporations. Talks with targeted institutions have to be started soon to discuss if there are opportunities that can be developed.
- (The perception of) High investment costs have already been cited as an important barrier preventing the large scale roll-out of PV in the Netherlands. Therefore Eneco has to maintain a close watch on the total costs of the proposition. Substantial installations are required to achieve low costs and low costs are needed to achieve substantial installations.

8.3.2 Recommendations for Science

The following recommendations are based upon the scientific goals of the research project to use the concentric systems approach to underpin and develop a strategy:

- Better methods should be found in dealing with interdependencies in sociotechnical systems. Literature agrees that these interdependencies between the technical, institutional and process systems is important, but literature in general does not provide the tools to deal with

these problems in a systematic way. A better framework to deal with these interdependencies would be invaluable.

- The concentric systems approach provides a good framework to deal with sociotechnical problems. The problem is however that the approach had to be customized for this research. No clear method has been described in available literature that provides a stepwise approach how to deal with the analysis of a problem, followed by the development of solutions to the identified problem. This might be due to varying properties of the identified problems. The meta-design model has been used implicitly during this research, but it does provide a number of steps to obtain the desired results. The meta-design model therefore has been useful in setting up the steps needed to develop the solutions.
- The application of the concentric systems approach has yielded interesting scientific results during the process of writing the thesis. It has become apparent that the method has a tendency in being too thorough and costing a lot of time. On the other hand it makes interdependencies between barriers very clear, making the approach very valuable. The approach have mostly been applied to infrastructure problems. However, this case has shown it has the potential of being applied successfully on a strategy problem as well. The characteristics of the research question of this thesis had the complexity as is generally found in infrastructure problems. Therefore it is recommended to consider the CSA to a broader set of problems than complex infrastructure problems. When the CSA is used for a larger variety of problems it can be further investigated whether the approach is suited for a wider range of problems or if the methodology requires a number of adaptations.
- CSA seems to be applicable to solve strategic issues like the case presented by Eneco. I think the CSA can be a very valuable approach to other strategy issues as well because it provides a chart which can be maintained for each of the barriers and building blocks more or less independently. So if the situation around one of the barriers changes the model could be adapted quite easily. The same can be said about changes occurring around the building blocks. The upfront investment may be higher at the beginning, but I am convinced that the flexibility and adaptability of CSA over time will deliver better results than doing a strategic plan every two years. Another great benefit is the fact that multiple stakeholders can work together on solving the barriers and creating the necessary building blocks.
- Mass Customization including a supportive approach on information provisioning can form a great strategy for complex products such as PV to gain greater market share through creating more structured options for consumers to buy a product that is individually tailored to their needs creating a much higher customer satisfaction. While products currently available to the customer are only able to satisfy parts of their requirements, resulting in a lower customer satisfaction.

8.4 Validation

The conclusion of chapter 7 touched upon the need for validating the chosen partial strategy as no process of validation is executed in this thesis. Validation is an important part for the motivation why a (partial) strategy works. Eneco wants to know if the recommendations and conclusions drawn in this are valid or applicable in the real world. Eneco does not want to invest into a (partial) strategy that has not yet been tested. This paragraph provides a set up how the conclusions and recommendations given here could best be validated.

Testing the entire strategy or in this case the partial strategy in one time would involve a very and complex validation process. It is easier to validate the building blocks making up the partial strategy. It is assumed that when the individual building blocks are validated correctly, that the partial strategy developed from these building blocks is validated as well. This is another benefit of the CSA.

However, when a large number of individual building blocks are used, the comprehensive strategy must be validated to expose interdependencies between building blocks that could not have been identified during the CSA. However it is difficult to present a validation method for validating the comprehensive strategy in this case. The validation method depends partially on the building blocks and the interdependencies between them from which the comprehensive strategy is built up.

8.4.1 Validation Mass Customization

To validate whether mass customization works for Eneco as part of the partial strategy two different methods are proposed. Method one uses a panel or conducts a survey amongst Eneco's perceived customers for the PV strategy. A second method is to execute an industry survey where mass customization has been applied and what the results have been achieved in respective industries.

For a customer survey Eneco has to set up a reference group of their customer target group. This target group likely contains current Eneco customers as well as non-Eneco customers. Eneco should ask its reference group about the problems they perceive as has been done during the stakeholder interviews performed in chapter 5. Secondly Eneco should ask the reference group whether they think the concept of the proposition (mass customization) can solve their problems.

If the customers think that the proposition solve their perceived problems then there is a large chance that the concept of mass customization is successful. Whilst if the customers think that the proposition does not solve their problems, Eneco could either discard the building block and change them, or set up a panel and ask the reference group how Eneco could improve the proposition to fit the customer's needs. A panel in this case can provide more elaborate answers than a survey could.

A second method of validating the outcome is checking the results mass customization has had in other industries, by means of an extended case study. As far as my personal knowledge concerned mass customization has not yet been applied in the PV industry. Therefore Eneco cannot compare the building bock with a case from the same industry. A case study provides Eneco with the answers to what the advantages and disadvantages of using mass customization are a given industry. When it appears that mass customization is successful in other industries but under similar conditions than it can be extrapolated that mass customization is a valid solution.

8.4.2 Interactive Information Approach

The interactive information approach can be best validated by a panel. The panel should consist of a reference group of customers. The panel is provided with two alternatives. The first is the interactive information approach (which was used as the second building block in Dell Model). The second could be the classical way in which a PV proposition is marketed.

Eneco can then asks two set of questions to the reference group. The first set of questions asking whether they prefer to be offered information in the classical way, or the interactive information approach way. The second set of questions to ask under which conditions they are more inclined to invest in a PV system. When the panel is in favour of the interactive information approach, the 'real' world customers are likely to accept that method..

8.5 Reflection

This report has presented the results of an 8 month research project on the topic of building a strategy for the large scale roll-out of PV in the Netherlands. In the end the research has provided interesting results and new insights for Eneco in developing a new product or strategy. During the research a number of obstacles have been encountered. The obstacles have been diverse in nature. Sometimes related to the chosen techniques and in other cases in trying to find solutions to not foreseen problems.

This final paragraph reflects on the research process which led to the conclusions and recommendations presented in this report. It discusses the value of the results for Eneco and highlights in greater detail the limitations of the chosen approach.

8.5.1 Usability for Eneco

The project was initiated in March 2011, after some deliberation between Eneco, the Technical University of Delft and the author till a suitable research question for the thesis was found fulfilling the requirements of the University and Eneco's requirements. A suitable subject was found: *to build a strategy, facilitating the large scale roll-out of PV for retail consumers in the Netherlands.*

It was impossible to develop or underpin a strategy in all its elements, nor does the author have all the expertise available to do so. The thesis therefore offers a number of recommendations that can help to underpin a PV strategy for Eneco contributing to the ultimate goal of facilitating the large scale roll-out of PV in the Netherlands. To my opinion this thesis has been successful in providing valuable contributions to Eneco to achieve its goals in the field of PV.

It is important to point out that the strategy elements, developed in the final chapters, are not the only opportunities for Eneco. The stakeholder interviews, the identified possibilities for partnerships as well as the extensive list of perceived market barriers by stakeholders (though this list will never be exhaustive!) contain a lot of useful information. For example: this list of barriers can be used in the future to test alternative strategies or solutions as well in developing building blocks to complement a robust PV strategy.

There are shortcomings to the usability of the findings of this research for Eneco as well. The thesis does not provide a comprehensive strategy about what Eneco should do. The aim of the thesis is to substantiate a possible future strategy. A second limitation for the usability of the thesis are the fast paced developments like decreasing prices for PV and the changing the environment including the changing perception of sustainable energy sources like PV by the market and by regulators. Stakeholder perceptions will change over time and will impact the outcomes of any strategy. Flexibility and adaptation to changing conditions is key. The recommendations however offer an approach to a PV strategy offering that flexibility over time. CSA showed to be very effective in this way. In doing so Eneco can develop a strategy that will hold for a longer period of time by increasing market confidence of consumers in a volatile market environment.

8.5.2 Scope

A shortcoming with regard to the scope of the research has been the demarcation on the individual homeowner with a well suited roof for PV. Various other groups, representing other large shares of the consumer market were left out in this research project. Collectives such as, VvE's and building corporations and tenants were left out because the institutional framework including net metering

and the structure of the energy tax is incommensurable with those of other consumer groups. These groups still represent a large market opportunity for the near future.

Another group which could benefit from a special product marketed to them, would be the small and medium enterprises. Especially those enterprises with a low electricity consumption will benefit the most from investing in a PV system. This group of small and medium enterprises were left outside the scope of the research as well.

A second issue related to scope, is that the research has not focussed on changing the institutional framework. In the interviews the participants made it very clear that they would like to see the government to take a more active approach in stimulating the development of PV in the Netherlands. Also these institutional issues were left outside the scope because it is something which cannot directly be influenced by Eneco.

However, if institutional changes were to be included, it could lead to some interesting new PV propositions. At the moment the net metering law is being amended to allow VvE's to invest in PV as well. If this would be the case large cities with multiple high rise apartment blocks could start investing in PV systems. This will open up a huge market, especially in the densely populated area where Eneco has their largest share of customers, the Randstad. These developments however are often lengthy and for now uncertain because it depends on the outcome of a political process.

For the future Eneco should review its formulated PV strategy and extend the recommendations given here to these groups of VvE's, tenants, SME's, etc. as soon as the opportunity arises to provide PV propositions to these groups. Once these groups are incorporated then Eneco would truly have a comprehensive PV strategy for the large scale roll-out of PV in the Netherlands.

8.5.3 Research Methodology used

Looking at the methodology chosen to develop this thesis a number of comments need to be made. First of all the morphological chart can be considered as taking a sledgehammer to crack a nut in combining building blocks from only two categories. One could comment that this could have been done with much simpler techniques, such as simply write down the complete strategies, combine them and judge whether they work or not.

I have chosen for this approach so Eneco can use this research and simply extend it. From where the author has left off, Eneco could simply add categories and options and work from there onwards by extending the chart and arrive at a more robust, complete and improved PV strategy. An extension of the number of barriers will provide Eneco a good and thorough understanding of the issues for a PV strategy. This will support the development of more well-designed building blocks which, when combined in the right way, will form a well underpinned PV strategy for Eneco.

Secondly, the CSA can be applied for these type of problems, though it increases the time spent on the research by creating more work following the steps outlined in chapter 2. The approach allows for a well-considered process of analyses and development of alternatives and solutions. From chapter 4 it became apparent that focus is necessary to arrive at any conclusions. The number of problems is simply too large to grasp at first sight. By further narrowing down the theories from which the building blocks are constructed the scope is further reduced. Once the building blocks are constructed the scope can be widened again by increasing the number of combinations in which the

developed building blocks can be combined. From this the potential strategies can be constructed. The structured nature of the CSA has contributed to the outcome obtained from the analyses and research.

Thirdly, the meta-design model has not received the attention that it should have gotten. During the research it has become apparent that it is difficult to derive the necessary requirements from the stakeholders constructing the meta-design model. The barriers and the barriers which have been excluded, should be used and included as requirements. This has been left implicit during the research and is a limitation in itself. A separate research project could have been devoted on devising the actual requirements from Eneco as well as from the other stakeholders. If Eneco wants a more complete and robust (partial) strategy they will have to develop more building blocks for the remaining issues.

8.5.4 Reflection on Analysis

Looking back at the analysis, the stakeholder interviews have been a marvellous experience. The process of distilling the barriers from the interviews can be considered as a biased process in essence. However this course of analyses has been chosen, because a practical decision had to be made. The approach however was supported by the findings in a relatively large number of interviews amongst a variety of stakeholders. The choices made in identifying the main barriers from the stakeholder interviews were taken on the basis of impartiality. There was no predetermined preference for either one of the barriers. On the other hand it presents just one element in a larger analysis and it was not the main goal of this research project.

When the research outline was first presented it was the intention to extricate one barrier for each element of the systems approach being the technical, institutional and process systems. Due to time constraints the decision was made to leave out the institutional system. There were two barriers identified in this system: “Contracting and cost and benefit allocation”, and ‘Policy (in)Consistency’ The first is left out because the focus in this research project is on customers. Investigating an issue such as contracting with external stakeholders and the allocation of costs and benefits between them is then of less interest. The second is left out because the policy for the stimulation of renewable energy takes a long time to influence and to change. The influence of Eneco on this is very limited. The selected technical and process barriers contributed a new aspect to the subject of this thesis, which had not been dealt with previously in the Netherlands.

Reflection on the technical system analysis shows that it has been very interesting to couple Mass customization to PV. Mass customization these days is often used in the computer industry: customizing your own personal computer and the automotive industry: customizing your car. This part of the analysis should be valuable to Eneco, because it can possibly create a unique selling point and an advantage above and beyond its competitors. However there are two important conditions to use mass customization:

1. Sufficient demand is necessary to offset the additional costs of customization
2. Prevention of information overload for the customer Information overload was one of the main problems as appeared from the interviews. Simple information systems for the customer could be a solution.

8.5.5 The writing process

Writing the thesis itself has been a big undertaking for me personally. During the work up and until the green light meeting, the thesis was written by each time adding part of the research to the thesis. Depending on the research question being worked on, the process would progress faster or slower. During writing my thesis there were meetings with the individual members or the complete graduation commission. These often helped me to progress further and to change certain parts of the thesis resulting in a better product.

However after the green light meeting in November the thesis became stuck. I became uncertain about changing which parts of the text. To solve this problem I organised a sparring group of both my parents and my girlfriend who recently wrote her own thesis. Their fresh and innovative new viewpoints helped me to get going again. The sparring group meeting during a weekend in November was therefore very helpful.

Ultimately their comments and the comments of the final meeting with the graduation commission, have been included into the final product which I think has improved considerably

8.5.6 Concluding

The eight months I have spent researching the large scale roll-out of PV in the Netherlands for Eneco has not only taught me a lot about the subject itself, but also about conducting research. Time management is crucial in conducting such a research project. Although I have overrun the allotted time for writing a thesis, in my opinion it was for the benefit of the thesis and of course Eneco. However in retrospect, the next time I will do a number of things differently.

The outcomes of the analysis have shown that the concepts of bounded rationality and customization contribute in developing interesting solutions. Solutions that contribute to solving the issue of high investment costs and the lack of investment in PV in the Netherlands.

The thesis has yielded interesting results for Eneco to build their PV strategy for the large scale roll-out of PV in the Netherlands. This research offers Eneco a solid approach and the building blocks to develop a comprehensive PV strategy.

Steven Sprokholt

December, 2011

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The bibliography is divided up into the following number of categories which are represented in Figure 24.

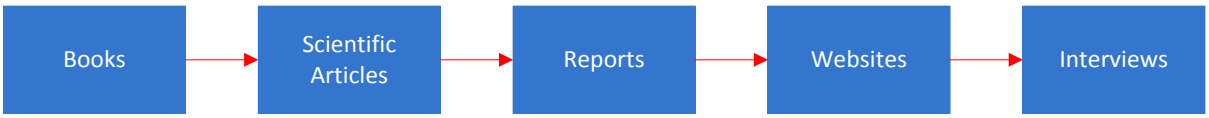


Figure 24: Bibliography Structure

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APPENDICES

"Because we are running out of gas and oil, we must prepare quickly for a third change, to strict conservation and to the use of coal and permanent renewable energy sources, like solar power."

President Jimmy Carter, televised speech, 18th of April 1977

Appendix A

The history of PV in the Netherlands and of Eneco (1973-2010)

The renewable energy market in the Netherlands started developing in the 1970's, right after the first[37] and second[38] oil crises. A diversification strategy was adopted by the Dutch government, resulting in two '*Energienota's*, (Energy White Papers) in 1974 and 1978. The two papers stressed the importance of a need for renewable energy sources, in order to become less dependent on foreign oil supplies. Among others, the option of PV as an alternative source was stressed and this led to fundamental research in PV (Negro, Vasseur, van Sark, & Hekkert, 2009; Holland Solar, 2010).

In 1986 a national research programme for PV was initiated by the national government. Firstly, the research programme aimed at building up/developing and maintaining expertise on PV (Negro, Vasseur, van Sark, & Hekkert, 2009). Secondly, it should promote the development of PV as the future energy provision of the Netherlands (Verbong, van Selm, & van den Burg, 2001).

In the late 1980's the Dutch government doubted whether solar PV could become an important part of the Dutch electricity system. According to De Jong et. al, it wasn't clear how to implement PV in the, at that time, centralized Dutch electricity system (de Jong, Weeda, Correljé, & Westerwoudt, 2005). Moreover, objections related to sufficient insolation to supply Dutch electricity (Ibid.). . In spite of these worries/doubts/uncertainties the Dutch government implemented the Support Regulation Energy Savings and Energy (SES) in 1988. This regulation was renewed in 1991. The Regulation compensated 40% of the purchase costs of a PV system and was considered to be an important step in the development of PV In 1990 research/attention started to shift towards increasing overall efficiency of PV systems including balance of system (BoS) components (Verbong, van Selm, & van den Burg, 2001).

In 1990 a new *Nota Energiebesparing* was published which stated the goal that in 2010 240 MW of installed PV should be realised. The realisation of the goal fell short, installed capacity in 2009 was 67.5 MW, a fraction of the planned 240 MW (IEA, 2010). According to Verbong et. al, it was the first time that a specific target was mentioned in a document (Verbong, van Selm, & van den Burg, 2001). The presentation of the *Nationaal Milieubeleidsplan in* 1992, increased PV research and renewable investment efforts by energy companies, although the targets were voluntary (van Rooijen & Wees, 2006). In 1995 Energie Centrum Nederland started to team up with (international) research groups which lead to an industrial solar PV module with an efficiency of 16%. The Netherlands acquired an important role in global PV research. For example, several demonstration projects were setup, which in the end led to increased PV system performance (Verbong, van Selm, & van den Burg, 2001).

In 1998 the *Energie Premie Regleing* (EPR) was introduced by the national government. Home owners received € 1,59 Wp^{-1} installed at the start of the subsidy regime (van Rooijen & Wees, 2006), which was later increased to € 3,50 Wp^{-1}. Consequently, PV module plants were setup and a genuine industry took foot. Negro et. al stress that there was an attempt at creating a mass market for PV, in cooperation with NGOs, leading to lower prices and learning effects (Negro, Vasseur, van Sark, &

[37] In October of 1973 the first oil crisis started due to the re-supply efforts of the United States to Israel which lead to an oil Embargo by OPEC. The oil crisis ended in March 1974. The impact of this first crisis was seen as an anomaly by governments.

[38] The second oil crisis was in 1978 when national turmoil started in Iran, resulting in the January 1979. The crisis led to oil shortages and panic on international oil markets, with rocketing oil prices as a result.

Hekkert, 2009). In 2001 the energy market was liberalized, which meant that PV had to compete with various other renewable technologies that were cheaper/more profitable. Renewable energy was mostly imported from abroad, from countries such as Germany (van Rooijen & Wees, 2006). The EPR subsidy remained for a short period of time. However, in cooperation with NGOs and energy companies, demonstration projects were still setup so future projects could learn from it. Municipalities also started to offer additional subsidies for installing PV systems (Sinke, Swens, Janson, & Witte, 2008). Projects could obtain funds from several different subsidies leading Eneco to offer solar PV systems for a purchase price of € 1 Wp^{-1} (Negro, Vasseur, van Sark, & Hekkert, 2009). In 2003, when a new government was just installed , environmental subsidies were however cancelled because of excessive financial stimulus packages. At the end of 2003 the EPR suddenly stopped. According to Dutch government due to the unfavourable and inconsistent subsidies and stimulation schemes. Investors were unwilling to invest and dedicated PV-businesses were stopped. In 2003, 19.3 MW of PV was installed, the following years this drops to around 1 to 3 MW per year (IEA, 2010).

When the *EPR regime* was in effect from 1998 through 2003, Eneco presented its first PV proposition. Eneco installed PV systems for consumers and provided an additional subsidy incentive to promote residential PV generated electricity. The PV system costs were very low, due to the generous public subsidies combined with additional subsidy given by Eneco. The project succeeded in terms of installed systems, however there were a number of difficulties. For example, due to technical problems most installed inverters failed after approximately 1 to 4 years of service, causing the PV system to malfunction. These inverters had to be replaced, which led to significant costs for Eneco. When the EPR subsidy regime was stopped by the government in 2003, Eneco stopped with the PV proposition. In the following years, no research was undertaken because it was simply too expensive, without subsidies. This led to a loss of expertise, both administrative and technical, which was needed for a roll-out of PV in the Netherlands.

The *Milieukwaliteit ElektriciteitsProductie,* (MEP) was introduced in 2003 by the national government to sustain the investment in renewable energy. The subsidies for PV were halved and investment costs remained high for PV-systems. Dutch research however continued with the help of EU funding (van Rooijen & Wees, 2006; Sinke, Swens, Janson, & Witte, 2008). In 2006 the MEP was abolished, because the sustainable targets for 2010 would be achieved without the subsidy. No national subsidies are available for PV, the industry including research institutions start to export abroad. This resulted in a collapse of the Dutch PV innovation system, because the subsidies stopped (Negro, Vasseur, van Sark, & Hekkert, 2009)

In 2007 a new government takes office that started to focus more on renewable energy. In collaboration with the Dutch PV industry, the government developed a new renewable policy (Negro, Vasseur, van Sark, & Hekkert, 2009). In April 2008 the *Stimulering Duurzame Energie* (SDE) was launched, which resembled the MEP system. With the SDE, producers could receive a premium, covering the additional costs on top of the retail price of electricity for a maximum of 15 years. This system can be compared with the German feed-in-tariff (FIT) system. The height of the subsidies was between € 0,30 kWh^{-1} and €0,60 kWh^{-1} and were dependent on the average electricity prices. The FIT was sufficiently high to make investing in PV a very profitable investment. In 2008 applications totalled 17.8 MW of solar PV modules while the budget allowed for 10 MW. Interests in society was thus high. Unfortunately industry had no experience with installing PV systems on such a large scale,

which led to installation delays and projects cancellations. Because registration and metering within the new subsidy scheme meant a lot of recurring costs and hassle for installing a PV system, the subsidy was ineffective for smaller PV-systems (Negro, Vasseur, van Sark, & Hekkert, 2009).

Eneco introduced a second PV proposition at the start of the SDE-subsidy regime. Customers and businesses could apply for subsidies and installation through Eneco. The main problem of the proposition was that a lot of subsidy applications were denied because the funds were quickly exhausted. . Whereas Eneco put a lot of effort in these applications, it resulted only in a very limited amount of installations. After two propositions, it can be concluded that Eneco received only limited results and a lot of dissatisfied customers due to rejected subsidy requests.

Dutch government cancelled SDE in 2010 due to the financial crisis and inefficiency of the initiative. Currently the SDE+ subsidy is introduced by EL&I (Verhagen, 2010). The funds of the SDE+ are auctioned off and the subsidy is gradually made available. The subsidy increases each phase (there will be four phases) until the funds are exhausted. The FIT of € 0,15 kWh^{-1} is auctioned off in the final phase. Relatively cheap technologies and projects have the highest chance of success in obtaining a subsidy. The SDE+ is financed by a levy on the electricity bill by commercial and residential users and started on 1st of January 2011. The funds will be made available in 2013 (Verhagen, 2010). The launch of the SDE+ marks another significant change in Dutch subsidies for renewable energy. The opeenvolging of new projects by Dutch government, creates uncertainty for parties that are willing to invest in renewable energy. In contrast, in Germany PV industry is booming, despite the restructuring and reducing of subsidies tariffs (Negro, Vasseur, van Sark, & Hekkert, 2009; Laird & Stefes, 2009).

While writing this thesis Eneco has presented a new PV proposition called *Zonnestroom*[1]. This proposition consisted of customers leasing a PV system during 10 years, after which the customer assumes ownership of the system. During these 10 years, a monthly fee is paid. The electricity generated by the PV system is settled with the electricity bill. A second motivation for Eneco is to gain experience in marketing, installing and servicing a significant number of PV systems. Eneco sold the 250 available promotional PV systems within one month's time. Equalling the number of PV installations Eneco's three installation companies achieved in the year before. Although the proposition is a success it is not continued (Verbeek, 2011).

Eneco continues to offer PV system packages through its installation companies, Tempus, GSU and Metapart. As it has done before the Zonnestroom proposition. The interest in these packages is limited due to the lack of subsidies and because of complicated regulations that consumers are confronted with when taking an investment decision (Morren, 2011).

Appendix B.

Net metering in the Dutch Electricity Act

B.1. Self-supply of Electricity in the Dutch Electricity Act.

According to the Ministry of Economic Affairs, Agriculture and Innovation (EL&I), the definition of self-supply is the following:

"Self-supply is the generation of electricity behind the meter, for example by a small consumer who has mounted a PV system or urban wind turbine on his roof:" (Ministry of Economic Affaris, Agriculture and Innovation, 2011)).

A schematic representation of this definition is provided in Figure 25.

The Electricity Act of 1998, established that small consumers[39], who feed-in less than 3000 kWh per year[40] into the grid (Electricity Act, Article 31c, second paragraph), may subtract the electricity fed in into the grid from the electricity they consumed from the grid. This is referred to as net metering. This does not only apply to solar PV systems by to any system that generates electricity at a consumer behind the meter, μ-CHP systems are included in the Act as well.

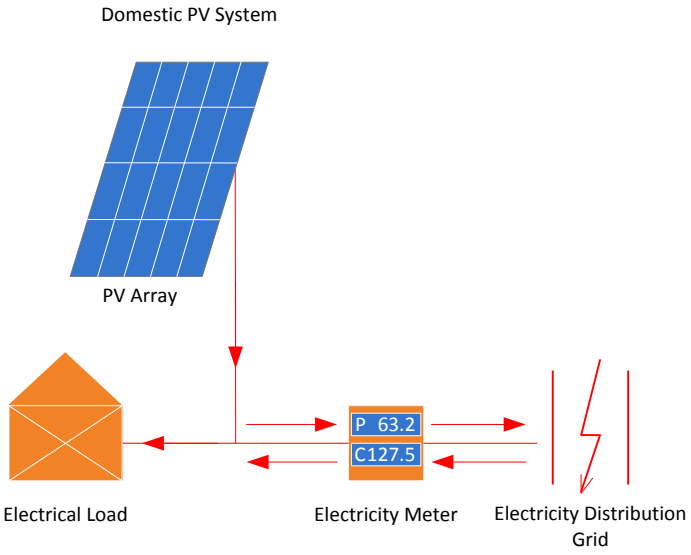


Figure 25: Domestic Electricity Generation behind the Electricity Meter

In the case a consumers feeds more than 3000 kWh per year into the grid, the consumer should be paid a fair compensation, by their energy supply company. The fair electricity compensation is determined by the Dutch Competition Authority (NMa) (Electricity Act, Article 95c, third paragraph).

There is another issue with net metering and that is the Energy tax (*Energiebelasting*). The energy tax is calculated on the basis of the electricity delivered by the connection to the distribution grid. Energy tax is calculated as well for electricity obtained by any other means than renewable electricity

[39]Definition of a small consumer is a consumer that has a grid connection capacity of less than 3 x 80 ampere's.
[40]Member of Parliament Diederik Samsom proposed an amendment of the Electricity Act increasing the feed-in limit to 5000 kWh per year. However, at the moment a majority of the energy companies takes 5000 kWh as a limit and there are energy companies applying unlimited net-metering.

generated behind the meter. The energy tax is only levied on the positive balance of the electricity bill once the electricity fed into the distribution gird is subtracted from the balance of electricity consumed from the grid. Consumers with a PV system do not have to pay taxes for their renewably generated electricity; the electricity fed into the grid is subtracted from their electricity consumed.

The flows of electricity shown in Table 24Figure 25 display the possible electricity flows in a domestic electricity system with a connected PV system. When the sun is shining and more electricity is generated than is consumed by the household, the excess electricity is fed into the electricity distribution grid. When this occurs the electricity meter shows the amount of electricity fed into the grid. It also happens that the electricity generated by the PV system is insufficient to meet the demand, in this case additional electricity is taken from the grid. The electricity meter shows, as normal, how much electricity is consumed. This is the case where the panel is connected behind the electricity meter.

At the end of the year the electricity supply company notes the meter readings, both the consumption and the fed electricity. The electricity fed into the grid is subtracted from the electricity consumed from the grid, this is the net metering that has been described previously. Energy taxes are paid over the final consumption of electricity.

B.2. Self-supply or electricity generation in front of the meter

The case described here includes projects where a consumer consumes electricity generated by a renewable energy project. The electricity is transported through a connection in the electricity distribution grid. This is considered self-supply in front of the electricity meter. This case is applicable to consumers who do not have a suitable location for generating electricity through for example a PV system. Figure 26, represents the case of electricity generated in front of the meter by a consumer.

This way of generating electricity does not fall under net metering, according to the Electricity Act. This is the case because there is no physical connection present between the consumer and the (collective) installation that generates renewable electricity.

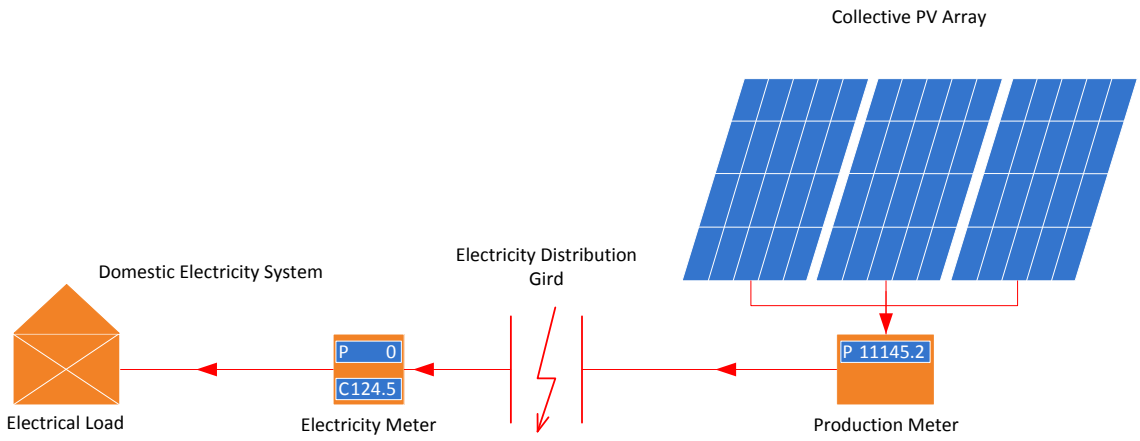


Figure 26: Electricity Generation in front of the meter by means of a Collective PV Array

This creates two issues when generating electricity in front of the meter. First, the set up here disqualifies itself to use net-metering. Second the exemption of the energy tax for consumers is only given for electricity generated behind the meter, which has been net-metered. In the case presented

above, where electricity is generated in front of the meter, energy taxes are levied on renewable generated electricity, creating a much more difficult business case.

B.2.1. Solutions for the issues with self-supply in front of the meter

The issue that generating electricity behind the meter experiences can firstly be solved by connecting the system with an electrical cable to the house behind the meter. In this case there is a direct physical connection, by means of the electrical cable, between the house of the consumer and the PV system.

A second solution[41] relies more in the interpretation of the relevant Acts. Looking at the legislation quoted above, it is stated that only the delivery of electricity is taxed by means of the energy tax. This means that the energy distribution company is taxable. Therefore, only the energy distribution company is liable for the delivery of electricity to the consumer. Therefore the energy distribution company is not liable if no delivery of electricity takes place of electricity while the connection works fine. As noted before in the first section of this appendix, if electricity is generated behind the meter by means of a renewable energy installation, the energy distribution company has not delivered anything because during the operation of the installation the electricity has been in ownership of the consumer.

This would imply that if the electricity generated by a collective PV array and is fed into the electricity grid and is consumed by the participants, does not mean that energy is delivered to the participants by the energy company. Because there is no delivery, to the consumers and no power purchase agreement is in place between the collective array and its participants, electricity companies, like Eneco, cannot calculate an electricity price. However, an electricity transport fee should be paid to the distribution grid operator, for example Stedin. The transport tariffs are established by the NMa.

There is an important case which underpins this argumentation. In the case of electricity theft, there is not an agreement between the energy distribution company and the consumer. In that case, according to the Ministry of Finance, energy taxes do not apply[42].

Because there is no delivery of Eneco present, no delivery is present in the definition provided by the Environmental Taxation Ground Act[43]. Because feeding in electricity into the grid and consuming that electricity through the grid by its participants does not make this a delivery by the energy distribution company to the consumers. There are no power purchase agreements for Eneco purchasing the power from the PV array, nor is there an agreement between Eneco and the participants in selling or delivering electricity.

This argumentation stresses there is no delivery, and no energy taxes are required to be paid by the consumers for their generated renewable electricity from the collective PV array. In this case Eneco could fulfil a role as a service company, administering the flows of electricity to the participants.

[41] This argument has been brought forward by Ernst & Young in an internal report of Eneco on the matter of generating electricity in front of the meter.
[42] Ministry of Finance, 3 November 2008, 'verschuldigdheid van BTW en Energiebelasting bij energiediefstal'. DV/2008/894 U
[43] Environmental Taxation Grounds Act in Dutch is the '*Wet Belastingen op Milieugrondslag (WMb)*'

Although this argumentation seems valid it is by no means assured that this argumentation holds in a Court of Law. This is the main reason why this structure has not yet been applied to collectives operating a wind turbine or a PV installation.

When laying down additional cabling or if extending the application of the current Electricity Act is not deemed appropriate a third solution is possible. The third solution is an amendment to the Electricity Act brought forward by Member of Parliament, Diederik Samsom. In an explanation of the amendment Samsom states the idea that the delivery of electricity from a collective renewable energy installation is not a delivery, in the sense that energy taxes are applicable but that it is transportation. In his amendment Samson proposes to make the law more clearly by amending the Electricity Act.

Samson furthermore wants to change Article 50 of the Environmental Taxation Grounds Act. The idea is to add a paragraph to Article 50, stating that self-supply should include collectively operated renewable energy installation in the Netherlands. This generates 100% renewable energy, delivered exclusively to its participants and installations which receive no other subsidies or stimulation measures. The electricity is delivered to its participants for € 0,00 kWh^{-1} and the administrative fee cannot be more than € 0,04 kWh^{-1}. Samson stresses in his proposal that the collective must have a non-profit orientation (Samsom, 2010).

The proposal of a non-profit orientation is however problematic. When is a collective a non-profit organisation for example? Because profits are necessary in order to operate the installation for upgrading, operating and maintaining the installation, as well as to cover any setbacks during the installations operation.

Appendix C

Interview Approach

For this thesis several interviews were conducted in order to grasp the developments in the area of PV systems. Textbox 4 shows the invitation letter sent to the interviewee. It briefly explains what my personal background; the research motivation; the direction of the research; and a brief demarcation. Moreover, a specific relation of the interviewee with the thesis was given.

Interview Questions

Textbox 5 provides an overview of the questions that were sent to the interviewee. Not all of these questions were sent to every interviewee. During the process of writing this research project, interview questions changed and evolved. Therefore, a selection of a number of questions was created, depending on the stakeholder that was interviewed. The limited number of questions was needed to ensure that in depth information was obtained. The shortlist was emailed to the interviewee to prepare for the interview. The letters were written in Dutch, since solely Dutch participants were interviewed.

Geachte heer/ mevrouw,

Als student Systems Engineering, Policy Analysis and Management aan de Technische Universiteit Delft, ben ik bezig met mijn afstudeeronderzoek voor de titel Master of Science. In opdracht van Eneco Shared Energy Solutions, onder begeleiding van Ir. Hans Kursten, doe ik onderzoek naar het vinden van mogelijke oplossingen voor voornamelijk proces-institutionele belemmeringen voor de grootschalige implementatie van zon PV- in Nederland. De onderzoeksvraag van het onderzoek is als volgt:

> *"How to underpin a strategy, facilitating the large scale roll-out of PV, for Eneco using a concentric systems approach?"*

De focus van het onderzoek ligt op de consumentenmarkt. Er is een groot potentieel voor zon PV systemen bij consumenten, die (deels) duurzaam willen voorzien in de eigen elektriciteitsbehoefte, de investeringen blijven echter achter. Mijn eigen ervaring met zon PV is het ontwerpen, aanvragen van subsidies en begeleiden van de installatie van het zon PV systeem op het dak van mijn ouders in Friesland. Dit project is de inspiratiebron van mijn afstudeeronderzoek.

Door middel van een 'concentrische systeemaanpak' probeer ik een groter inzicht te verkrijgen waarom de investeringen in PV in Nederland achterblijven. Met de systeemaanpak wordt bedoeld dat zowel technische, institutionele als proces factoren worden meegenomen. De systeemaanpak impliceert een brede zoektocht naar het probleem. Het ontbreken van subsidies is een (belangrijke) oorzaak van de achterblijvende investeringen. De focus van het afstudeeronderzoek ligt echter niet op dit aspect van het probleem. De effecten van subsidies op de ontwikkeling van duurzame energie zijn zowel in Nederland als in de wetenschap bekend. Het onderzoek richt zich vooral op andere oorzaken van het achterblijven van investeringen in PV.

Twee van de belangrijkste oorzaken worden gekozen en met behulp van een gedetailleerde probleemanalyse verder uitgewerkt. Op het moment dat er meer bekend is van de problematiek zal door middel van een wetenschappelijke inslag alternatieven geformuleerd worden die als grondslag voor de uiteindelijke PV strategie dienen.

Interviews met verschillende actoren vormen een belangrijk onderdeel van het afstudeeronderzoek. Ten eerste maakt het mogelijk om vanuit verschillende perspectieven oorzaken te formuleren die ten grondslag liggen aan het achterblijven van investeringen in zon PV. De interviews maken dus een breed en 'kleurrijk' beeld van de oorzaken mogelijk.

Ten tweede dragen de interviews bij aan het begrenzen van de ontwerpruimte voor het vinden van alternatieven en oplossingen voor de problematiek. De interviews hebben een open karakter zodat, doelen, belangen, interesses en problemen kunnen worden aangegeven. Dit helpt bij de verdere afbakening van het afstudeeronderzoek.

Het interview met u, is voor mij en mijn afstudeeronderzoek van groot belang. [UITLEG BELANG VAN INTERVIEW PERSOONLIJKE INVULLING]

Indien u nog vragen heeft dan hoor ik dat graag, onderstaand zijn mijn contactgegevens vermeld.

Met vriendelijke groet,

Steven Sprokholt

Textbox 4: Interview Invitation Letter

Ter informatie

Dit interview wordt gehouden als onderdeel voor mijn afstudeeronderzoek. Het is een belangrijk onderdeel van de actorenanalyse en dienst als basis voor het identificeren van barrières en kansen voor het investeren in zon PV met betrekking tot de consumentenmarkt. De actorenanalyse vormt tevens de basis voor het vaststellen van eisen en beperkingen voor het onderbouwen van een PV strategie voor Eneco.

Het interview is in drie delen opgesplitst. Het eerste deel bevat een aantal algemene vragen die aan elke actor worden gesteld, het tweede deel bevat specifieke vragen en deel drie bevat de overige vragen.

Algemene Vragen

- ✓ Welke activiteiten onderneemt u / uw organisatie met betrekking tot de zon PV markt?
- ✓ Wat zijn de ambities van uw organisatie met betrekking tot zon PV?
- ✓ Welke rol ziet u weggelegd voor de volgende bedrijven met betrekking tot zon PV?
    - Consumenten/VvE/Collectieven
    - Energie bedrijven
    - Netbedrijven
    - Installatiebedrijven
    - Nationale overheid
    - Banken en andere financiële instellingen
    - Lokale overheid, gemeenten, provincies
    - AgentschapNL
    - Consumentenbond
    - Anderen,….

Specifieke vragen

- ✓ Met welke projecten en/of activiteiten bent u / is uw organisatie betrokken op het gebied van zon PV?
    - Kunt u een korte omschrijving geven van deze/dit project(en)?
    - Wat is de looptijd van deze/dit project(en)?
    - Hebt u meer informatie beschikbaar over deze projecten?
- ✓ Ziet u barrières/kansen die deze projecten beïnvloeden?
    - Technologisch van aard?
    - Institutioneel (wetten/regulering)?
    - Proces (actoren) technisch?
    - Kunt u de genoemde barrières/kansen verder specificeren?
- ✓ Ziet u oplossingen en/of andere actoren die u kunnen helpen met vinden van oplossingen of het exploiteren van de voorgaande kansen en barrières?
    - Bijvoorbeeld het amendement van de “Elektricteitswet” door Tweede Kamerlid Dhr. Samsom?
    - Andere oplossingen,…

Overig:

- ✓ Aan welke voorwaarden moet voldaan zijn, volgens u/uw organisatie, voordat consumenten op grote schaal gaan investeren in PV?
    - Welke rol kan u/uw organisatie hierin spelen om dit te faciliteren?
- ✓ Kijkend naar de toekomst, hoe zal de komende jaren de rol van u/uw organisatie zich ontwikkelen met betrekking tot zon van PV?
    - Korte termijn (2011 – 2015)
    - Middellange termijn (2016 – 2020)
- ✓ Welke partijen zijn uw gesprekspartners, op welke gebieden werkt u samen met andere actoren/marktpartijen?
    - Is het logisch om samen met Eneco te werken om de zon PV problemen op te lossen? Waarom wel/niet?
        - Welke condities zou u/uw organisatie aan een dergelijke samenwerking stellen?

Textbox 5: Interview Question Overview

Appendix D

Comparative Analysis

D.1. Photovoltaic Systems

D.1.1. Introduction

The photovoltaic effect was first discovered in 1839 by the physicist A.E. Becquerel. The effect makes it possible to convert sunlight directly into electricity. However through the 19th century and until the last decade of 20th century there was no use for applying the technology in our electricity system. The technology was too expensive and too unfeasible to apply. At the time of the invention there was an oversupply of cheap fossil fuels and the harmful by-products of fossil fuelled energy use were largely ignored.

During the 1950's the first application of PV was developed. The space programme required a source of energy that could sustain long spaceflight mission without a connection to the earth based fossil fuel supplies. PV seemed reliable and consistent enough to power space machinery with electricity. This lead to the development of the first PV cell, with an initial efficiency of 6%, by Bell laboratories in 1954. As the space programmes proceeded and technological advancements were made, PV cells became the way to power satellites in space. Until the 1970's the technology was never seen as a means to generate power on Earth. The first oil crisis and the awareness of the negative effects of fossil fuel combustion lead to increased public support for developing PV-technology.

After the 1970's the PV industry has achieved very high growth rates of around 30% per year. The growth rates were achieved because the microelectronics and semiconductor industries invested in PV related technology applications. The last twenty years these growth rates have been sustained by government renewable energy support measures (Zeman, 2010).

D.1.2 Physics of Photovoltaic Cells.

Photovoltaic cells convert light (photons) into 'charge carriers' and the 'photo-generated charge carriers are subsequently separated in the semiconductor materials. The semiconductor material is therefore at the heart of the solar cell. There are a number of semiconductors that are suitable for the conversion of photons into electrical energy. In this paragraph the working of a typical solar cells is described. Figure 27 shows a typical silicon solar cell. In the p-type base layer the photons are converted into charge carriers. The p+- and n+-type doped semiconductor layers help to separate the photo-generated charge carriers.

The p+-type and n+-type layers are connected to metal contacts that collect the separated charge carriers and connects the solar cell to a load. The load is needed to complete the electric circuit and to let the generated electric energy flow.

When a photon with a particular wave length excites an electron in the semiconductor charge carriers are created. The electron jumps from the valence band to the conduction band of the semiconductor material. The (photonic)energy that is required to excite an electron to the conduction band is called the band gap energy. The required energy is different for different semiconductor materials. Longer wavelengths, contain less energy and are unable to generate charge carriers. The (photonic)energy in that case is converted into heat instead of electricity. Under normal

circumstances charge carriers will eventually recombine within the semiconductor materials. To avoid this, the p and n doped layers attract the charge carriers instead of allowing recombination of the charge carries in the base layer.

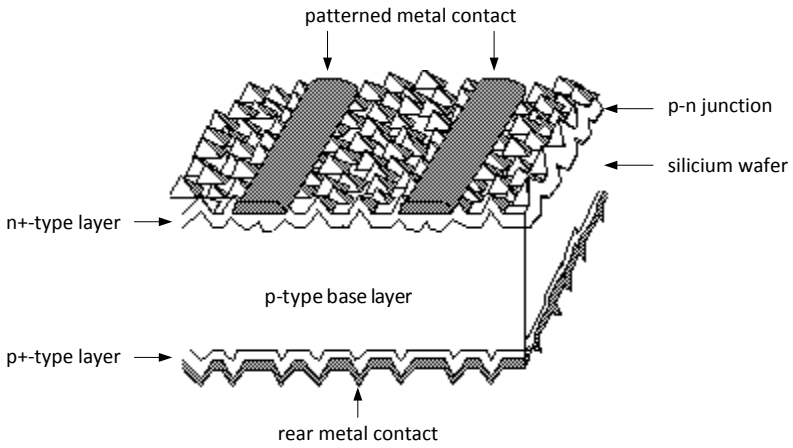


Figure 27: A typical structure of a Silicon based solar cell (Adapted from: Green 2003)

D.1.3 Solar Cell Generations

1st Generation Solar Cells

The first material used for solar cells was mono-crystalline silicon in the Vanguard I satellite. The solar cells used for this space application became the first terrestrial applied solar cells as well. Over the years the efficiency increased dramatically accompanied with a dramatic decline in the costs of solar cells. This enabled crystalline silicon to become the dominant solar cell design. Crystalline solar cell technology does not only incorporate mono-crystalline silicon (m-Si) but multi-crystalline silicon (c-Si) solar cells as well.

Both these technologies that use bulk crystalline silicon are referred to as "first generation solar cells". The main issue with these cells at the moment is that their costs are dominated by material costs: silicon wafer, glass cover and other encapsulates. Although the technology has been available since the 1950's, there are ample opportunities to improve the design further. Current m-Si and c-Si solar cells have efficiencies up to 20%, the efficiency is expected to increase to over 25% by the year 2030. The main challenge for first generation solar cells will remain to keep the costs down.

2nd Generation Solar Cells

Material costs of solar cells are now seen as one of the largest limitations for solar cell application. Therefore research has been redirected to develop "thin-film solar cells". These represent the 2nd generation of solar cells and are manufactured by using different semiconductor materials: Copper Indium Gallium diSelenide (CIGS), Cadmium Telluride (CdTe), hydrogenated amorphous Silicon (a-Si:H) and even Titanium oxide nano-crystals covered with organic molecules representing dye-sensitized nano-structured solar cells. The goal with thin film solar cells is further cost reductions while increasing the efficiency to around 18%. Current commercial thin film solar cells have efficiencies ranging between 4 – 12%. The efficiency increase is important when systems are installed with limited available space (roofs, facades, etc.) to generate sufficient power to fulfil customers' needs.

The main characteristic of third generation solar cells are their high conversion 3rd Generation Solar Cells

These higher efficiencies are attained by multi-junction cells, which means that two or three solar cells are stacked to convert more of the available light spectrum into electricity. Different materials are used such as Gallium Arsenic (GaAs) and Indium Phosphorous (InP), to absorb more of the light spectrum. These solar cells achieve efficiencies over 42%. Another way to increase the efficiency of solar cells is to concentrate the light that falls on the solar cells up to 1000 times. Efficiencies over 30% can be achieved with single junction solar cells. Third generation solar cell concepts are applied in space. In the short to midterm it is unlikely for the technologies to become commercially available for terrestrial application. These concepts are therefore not taken into account when formulating the Eneco PV strategy (Zeman, 2010).

D.1.4. Solar Cells Applications

Photovoltaic solar cells play an important role in our lives. PV systems have a wide variety of applications. They can power small calculators and wrist watches that are used every day. PV systems are used in a variety of more complicated systems as well. They provide power for telecommunications, water pumps, lighting, or remote locations where electricity is needed. Five primary market segments can be identified for PV applications (Zeman, 2010):

i) Consumer products, watches, calculators, lanterns, mobile phone chargers
ii) Off-grid, standalone power systems for residential application.
iii) Off-grid industrial/commercial power systems for water management, telecommunications and lighting.
iv) Grid Connected PV systems, residential and commercial distributed generation concepts to power buildings and appliances, reducing our carbon footprint.
v) Space applications, to provide electricity to satellites and spacecraft.

Off-grid systems refer to PV systems that are not connected to the electricity grid. These systems require batteries or other storage systems for continued reliable electricity supply, increasing system costs. Grid connected systems take advantage of grid access to balance system output. The grid operates like a battery with unlimited storage capacity. Absorbing excess generated electricity and delivering 'unlimited' electricity if needed. In the Netherlands over 90% of the installed PV systems in the Netherlands is grid connected (IEA, 2010). Therefore this study will focus exclusively on grid connected consumer PV systems.

Advantages

- PV systems are modular, allowing for easy installation at a site, as well as sizing of the system itself to meet the needs of the consumer and the site. A 3-5 kW_p PV-system on the roof of a house can meeting at least the partial electricity demand of the consumer (Kaplan, 1998; Shum & Watanabe, 2007).
- Electricity generated by a grid-connected PV system is located close to where the demand for electricity is. In case of installation on a rooftop, the demand is located only metes away. The electricity generated should thus be compared to the distributed electricity costs, rather than the wholesale electricity prices (Owen, 2006; Shum & Watanabe, 2007).
- Due to the close proximity between the supply and demand of electricity, losses due to the transmission of electricity are minimized.

- PV systems are a safe way to generate electricity there are no moving parts, no noise is emitted, no dangerous or hazardous fuels or other emissions during production of electricity (Zeman, 2010). The energy payback time of a PV systems is largely dependent on location and production method but generally lies between 1 to 3 years (Alsema, 2012).
- Electricity costs of a PV system are largely dependent on the investment costs this means that the electricity produced by a PV system has very little price fluctuations. The price of conventional generated electricity is mainly dependent on fuel costs, this can result in severe price shocks (Kaplan, 1998; Neuhoff, 2005; Owen, 2006).
- Because roof-mounted PV systems are often visible and recognisable from outside, it can be a way to carry out the message that the home owner is concerned with the environment (Christie, 2010).
- PV system have a long economic lifetime, today the(economic) life expectancy of a PV system is over 30 years. Some manufacturers of solar panels provide performance guarantees of 80% after 25 years. The inverter however has a shorter lifetime, after approximately 10 years, the inverter has to be replaced (Zweibel, 2010).
- System costs continue to decline, the system costs are for a large part dependent on the PV panel costs, other major factors influencing the systems costs is the balance of system component or the inverter. The costs of inverters are declining as well, although at a lower rate than the PV-cells. Installation costs are likely to remain constant (Shum and Watanabe, 2007).
- Overall, system efficiencies are continuing to increase, indicating that more electricity is generated per m^2. In combination with the declining costs of solar panels the technology is rapidly approaching grid parity. This means that PV produced electricity is becoming as expensive or cheaper as retail electricity (Baghdari et al, 2009).

Disadvantages:

- The generation of electricity generated by a PV-system has an intermittent character. Meaning that the output of the system varies considerably with time. This is because the generation of electricity is dependent on available light. Cloud cover considerably reduces the output of PV and during the night the output of a PV-system is reduces to zero.
- Although the prices of PV systems have dropped considerably over the years and according to many sources are likely to do so in the future (A.T. Kearney, 2009; Zeman, 2010; Zweibel, 2010), the prices of PV-systems remain too high for most residential consumers to proceed to investing. The cost of electricity generated by PV systems is dependent on its location and the price paid for the system. PV generated electricity at the moment costs more than retail electricity from the grid.
- Investing in PV systems is problematic because of the amount of factors that come into play when investing: subsidies, production meters, double meters, certificates, installation, system configuration, types of panels, roof orientation, pay-back periods, investment costs, permit requirements, etc. All these factors make investing in a PV-system a complex affair. The consumer is unable to make a decision because he cannot foresee all the outcomes properly and because of this they will abandon their investment plans.

D.2. μ-CHP systems

μ-CHP is the cogeneration of heat and electricity on a small domestic scale often powered by natural gas. μ-CHP is used where an (intermittent)heat demand is present and can cogenerate an electricity output of around 1kW$_e$. μ-CHP systems that generate more electricity but those require higher heating demands more than even a large household can provide. A μ-CHP-system is a natural gas fired boiler that produces hot water for heating and generates electricity, during heating to supplement the electricity bought from the grid. This process raises the overall system efficiency resulting in significant CO_2-emission reductions. In the Netherlands this technology is also referred to as the HRe-ketel or micro-WKK.

There are two main technologies of μ-CHP, one is a Stirling engine, the other is a fuel cell. Both produce hot water and generate electricity but they do so at different efficiencies. The Stirling engine produces heat with a high efficiency around 80% and 15% for electricity, while a fuel cell can achieve electrical efficiencies up to 55%, and a heat efficiency of around 40%. Fuel cell μ-CHP units are outside the scope of this research, they remain too expensive to consider for installing them in households. μ-CHP units using a Stirling engine are inside the scope of this research. It should be noted that μ-CHP is a technology that is still in its infancy when compared to the more mature PV technology. This is reflected by the number of manufacturers that provide μ-CHP systems for the Dutch market. Remeha is the only manufacturer that offers a μ-CHP system for the Dutch market, compared to the dozens of manufacturers that sell PV-panels on the Dutch market.

The comparison on investment costs between the different technologies is rather difficult, because part of the system costs represents the investment in the heating system, another part the investment in the electricity generation system of the μ-CHP-system. To make an equal comparison between the technologies the entire system cost is divided by the electrical power of the system. This will result in a higher installed investment costs for a μ-CHP-system.

Advantages

The advantages of a μ-CHP system are the following:

- Delivering distributed electricity, in the same way as a PV system would. This reduces transmission system losses.
- μ-CHP, generates both heat and electricity from natural gas. In this comparative analysis the focus is on the produced electricity for residential purposes. The electricity generated has, when the generation of heat is taken into account, lower CO_2 emissions than electricity from the grid. Because the overall CO_2 emissions are lower with this technology, substantial emission reductions can be achieved if applied well.
- As stated earlier, PV is an intermittent renewable energy source, μ-CHP on the other hand is a much more controlled technology. In domestic application, the appliance is heat load following. Electricity is thus only generated once there is a heating demand in the house. Heating demands can be predicted quite accurately on a day-by-day basis and can thus be considered not-intermittent.
- A μ-CHP system has very low emissions of various types than electricity that is produced from conventional sources. CO_2, SO_x, NO_x, fine particulate emissions are lower (BRON, XXX).

- The technology could be implemented in every household that currently operates a natural gas fired central heating system. The most important requirement is a natural gas connection. In the Netherlands virtually every household has a natural gas connection.
- μ-CHP systems, can be made renewable when the system is fired with biogas instead of natural gas. The operating costs of a biogas fired system will be higher due to the higher costs of biogas compared to natural gas.

Disadvantages

- The μ-CHP system under consideration use a stirling engine to generate both heat and electricity. A problem with the stirling engine is to quickly start generating electricity when a heating demand is met. During the 'warm-up' electricity is generated inefficiently because the temperature difference in the Stirling engine is not high enough. Resulting in higher CO_2 emission, rather than lower emissions.
- When natural gas is used as a fuel instead of biogas, the system is using a non-renewable energy source and the system cannot be considered as sustainable. It does not decrease our dependence on fossil fuels, indicating that there is a high risk of price shocks (BRON, XXXX).
- Still using natural gas, a fossil fuel instead of a renewable resource. You are using the fossil fuel natural gas more efficiently but not reducing the dependence on fossil fuel resources.
- A substantial heat requirement is needed to efficiently generate electricity with a μ-CHP system. This means that the system is only suitable for large homes. In these larger homes the system can meet the partial electricity demand. New built homes are well insulated, (Low EPC-values), resulting in a low heating demand, making new built homes less suited for a μ-CHP system.
- It is not always the case that when heat is required, electricity is required as well. This means that net metering is applicable to μ-CHP.

D.3. Urban wind turbines

In this paragraph micro- or often referred to as urban wind turbines are investigated. Urban wind turbines are small wind turbines that can be installed in the urban environment. The urban environment, can be defined as cities, industrial estates and business parks. Urban wind turbines differ from their more common brother by scale and application. Wind turbines that are installed for on- or offshore electricity generation, typically have an electrical power in the MW range. Urban wind turbines are much smaller. Urban wind turbines have an electrical power ranging between 1 kW to 15 kW.

The performance of wind turbines is largely dependent on the wind velocity at a specific location. The power output of a wind turbine is proportional to the cube of the wind velocity. This implies that if the wind velocity reduces from 4 m s^{-1} to 3 m s^{-1} the power output reduces by a factor of more than two. Wind speed is not the only determining factor with regard to power generation. In the urban environment where these turbines are applied there is a lot of turbulence and wind conditions change rapidly. Rapidly changing wind directions requires wind turbines to reorient themselves into the wind, during this period they are less efficient. Wind turbines can also be categorized in a number of different wind turbine types (Horizontal- and Vertical Axis Wind Turbines (HAWT and VAWT) or combinations). Urban wind turbines are available in these different types. This comparative analysis however, does not distinguish between these different (urban) wind turbines types. In appendix E, the advantages and disadvantages of urban wind turbines are explained further.

Advantages

- People are interested in investing in urban wind turbines, in part due to their visibility to the outside world, showing that one is sustainable. It can promote others to become more sustainable as well. It can function to set an example to other. PV has the same function, urban wind turbines however are often more visible than solar panels, due to their size and positioning, to exploit the best wind conditions possible.
- The generated electricity by urban wind turbines is considered to be distributed electricity, therefore system transmission losses are lower when compared to conventional generated electricity.
- Urban wind turbines are a sustainable and renewable source of electricity. It contributes to the reduction of CO_2 emissions. During operation of a wind turbine there are no emissions, the wind turbine only uses wind to generate power. Only during the manufacturing of (urban) wind turbines there are CO_2 emissions.
- Large wind turbines have issues with regard to noise production and bird strikes. Smaller wind turbines are less susceptible to this due to their smaller scale.

Disadvantages

- Not all roofs or locations are suitable to install and operate an urban wind turbine. A wind turbine creates forces on the roof, for which it may not have been designed to cope with. This leads to safety issues during high wind conditions. An option could be to place the wind turbines on a tower, but this would make them less suitable to locate them in an urban wind turbine. Placing the turbines on large poles makes them more susceptible to planning permission.
- The quality and the wind velocity on rooftops is in general low, due to the complex interactions between buildings. This can result in a low yield of the wind turbine, often below

the factory specifications. (NWEA). The wind conditions can have an impact on the longevity of the turbine. The changing wind conditions can exert abnormal forces on the rotor blades or other components of the turbine.

- As said in the introduction, the performance of wind turbines is largely dependent on the wind velocity.
- There are no uniform rules in the Netherlands for siting an urban wind turbine. In most cases however one has to apply for a planning permit. This creates uncertainty and confusion for investors willing to invest in this technology.
- The technology remains expensive looking at both the investment costs and the calculated electricity costs. This is likely to improve in the future with the market slowly taking off, not only resulting in lower investment costs, but lower electricity generation costs as well.
- The technology is still at the bottom of the learning curve, this means that multiple problems have to be solved, before the technology becomes available for large scale applications.

D.4. Comparative Analysis

Eneco considers PV as a promising technology for consumers to generate part of their electricity needs themselves while at the same time attribute to their sustainability goals (Eneco, 2011a) this will be explained in more detail in paragraph 3.2. A thorough motivation for this technological choice is however lacking and should be well substantiated, if Eneco wishes to proceed with their objectives. The comparative analysis looks for other technologies that can fulfil a similar role as PV. These technologies could possibly outperform PV at multiple levels:

1. *Is PV the most appropriate technology choice for Eneco to build a (PV) strategy, considering technological, institutional and process factors?*

Alternative technologies can be cheaper or have greater advantages for Eneco and its customers. Executing this analysis prevents the development of a strategy based upon an inferior or immature technology, which of course would harm the objectives of Eneco in the long-term can harm, not in the least part due to the wrongful allocation of resources. The final motivation for executing a comparative analysis is that it is often necessary to expand the boundaries of analysis and find out what other developments could be used to achieve the main strategic goals of Eneco.

The comparative analysis in this thesis project focuses on the technology for the generation of renewable electricity. Other technologies are chosen when their characteristics are similar to PV and these technologies can be applied on a similar scale as a consumer PV system. The technologies are suited to have a power output between 1 to 15 kW. This output enables consumers to invest in a sustainable technology meeting part or all of their electricity requirements. The technologies can be installed “behind the meter”(see Appendix B.)

The electricity generated is for a larger part used by the consumers themselves. If the consumer generates an excess of electricity, this excess of electricity generated can be sold to the grid[44]. In case there is none or insufficient electricity generation to meet the electricity demand of the consumer the difference can be supplied by the grid.

For individual consumers, there are multiple ways in making their electricity consumption more sustainable. The most important options are listed below with their respective advantages and disadvantages:

- Energy collectives. These are collectives where a number of consumers join forces. An energy collective has the advantage of creating economies of scale and scope resulting in relatively low investment cost per consumer. However there are a number of disadvantages as well: there is uncertainty whether the electricity generated by the collective installation can be used to settle the consumer’s electricity demand (Ernst & Young, 2009). Energy collectives are not in the scope definition of this thesis as will be explained in paragraph 2.7.1.
- Green certificates. Green certificates ensure that the electricity bought has a renewable origin. Green certificates are bought by consumers as ‘*groene stroom’* from their energy supply company. Nearly all Dutch energy supply companies offer *‘groene stroom’* as part of their product portfolio. The main advantages are that a consumer does not face high system investment costs and the product can be easily chosen. The disadvantage is that green

[44] Grid, in this instance refers to the electricity supply company

electricity certificates can be from a disputable origin, for example not all biomass can be considered renewable (Sebastián, Royo, & Gómeza, 2011).

- Another option consumers have is to invest in large scale wind and biomass installations. However this would involve a certain form of collective installation as well as electricity generation 'in front of the meter'. Individual investments are too large for a single consumer to bear. As will be explained collectives are beyond the scope of this thesis.

The two technological alternatives compared to PV technology are different by the technology used to generate electricity. The first technology under consideration is micro-Combined Heat and Power (μ-CHP), the second technology is the urban or micro wind turbine. Both technologies are cheap enough for an individual consumer to invest in it. The alternatives are well suited to be placed behind the meter and used to generate electricity at the household level.

The choice for μ-CHP can be considered disputable as it can run on two fuels: biogas and natural gas. When fired on natural gas, substantial CO_2 reductions can be achieved in comparison to electricity from the grid. The CO_2-reduction is achieved by producing electricity at the same time as there is a heat demand in the system, increasing overall system efficiency (Peacock & Newborough, 2005; Kuhn, Klemeš, & Bulatov, 2008). When the system runs on biogas it is fuelled by a renewable energy source and μ-CHP can be considered as renewable energy.

An urban wind turbine generates electricity, by converting wind power to electricity. Wind turbines can be placed in gardens or on rooftops. In the following paragraphs the main-advantages, disadvantages and characteristics of the technologies are explained further. Further details can be found in Appendix D.

An objective tree is made to develop the selection criteria for PV, μ-CHP and urban wind turbines to be compared. This objective tree translates the objectives of Eneco into criteria. These criteria are used to evaluate the different technologies and see which alternative has the best overall performance. The results are presented in Table 19 followed by the conclusion. The objective tree can be found in Appendix E E.

	Photovoltaic systems	Micro-CHP	Urban windturbines
Installed investment costs [€ kW^{-1}_{el}]	2500[a/f]	4000[b]-10500[z]	2000-3500[c]
Electricity Costs [€ kWh^{-1}]	0.23[g] – 0.50[f]	0.12 – 0.32[b], heat load dependent	0.50[e]
Maintenance Costs [%]	<1[a/m]	1-3	1 – 3[d]
(Economic) Lifetime [yr]	30[a/m]	20[b]	10[c] - 20[c/d]
Capacity Factor [kWh / kW]	850-1000[f] kWh kW_p^{-1} jr^{-1}	In large part dependent on heat demand	150 – 400 kWh kW^{-1} [e]
Safety	Safe	Safe	Susceptible to wear and tear[e]
Input	Sun	Bio gas – Natural gas	Wind
(LCA) Carbon Emission [g CO2 kWh^{-1}]	21.65[a]	0 - 190[h]	11.32[a]
Unit Production Resources	Rare earth metals, Toxic substances[k/l]	None	Rare earth metals
Recycling [% of components]	100	100	100
Energy payback [yr]	1 – 3[k]	n.a.	1 – 3[e]
Sizing	Modular[a]	One-off	One-off
Installation	Easy	Medium	Medium (planning)[i]
Capacity potential of the technology	High (the system can be scaled to the power requirements, once grid parity is achieved a take-off can take place)[a]	Low (new built homes have low heating requirements which does not justify investments in μ-CHP systems)	Uncertain [e] (because the application is relatively new there is a high uncertainty with regard to the role it may play in our energy supply)
Site Specificity	Medium [CITATION NEEDED] (South facing, <30 degrees angle)	Medium - High (Sufficient heat demand)	High [e] (Highly dependent on wind conditions)
Permit procedures	None [i], for most applications, only for the feeding in of electricity to the grid	None, only for the feeding in of electricity to the grid	Unclear [e/j] Building permit is required when the turbine required a tower (most cases), as well as for feeding in electricity

[a] A.T. Kearney
[b] Kuhn, Klemeš, & Bulatov, 2008, Remeha Evita
[c] Cace & ter Horst, 2007
[d] Peacock, Jenkins, Ahadzi, Berry, & Turan, 2008
[e] NWEA, 2009
[f] ECN, 2010
[g] Greenchoice, 2011
[h] Houwing et al, 2008
[I] Ministerie van VROM, 2010
[j] IT Power, 2006
k Alsema et al., 1998; de Wild-Scholten & Alsema, 2004
[l] Zeman, 2010
[m] Zweibel, 2010

Table 19: Comparative Analysis of Three Distributed Generation Technologies

Photovoltaic Cells

In Appendix D.1, a detailed overview is given of the advantages and disadvantages of PV for generating electricity behind the meter. This paragraph provides an overview of the main advantages and disadvantages of PV in comparison to the other two presented alternatives.

Micro-Combined Heat & Power

A description of μ-CHP is provided in Appendix D.2. The same appendix provides a more detailed overview of the advantages as well as disadvantages of μ-CHP systems. This paragraph gives an overview of the main advantages and disadvantages:

Micro-scale wind or urban wind turbines

A description of the urban wind technology is provided in Appendix D.3. This appendix provides a more detailed overview of the advantages as well as disadvantages of μ-CHP systems. This paragraph lists the main advantages and disadvantages:

Conclusion Comparative Analysis

To come to a conclusion Table 19 is transformed into a scoring table. The criteria are scored between one and three. A score of one is given to the highest ranking alternative while a score of three is assigned to the worst alternative. All of the criteria are given an equal weighing to compare the different alternatives on an equal footing. This way a Simple Multi Attribute Rating Technique (SMART) – card is obtained. Table 20, shows the SMART CARD for this analysis.

	Photovoltaic systems	Micro-CHP	Urban windturbines
Installed investment costs [€ kW^{-1}_{el}]	1	3	2
Electricity Costs [€ kWh^{-1}]	2	1	3
Maintenance Costs [%]	1	2	2
(Economic) Lifetime [yr]	1	2	3
Capacity Factor [kWh / kW]	1	2	3
Safety	1	1	2
Input	1	2	1
(LCA) Carbon Emission [g CO2 kWh^{-1}]	2	2	1
Unit Production Resources	3	1	2
Recycling [% of components]	1	1	1
Energy payback [yr]	1	2	1
Sizing	1	2	2
Installation	1	2	2
Capacity potential of the technology	1	3	2
Site Specificity	1	2	3
Permit Procedures	2	1	3
TOTAL	**21**	**29**	**33**
SCORE	**1**	**2**	**3**

Table 20: SMART-Card Comparative Analysis

As can be seen from the analysis, a PV system ranks as the best technology considering the requirements for generating electricity behind the meter, whilst the urban wind turbines ranks as the worst technology. The urban wind turbine suffers from the fact that the technology is positioned at the start of the learning curve (NWEA, 2009), while PV is further ahead on the learning curve.

The main issue with the μ-CHP is that it suffers from high costs as well as the fact that it is disputable whether it is genuinely sustainable. A second problem is the required heat load characteristic of the system. Electricity generation only occurs when there is a sufficiently high heat demand, while at the same time insulation requirements for homes are increasing (ECN, 2009). This further reduces the attractiveness of for μ-CHP. Therefor μ-CHP is not a preferred alternative.

Concluding, PV is the right technology as has been implied by Eneco from the start of the research. PV is the best suited, although not perfect, technology for generating electricity behind the meter. Based on the analysis PV-systems will be used to underpin a new Eneco strategy. An important remark has to be made: the technological developments in the field of renewable energy sources go fast. It is therefore important to check the attractiveness of the different technologies from time to time in order to check if the strategy is still the best strategy

Appendix E

Eneco Objective Tree

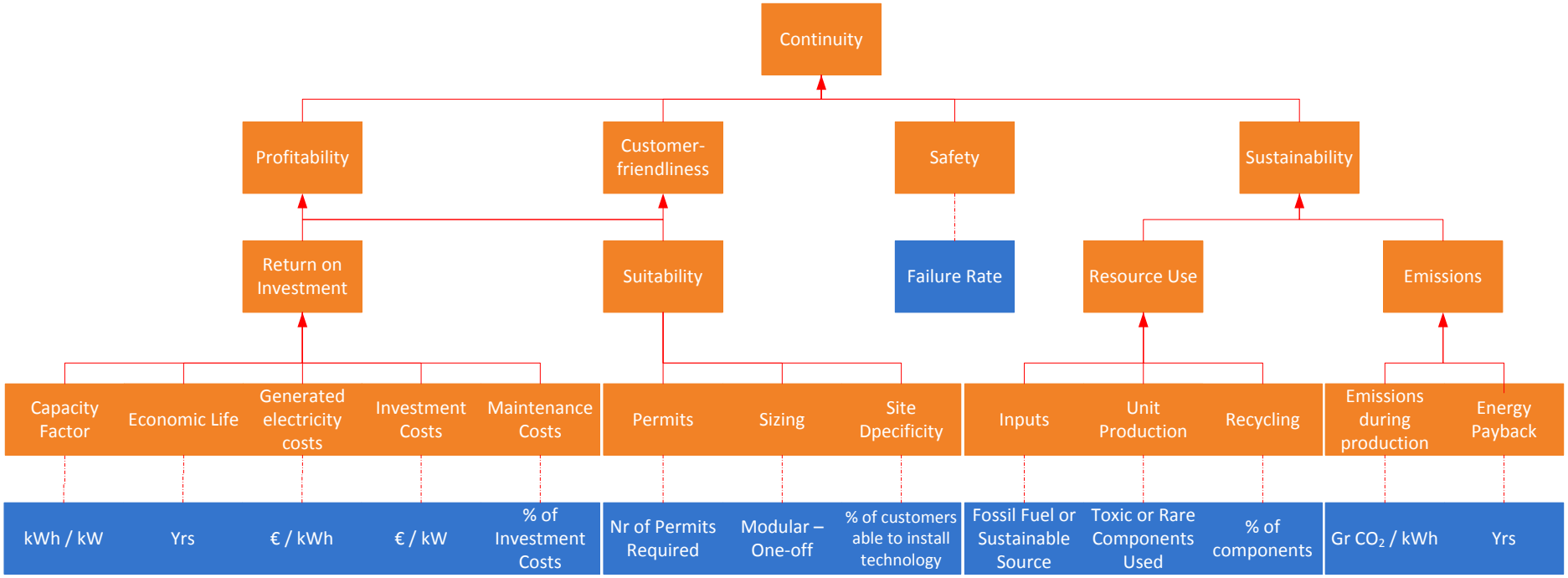


Figure 28: Objective-tree Eneco for the comparative Analysis

Table 26 presents the objective tree of Eneco. The main objective of Eneco is continuity of the organisation. Eneco aims to assure the continuity of the organisation by profitable operations and, by means of marketing themselves as a sustainable energy supply company. The question is however how profitability can be assured. This is done on the one hand by the underlying criteria, with their operationalized units of measurement in the blue boxes. However, a profitable technology in essence needs to be suitable for application as well, therefore the application potential of a technology in the Netherlands is taken into account in the comparative analysis. Suitability has a second argument for being an important criterion. If consumers want to

install a certain system, and they are told that the technology is unsuited, consumers are likely to be disappointed. With the consequence that Eneco loses business. This must be prevented, and in order to do so, an alternative has to score well on permits, sizing and site specificity of a technology.

Since sustainability is an important aspect of Eneco's strategy, it contributes to the continuity of the company. Sustainability has therefore be taken into account and this is done in two ways. Firstly, the life cycle carbon emissions and the energy payback time of the installation are taken into account Secondly the manufactured technology should not place a disproportionate pressure on the earth's resources. The blue blocks are the operationalized criteria, that are used as scoring criteria in the comparative analysis.

Appendix F

Stakeholder Analysis

F.1. Invited Stakeholders

Name	Company / Organisation
Dhr. Ad van Wijk	Professor Future Energy Systems - TU Delft
Dhr. Arno de Graaf	Chairman Resident Collective Biesland
Dhr. Dennis Gieselaar	Oskomera Solar Systems – System Builder
Dhr. Diederik Samsom	Member of Parliament (PvdA)
Dhr. Mark Jan Roesink	ASN Bank / Green financing
Dhr. Edwin Koot	Solarplaza / Solar industry platform
Dhr. Ernst Vuyck	Consultant Ecofys / Energy Consulting Firm
Dhr. Jan Rotmans	Professor Transition Management – Eramsus University Rotterdam
Dhr. Jan Willem Zwang	Green Spread / Sustainable Project Developer
Mevr. Inge Wijgerse	Stedin / Distribution System Operator
Dhr. John van Dungen	GSU / Installation Companies
Dhr. Martijn Schootstra	Holland Solar / Solar PV Industry Association
Dhr. Martijn Verbeek	Eneco Retail / Energy Company
Dhr. Peter Paul Weeda	Eneco Solar Bio Hydro / Energy Company
Dhr. Ed Buddenbaum **Mevr. Suzanne Vrijmoed**	Directorate Energy / Minsitry of Economic Affiars, Agriculture and Innovation
Dhr. Wim Sinke	Professor Solar Energy ECN / Dutch Energy Research Institution
Dhr. Bert Janson	AgentschapNL / Self Standing Governing Body Dutch Ministry of Economic Affairs
Dhr. Martijn Verbeek	Eneco Retail / Sr. Consultant / Specialist
Dhr. Pieter Duisenberg	Eneco Staven / Directeur Finance Energiebedrijf

Table 21: Invited Stakeholders Overview

Table 21 shows the list of stakeholders invited to participate in the interviews as well as their respective associations or stakeholders. The stakeholders have been identified through the professional network of my supervisor at Eneco by using the concept of the value chain. The identification through the value chain and the position of each invited stakeholder on the value chain can be seen in Figure 29.

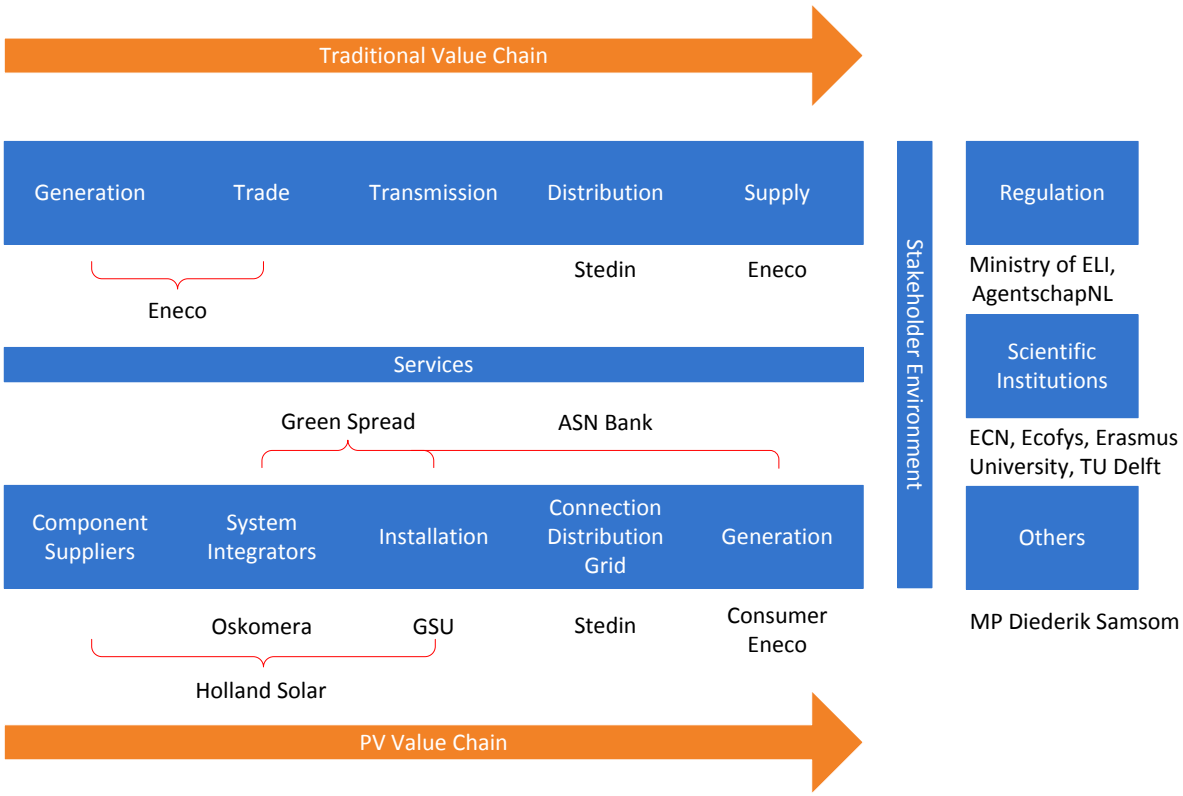


Figure 29: Invited Actors for Interviews and their role in the current and future energy infrastructure

The figure above represents an overview of the roles of the stakeholders in the current infrastructure value chain. The stakeholders that have accepted the interview invitation and have been interviewed during the research project, are presented in Table 22.

Interviewee	Company / Association	Transcript
Dhr. Ed Buddenbaum **Mevr. Suzanne Vrijmoed**	Ministry of EL&I – Energy Directorate	Transcript I
Dhr. Peter Paul Weeda	Eneco Solar Bio & Hydro	Transcript II
Dhr. Martijn Schootstra	Holland Solar	Transcript III
Dhr. Ardo de Graaf	*Bewonerscollectief Biesland*	Transcript IV
Dhr. Jan Willem Zwang	Green Spread	Transcript V
Dhr. Mark Jan Roesing	ASN Bank	Transcript VI
Dhr. Rien Morren	Eneco *Installatiebedrijf* GSU	Transcript VII
Dhr. Diederik Samsom	Member of Parliament Kamerlid PvdA	Transcript VIII
Dhr. Wim Sinke	ECN	Transcript IX
Mevr. Inge Wijgerse	Stedin	Transcript X
Dhr. Bert Janson	AgentschapNL	Transcript XI
Dhr. Martijn Verbeek	Eneco Retail	Transcript XII
Dhr. Pieter Duisenberg	Eneco Staven (Finance)	Transcript XIII

Table 22: Interviewed Stakeholders

F.2. Stakeholder Analysis

Below the Stakeholder Analysis is performed and presented in greater detail below. The steps taken in performing the analysis have been made explicit.

F.2.1. Step 1 – Problem Formulation

The first step in the TU Delft stakeholder analysis is to define an initial problem formulation. An initial problem formulation acts as a departure point for the stakeholder analysis. The problem is formulated from the perspective of the problem owner and focusses on finding possibilities for Eneco to take a leading role in PV systems? (Enserink, 2010). The main research problem and motivation of the research have been described extensively in chapters 1 and 2 of the thesis.

Facilitating the large-scale roll out of solar PV in the Netherlands is not a task which Eneco can take up alone. Eneco needs other stakeholders to contribute and cooperate in facilitating the roll-out of PV successfully. To form a coalition of stakeholders it is important to obtain an overview of the stakeholders involved with solar PV for consumers in the Netherlands. The problem formulation for the stakeholder analysis is therefore:

> *How does the stakeholder network for the large scale roll-out of solar PV for consumers in the Netherlands look like and what are possible opportunities or partners for Eneco concerning the facilitation of the large scale roll-out?*

F.2.2. Step 2 – Inventory of the stakeholders involved

The second step in the TU Delft stakeholder analysis is making an inventory of all the stakeholders involved. Enserink et al. (2010), provides several methods for identifying stakeholders involved. The methods used for the stakeholder analysis are, the *imperative*, *positional*, *reputational*, *social participation* approach and the *opinion leadership* method. Table 23 on the following page shows a quick scan of the stakeholder environment.

An important notion should be made with regard to the scan of stakeholders. Previously, the *Ministry of Volkshuisvesting, Ruimtelijke Ordening en Milieu* (VROM) was concerned with solar PV in the built environment. However, the responsibility of solar PV in the built environment and the application for planning permissions, are now the responsibility of the Ministry of Interior[45]

[45] During the last elections in year a new government was elected into office and government has reduced the number of Ministries. The former Ministry of VROM has been merged with a number of other Ministries. The directorate responsible for housing has been merged with the Ministry of Internal Affairs. Source: http://www.rijksoverheid.nl/nieuws/2010/10/14/kabinet-rutte-beedigd.html queried: 07-09-2011

Stakeholder	Type of Stakeholder	General Description
Eneco	Company	A Dutch energy supply company with high ambitions with regard to sustainability. Eneco wants to increase the penetration of (distributed) renewable energy sources in the Netherlands.
Ministry of Finance	Government	Responsible for the Dutch budget; the budgets for the other ministries; and the collection of taxes, among others solar PV energy taxes.
Ministry of Economic Affairs, Agriculture and Innovation (ELI)	Government	Responsible for the Dutch energy infrastructure and environmental regulations The Ministry also creates conditions for prosperity and entrepeneuring in the Netherlands.
Ministry of Internal Affairs (IA)	Government	Responsible for ensuring affordable, safe and energy efficient housing in the Netherlands.
Consumers	Consumer	Consumers want low utility bills and a majority wants that during the generation of electricity no negative environmental effects occur. Consumers are generally concerned about rising energy prices.
Holland Solar	Interest Group	Holland Solar is a Dutch interest group focusing on Dutch solar PV This group wants to contribute to the prosperity of the industry.
Bewonersvereniging Biesland	Interest Group	Representing the residents of the neighbourhood Ypenburg, nearby The Hague. The group wants to increase the share of renewable energy in Ypenburg.
Green Spread	Company	Green Spread advises organisations in reducing their energy consumption. The Company also develops and operates renewable energy installations.
ASN Bank	Company	Promoting sustainability to society. ASN Bank does not invest in projects where negative climate effects take place..
Installation company GSU	Company	This company designs, installs and maintains PV installations. GSU is becoming a large installer of PV systems for consumers in the Netherlands.
MP Diederik Samsom (PvdA)	Government	Opponent of a completely sustainable Dutch energy system by 2050. Therefore investment in renewable energy have to be made attractive for consumers, so they can fulfil part of their electricity requirement through solar PV.
Prof. Wim Sinke (ECN)	Institute	ECN develops high quality knowledge and technology for the transition from a fossil fuel based system to a renewable energy based system.
Stedin (Including the other electricity distribution system operators)	Company	Stedin is responsible for the construction, extension, maintenance and operation of the electricity and gas distribution grids in the provinces Utrecht and South-Holland.
AgentschapNL	Government	AgentschapNL aims to strengthen the Dutch economy and the environment. The Agency contributes to the sustainable development of the Netherlands, in cooperation with partners from the industry.
Milieucentraal / Greenpeace	Interest Group	Making information available to society concerning the environment and energy. With this information, organisations and consumers should change their behaviour in such a way that it impacts the environment in a positive way.
Consumentenbond / Vereniging Eigen Huis	Interest Group	This consumer association represents the interests of all consumers. The main goal is to allow consumers to make better choices with respect to man and the environment.
PV system supplier	Company	Focus on designing, developing and integrating reliable solar PV systems for most situations. Making sustainable technology available to consumers.
Real-Estate developers	Company	Real estate project developers want to realise sustainable and high quality new real estate for their clients, while realising a high return on investment. Some include more renewable energy technologies in the projects they develop.
Local Government	Government	The local government is aimed at the wellbeing and welfare of their citizens. The majority of local governments are in favour of stimulating the penetration of solar PV in their municipalities.

Stakeholder	Type of Stakeholder	General Description
Welstandcommissie (Building inspectorate to enforce the external appearance of buildings)	Commission	The *Welstandscommissie* is an independent commission that advices municipalities with building permits. The commission also protects the quality of the built environment.
ODE	Interest Group	Energy demand is increasing and fossil fuels are wasted, making us dependent on unreliable suppliers, that pollte the environment. ODE aims for renewable energy which is generated locally.

Table 23: Quick scan of the stakeholders involved in the large scale roll-out of PV in the Netherlands

F.2.3. Step 3 – Mapping the formal relations between the stakeholders

The formal tasks of stakeholders, their relationships with other partners and government legislation are extensive. It is difficult to show all the formal and informal relations accurately in a diagram or figure. Therefore a number of relationships are not displayed in Figure 15 and other relationships are simplified. What is clear from the formal relationship chart is the 'spaghetti' of relations present in the stakeholder network (De Bruijn & Ten Heuvelhof, 2008). The 'spaghetti' shows that the stakeholder network is a complex one, with both formal and informal relationships between stakeholders.

Whereas the stakeholder network can be described as complex, the network creates opportunities as well. A selected group of stakeholders can exert a maximum amount of influence by using their formal and informal relationships with other stakeholders. To maintain a readable 'spaghetti' representation of the stakeholder network, a number of stakeholders are depicted simpler, as is shown in Figure 30. The figure shows the following:

- The competitors of Eneco are left out, because at many points in the PV value chain competitors are active. These competitors are active at the level of the installation companies, at the level where companies offer PV propositions and there are competitive the energy supply companies. What is important to keep in mind is in the whole commercial chain competitors of Eneco are active.
- Eneco is represented as an integrated energy supply company, but DSO and the installation companies are balancing on the boundary of Eneco's sphere of influence. That is because DSO's are/is also active at other locations in the Netherlands whereas Stedin does not have national coverage. The same applies for the installation companies, which are mainly active in the Randstad.
- The relationship between consumers and AgentschapNL is not displayed, because, since 2010, AgentschapNL does not offer PV subsidies or stimulates the consumer directly.
- There are indirect relationships present between stakeholders, such as the relationship between the PV industry; PV installation companies and PV system suppliers. They are mainly represented by their trade association on the national government level. While conducting business is done by individual stakeholders.
- The relationship between consumers and the building inspectorate with regard to planning permission has been made explicit. Although according to the form Ministry of Housing (VROM), which now falls under the Ministry of the Interior, most PV installations do not

require permits, multiple stakeholders expressed this is likely to change when PV takes off in the Netherlands. Therefore this relationship is not taken into account[46].

- Three ministries are active in the Netherlands with regard to solar PV for consumers, namely Ministry of Economic Affairs and Agriculture, Ministry of the Interior and Ministry of Treasury. These ministries are largely responsible for creating the institutional framework. The Ministry of Economic Affairs and Agriculture is the most active in developing the institutional framework for consumer PV. The Ministry develops the institutional environment of the electricity sector, it provides subsidies, raises taxes and develops energy policy, of which solar PV forms just a small part.
- The Electricity Act maps out the formal relations and responsibilities between especially the energy companies (Eneco) and the distribution system operators (Stedin). Eneco cannot meter their consumer's connections because this is the responsibility of the DSO. Stedin on the other hand is not allowed to charge consumers for their connection to the electricity grid directly; they are paid by the energy companies from the consumers utility bills in exchange for the metering data.
- Municipalities and provinces can play an important role in the stimulation of renewables, amongst other PV. Municipalities have a number of instruments they can use to promote renewable energy, such as subsidies and local building regulations. In The Hague, for example, residents can apply for an investment subsidy[47].
- There are a large number of interest groups active or passive with regard to PV. These groups are displayed as one group in Figure 30. Interest groups often cooperate together to achieve their goals, mainly with other partners, such as municipalities or ministries.
- The ministry of Finance collects the energy taxes from the energy supply companies. The ministry controls the budgets of the different ministries and thereby partly controls the budget of ministry of EL&I. Thereby controlling the budget available at EL&I to stimulate renewable energy, including PV. Secondly if net metering would become available on a large scale they would miss out on a large amount of Energy taxes. As can be seen in Appendix B

[46] http://www.allesoverzonnepanelen.nl/wp-content/uploads/2011/01/Brochure-zonnepanelen-en-vergunningen.pdf last queried: 01-09-2011

[47] http://www.denhaag.nl/home/bewoners/to/Subsidie-voor-zonnepanelen-op-uw-dak.htm last queried: 10-10-2011

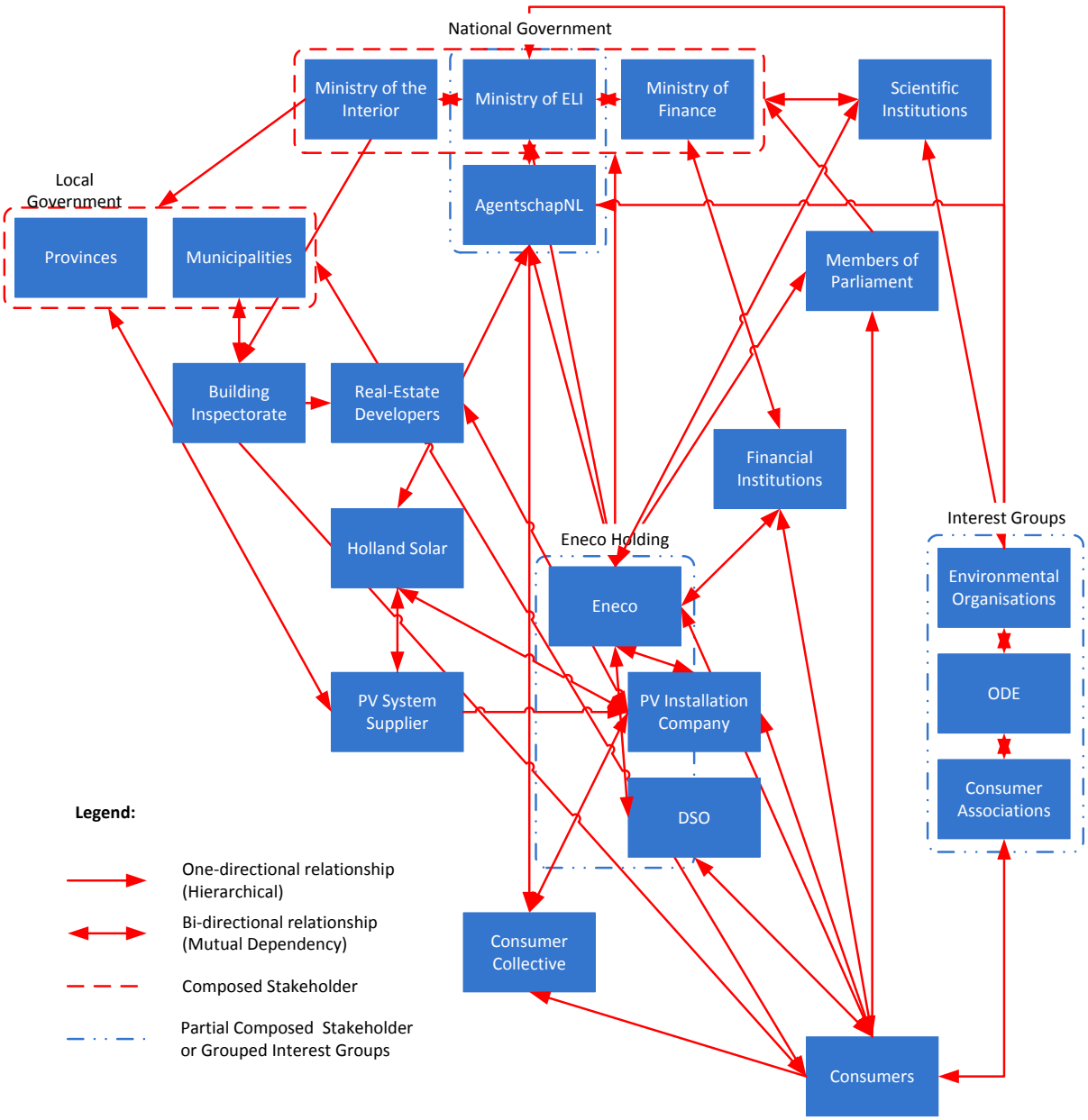


Figure 30: Formal Relations Chart

Figure 15 which is shown in the main text of the thesis on page is a selection of the stakeholders as represented in Figure 30 The main stakeholders are identified at the final step of the stakeholder analysis. The relations between the stakeholders are described in greater detail as well. The relations are required to gain a greater understanding of the relations in the network. The detailed relationships as well as the general relationships displayed in Figure 30, of the stakeholder network (Enserink, 2010). In the Netherlands the stakeholder network is often characterized by a high degree of cooperation, even though a hierarchical nature is present. These hierarchical relations do however not imply that a stakeholder can simply push his interests through. This is also known as the *poldermodel.*

F.2.4. Step 4 – Determining the interest objectives and problem perceptions of the stakeholders

Table 24, provides an extensive overview of the interests, objectives and problem perceptions of the stakeholders . Below the concepts interest, objectives, problem perception and desired solution are explained.

- *Interests* are the issues that matter most to an actor. Usually interests have a clear direction. Interests are not directly linked to a concrete problem situation, as opposed to objectives and interests are relatively stable.
- *Objectives* indicate what actors wish to achieve in a certain situation, which change they would like to realize (or what they would like to preserve). Actors use these objectives as a measure to judge the existing situation (Enserink et al. 2010).
- *Problem perceptions* are the image that actors have of the world around them. Actors use these objectives as a measurement tool to judge the existing situation.
- *Desired Solution* shows the perceived or ideal solutions to the problem or issue as perceived by a stakeholder. Stakeholders can obviously prefer a similar or opposite solution.

Stakeholder	Interests	Objectives	Perception	Desired Solution
Eneco	Becoming a large sustainable energy supply company by 2030.	Increase the penetration of Solar PV with consumers. Eneco wants to become a major PV system service company.	Although there is steady decline in the costs of PV system components, there are still a number of barriers preventing a lucrative PV proposal for consumers.	A large majority of consumers have a solar PV system on their roof, with ancillary service provided by Eneco subsidiaries (maintenance contracts, monitoring, electricity contracts, financing, etc.). These consumer PV systems will contribute to the goal of Eneco in supplying their customers with 100% renewable electricity by 2030.
Ministry of Finance	Sustainable government budget.	Maintaining or increasing the income from the energy taxes. Any other scheme than the energy tax, should lead to equivalent income.	Larger penetration of PV systems at consumers threatens the income derived from the energy tax. Any change to current legislation increasing the applicability of net metering, and reducing state income is unacceptable.	Changes to the current system of energy taxes, is acceptable. Under the condition that a loss in energy taxes is compensated by revenues elsewhere.
Ministry of Economic Affairs, Agriculture and Innovation (EL&I)	Stimulating the Dutch industry, guaranteeing the security of supply of electricity and gas.	Increasing the share of renewable energy in the Dutch energy mix at the lowest possible costs while at the same time stimulating Dutch industry.	Solar PV for consumers is almost achieving grid parity, therefore additional stimulation measures are not necessary. EL&I wants to stimulate the PV industry, the manufacturers of PV modules and PV module machines. Stimulating the installation of solar PV in the Netherlands is not seen as cost-effective. EL&I, does have an interest in stimulating the development of PV in the Netherlands, however their instruments are limited to changes in laws and regulation.	Grid Parity should be achieved soon, making the need for consumer subsidies obsolete. New companies have to stand up to bring PV to consumers. Companies creating innovative new concepts driving the costs down even further.
Ministry of Internal Affairs	IA: “IA contributes to affordable, safe and energy efficient homes for neighbourhoods where Everybody counts and participates.” Taken from the website of the Ministry of IA	A building should not endanger its occupants, its users and the environment. Therefore IA establishes requirements for the safety, health, usability, energy efficiency and the environment. These requirements are laid down in het “bouwbesluit”.	There is a trade-off between stricter building requirements while keeping new homes affordable. More often the requirement of affordability prevails over the environment and energy efficiency.	The market incorporates more energy efficient measures because the consumers asks for those measures.
Holland Solar	Representing the Dutch solar PV industry, mostly the PV installation companies. As well as	Increasing the share of solar PV in the Dutch electricity mix. Thereby stimulating the growth of the industry	The Dutch government is not that concerned with increasing renewable energy in the Netherlands. There are no	The best solutions according to Holland Solar are:

Stakeholder	Interests	Objectives	Perception	Desired Solution
	lobbying for the industry.	Holland Solar represents. Also, solar PV must be integrated in Dutch legislation.	Ambitious goals and there are numerous barriers impeding the implementation of solar PV.	– Increasing the net-metering threshold – Enabling collective self-supply – Increasing the energy tax for large-scale consumers.
Bewonersvereniging Biesland	Representing the residents of the neighbourhood Ypenburg, nearby The Hague They want to increase the share of renewable energy in their neighbourhood.	Investing in a collectively owned solar PV installation at a nearby farm and on the local primary school. The electricity should be sold to the school, farm and participating households. The profits of the collective installation should benefit the residents of the neighbourhood.	The current legislation concerning solar PV, the net metering, energy taxation, and other related components are deemed unfair. Also, Eneco is not concerned with the welfare of its consumers; all they want is to maximize profits. Instead, subsidies or similar schemes are beneficial to the realisation of projects for consumers.	Collective self-supply is considered as a good solution to households problems. Another solution could be to change all the legislation in the Electricity Act. For example to convert from a fixed cost system to a variable cost system.
Green Spread	Green Spread advises organisation in reducing their energy consumption as well as developing and operating renewable energy installations.	Increasing the number of installed PV systems that Green Spread develops, operates and maintains.	There are ample possibilities to develop cost-effective PV installations. Waiting for new legislation leads to nothing/ is not the way forward. A major problem remains the uneven-playing field between renewable and non-renewable energy.	Levelling the playing field between renewable and conventional generated electricity. This includes abolishing the shadow subsidies given to nuclear and fossil fuel generated electricity. Also, it is important to enable the collective self-supply of electricity. Lastly, it is important to offer “care-free” packages for consumers.
ASN Bank	Promoting sustainability to society. ASN Bank does not invest in projects where the negative effects are pushed towards future generations or shifted to the environment. Investments made by ASN Bank should yield a fair return and contribute to the long term continuity of the bank and banks financed projects.	Investing in renewable energy projects contributes very well to ASN’s interests. It provides a good return on investment while at the same time promoting sustainability to society.	There is a large demand for solar PV by consumers and society in general. However, at the moment there are issues concerning quality and costs of PV systems. The national policy concerning renewable energy is inconsistent and has no long term orientation.	Collective self-supply of energy is a non-achievable goal. For banks, PV system financing should become a standardized product. Cooperation between partners is an important factor for project success, with or without subsidies.
Installation company GSU	Focusing on making their own activities more sustainable. Investing in renewable energy sources as well as infrastructure	Designing, installing and maintaining PV installations. Becoming a large installer of PV systems for consumers in the Netherlands.	There is a large interest of consumers in PV systems. However, the payback-periods and costs of PV systems are deterring consumers from investing in a system	Care-free consumer packages could be, one however intensive cooperation between parties is very important.

Stakeholder	Interests	Objectives	Perception	Desired Solution
	with the goal of a reliable and affordable energy systems			Collective self-supply would be a great opportunity for GSU to install more PV systems for consumers. Another option would be creating a truly level playing field.
MP Diederik Samsom (PvdA)	The creation of new green jobs in industries where there are large opportunities for the Netherlands. Reducing the carbon-footprint of the Netherlands by 30% compared to 1990 levels. This should be done by increasing the renewable generation of electricity.	Creating a completely sustainable energy system by 2050. Making investment in renewable energy attractive for consumers so they can fulfil part of their electricity requirement by solar PV.	Dutch policy regarding renewable energy will not make the difference in the transition towards a renewable energy system. The installation industry still has a lot to learn in installing solar PV systems. According to the PvdA, grid parity is still some time away from us because of the involvement of, at the moment, high costs.	The amendment to the Electricity Act as was presented by MP Samsom will in one form or another be implemented in the coming 2 years. International cooperation is needed to mobilize the capital and infrastructure needed to roll out PV for consumers once grid parity is achieved.
Prof. Wim Sinke (ECN)	ECN develops high quality knowledge and technology for the transition from a fossil fuel based system to a renewable energy based system.	ECN develops solar cell and panel modules to increase the energy efficiency of PV systems as well as the price / performance ratio of solar panels. ECN advices actors on energy policy, among others the national government.	The Dutch PV market is very small in comparison to other countries. The only policy measure stimulating the investment in PV systems is net-metering. There is however a large demand from the market for innovative concepts that enable the large scale roll-out of PV in the Netherlands. The risk is however that the national government stops stimulating renewable energy, leading to a halt in the process of energy transition.	The proposed amendment of MP Samsom is a step in the right direction even though large-scale consumers fall outside the scope of the amendment. Fortunately, this group does not make-up a large part of the market. Fiscal incentives is a well-suited instrument to stimulate investment in PV for corporation. Corporations should be included because they represent a large market and can help drive down PV system costs. The Dutch solar PV market should be organized more efficiently.
Stedin	Stedin is responsible for the construction, extension, maintenance and operation of the electricity and gas distribution grids in the provinces Utrecht and South-Holland.Stedin is responsible for a safe and reliable energy transport. Stedin registers which connection	Stedin has two explicit main objectives, – Utilizing all the opportunities of distributed energy generation (including solar PV); – Maintaining its position as a reliable, affordable and efficient distribution grid operator anticipate on changes in the environment.	The current distribution grid, has no problems in coping with a large penetration of solar PV in the Netherlands. The distribution grid at the neighbourhood level is very robust. Stedin still has many things to learn on the effects of large shares of distributed electricity generation on the distribution grid.	The development of new business models and enabling collective self-supply. Smart Grids, do form an important part of the solution for Stedin in meeting their set requirements

Stakeholder	Interests	Objectives	Perception	Desired Solution
	supply energy to the grid as well as transmitting the meter data to the energy supply companies			
AgentschapNL	AgentschapNL aims to strengthen the economy and the environment. Contributing to the sustainable development of the Netherlands, today and in the future, in cooperation with partners from the industry.	AgentschapNL wants to stimulate the integration of solar PV in the built environment. It also stimulates the development of new innovative products in order to be ready for grid-parity. AgentschapNL has as an objective to monitor current policy for the effectiveness.	There is a great interest of consumers and companies to invest in solar PV, however PV still proves to be too expensive. There is still also a large demand for accurate information about solar PV (industry) as well as quality standards for the installation trade. There is still a large need from the industry for AgentschapNL to facilitate in bringing market parties together in developing new products. AgentschapNL can fund (part of) the research required for the product development.	– A market party gathering accurate information for market parties. – A certification process, setting minimal quality standards for the installation trade. – "Care-free" solar PV propositions, reducing the cost-barriers. – A stimulation measure such as collective self-supply or net metering extension. However, such a measure should involve zero costs for the government.
Consumers	Maintaining and increasing their personal welfare, such as financial, environmental and health welfare.	In the face of rising electricity prices, consumers want to reduce their future electricity costs. At the same time consumers wish to reduce their environmental footprint.	Solar PV is a popular way to hedge the rising costs of electricity. However they feel that PV systems remain expensive and have long payback times. This situation withholds them from investing in a solar PV system. Consumers also perceive the market as non-transparent. Most consumers do not have the knowledge available to make an informed decision.	Possible solutions: – The national government should implement investment subsidies. – Establishing a FIT-system like in Germany. – Enabling the collective self-supply of electricity. – Market parties promoting care-free solar PV propositions. – Clear and unbiased information on solar PV.
Milieucentraal / Greenpeace	Making information available to the masses about the environment and energy. With this information, organisations and consumers should change their behaviour in such a way that it impacts the environment in less polluting/ a positive way.	Providing the market with clear and (accurate) information about solar PV. Stimulating the investment in solar PV.	There is a lot of biased and inaccurate information available to consumers and other stakeholders. The market for solar PV systems is developing quickly and system prices are reducing fast/quickly Because grid parity is almost achieved it is time for consumers to start investing in solar PV.	Clear information should be given to the consumer. Any stimulation would be preferable such as collective self-supply.
Consumentenbond / Vereniging Eigen Huis	This consumer association represents the interests of all consumers. The main goal is to	Consumers need clear and unbiased information. There is a lot of biased information available to consumers	Not Available	Not Available

Stakeholder	Interests	Objectives	Perception	Desired Solution
	allow consumers to make better choices with respect to society and the environment.	through the internet. Although the Consumentenbond is currently inactive on solar PV, they can test and compare different solar PV propositions in the future.		
PV system supplier	Focus on designing, developing and integrating reliable solar PV systems for most situations. Making sustainable technology available to the masses.	Becoming a large market party on the consumer market, while maintaining profitable margins on the sold products.	There is a lot of competition in the markets for PV system components. This puts a lot of pressure on the margins and on product quality.	Achieving grid parity as soon as possible, the demand for solar PV systems will increase, allowing for larger margins in the market. Any solution that contributes to more system being sold is preferable for the system suppliers.
Real-Estate developers	Real estate project developers want to realise sustainable and high quality new real estate for their clients, while realising a high return on investment.	Selling high quality homes for consumers. However, these homes should be built at the lowest possible costs, while meeting the requirements of the building codes.	The current real-estate market is slowly developing. There is a lot of competition on prices by real-estate developers. Meaning that energy-efficiency measures are not taken because they are too expensive in the opinion of real-estate developers. There are however exceptions between the real-estate developers in the degree to which they design homes with energy consumption in mind.	Setting higher and stricter Building Code requirements. Creating equal competition between project development without compromising sustainability to keep building costs to a minimum. Another possible solution would be cooperation between PV system suppliers and energy supply companies to install homes out with a PV system.
Local Government	The local government is aimed at the wellbeing and welfare of their citizens in the long-term.	To improve the wellbeing of their citizens, municipalities and provinces want to lower their footprint on the environment and making the region more sustainable. They want to achieve this by promoting distributed sustainable energy in their province / municipality.	Municipalities see a demand for solar PV by their citizens. Because the national government does not promote solar PV at the consumer level, municipalities and provinces are taking up this role. Municipalities Take measures to stimulate the development of PV and other renewable energy sources. They see PV as an important technology because there is less public resistance against solar PV than large scale wind-turbines.	There are a number of solutions to the problem that the local government is interested in: – Providing (investment) subsidies on solar PV systems. – Initiating collective self-supply projects. To install PV systems on town halls, community buildings and provincial government buildings, to promote sustainability.
Welstandcommissie (Building inspectorate to enforce the external appearance of	The *Welstandscommissie* is an independent commission that advices the municipalities if building permits should be issued	At the moment the *Welstandscommissie* does not have a clear role in the solar PV discussion. This is because under most circumstances solar PV systems are	There are a lot of different types of solar PV panels available in the market. Their orientation and design is always changing. There is no single standard in mounting a	The main solution of the Welstandscommissie would be the development of more aesthetically pleasing integrated solar PV

Stakeholder	Interests	Objectives	Perception	Desired Solution
buildings)	for renovation and new buildings. They have to protect the quality of the built environment.	building permit free. The *Welstandscommissie* can only judge a building permit request. However in the future, with a more stricter Building Code, they may gain the resources to block PV system development.	PV system on the roof of a building. The *Welstandscommissie* can judge in the future that stricter requirements should be set on the installation of solar PV systems.	systems. As well as improved methods of mounting solar PV systems. If the penetration of solar PV increases this could lead to aesthetically displeasing external quality of the build environment. Finally a solution could be to have stricter building code requirements.
ODE	Energy demand is increasing and fossil fuels are not environmentally friendly. Fossil fuels makes us dependent on unreliable suppliers, while they pollute the environment. Renewable energy, generated locally, leads to energy independency.	ODE wants that consumers generate a greater share of their electricity needs themselves. ODE attempts to accomplish this by providing information to consumers about solar PV. ODE is also active with lobbying at the national government level to create more favourable investment conditions.	There is a strong lobby in the Netherlands working against large scale generation. This lobby consist of large energy supply companies, like Vattenfall, RWe and Eon. ODE also argues that too little is being done to make solar PV more attractive for consumer. For example, there are currently no subsidies and net metering has only a limited scope.	The perceived solutions of ODE are intended to make it easier and often more profitable for consumers to invest in solar PV. A solution could be an extension of net metering, or self-supply At the same time accurate information has to be provided to consumers.

Table 24: Inventory of the stakeholders involved in the large scale roll-out of solar PV in the Netherlands

F.2.5. Step 5 – Analyse interdependencies

Table 25 provides an overview of the determination of critical and non-critical actors. The resources depicted in the table show the resources available to a stakeholder to influence the problem solving process. The following resources are identified by Enserink et al., 2010:

- Authority
- Money
- Organisation
- Legal Procedures
- Position
- Knowledge
- Information
- Protests

Most of these resources are fairly straightforward, however the following two resources need some further explanation. Organisation refers to the ability of a stakeholder to effectively mobilize and use resources to tackle an issue. Position refers to the position of a stakeholder in the network to influence other actors or mobilize other actors.

The degree of replicability indicates if the resources of a stakeholder can be replaced by other stakeholders. If not then, the resources that actor possess is limited, otherwise the replicability is mediocre or large. Money is a resource that is not really replaceable, although multiple stakeholder have access to funding. Money can only be spend once, and obtaining financing from other stakeholders will have strings attached. Knowledge on the other hand is easier to replace, because it is possible that many stakeholders have similar knowledge available.

The level of dependency refers to if an actor has much influence over the problem or its solution. Thus:

- High level of influence > high dependency level
- Low level of influence > limited dependency level

Finally actor criticality, an actor is determined as critical when he has the ability to realize solutions ("*power of realization*") or to block certain solutions ("*blocking power*"). These are the actors that cannot be ignored by the problem owner when dealing with problems or developing solutions (Enserink et al, 2010 p .84). The Ministry of Finance and the municipalities are both excluded from being determined as a critical actor, although they have significant power and resources. The Ministry of Finance is excluded because they are only interested in the consequences of a change of the current institutional framework. Changes which would result in less energy tax income (Buddenbaum & Vrijmoed, 2011). The municipalities are excluded because the developed PV proposition should be universal. If the proposition is aimed at and compatible with the policy of different municipalities than there cannot be a universal roll-out of PV in the Netherlands.

Stakeholder	Important Resource	Degree of Replace ability [Limited / Mediocre / Large]	Dependency [Limited / Mediocre / High]	Critical Actor [Yes / No]
Eneco	– Money – Organisation – Position – Knowledge	Limited	High	Yes
Ministry of Finance	– Authority – Money – Position	Mediocre	Limited	No
Ministry of Economic Affairs, Agriculture and Innovation (EL&I)	– Authority – Money – Organisation – Legal Procedures – Information	Limited	High	Yes
Ministry of Internal Affairs (IA)	– Authority – Money – Organisation – Legal Procedures	Limited	Limited	No
Consumers	– Information – Organization – Protests	Limited	High	Yes
Holland Solar	– Position – Knowledge – Protests	Limited	Limited	No
Bewonersvereniging Biesland	– Money – Information – Protests	Large	Limited	No
Green Spread (Companies)	– Money – Organization – Knowledge – Information	Large	Limited	No
ASN Bank	– Money	Limited	Mediocre	Yes
Installation company GSU	– Knowledge – Information	Limited	High	Yes
MP Diederik Samsom (PvdA)	– Authority – Legal Procedures – Protests	Limited	Mediocre	No
Prof. Wim Sinke (ECN)	– Position – Knowledge – Information	Mediocre	Limited	No
Stedin (Including the other electricity distribution system operators)	– Money – Organisation – Knowledge – Information – Protests	Limited	High	Yes
AgentschapNL	– Authority – Money – Organisation – Position – Knowledge – Information	Limited	Mediocre	No
Milieucentraal / Greenpeace	– Organisation – Legal Procedures – Position – Knowledge – Protests	Mediocre	Limited	No

Stakeholder	Important Resource	Degree of Replace ability [Limited / Mediocre / Large]	Dependency [Limited / Mediocre / High]	Critical Actor [Yes / No]
Consumentenbond / Vereniging Eigen Huis	– Authority – Legal Procedures – Knowledge – Information	Mediocre	Limited	No
PV system supplier	– Organisation – Knowledge – Information	Limited	High	Yes
Real-Estate developers	– Money – Organisation	Mediocre	Limited	No
Local Government	– Authority – Money – Legal Procedures – Position	Limited	Limited	No
Welstandcommissie (Building inspectorate to enforce the external appearance of buildings)	– Authority – Legal Procedures – Protests	Limited	Mediocre	No
ODE	– Knowledge – Information – Protests	Mediocre	Limited	No

Table 25: Table determining critical and non-critical stakeholders source

F.2.6. Step 6 – Stakeholder classification and specification

During this step the stakeholders are classified according to their 'dedication' with the perceived problem of why there is not a large scale roll-out of PV in the Netherlands. Dedicated actors are actors that are intensely involved and affected by the problem. Non-dedicated actors are actors that are not directly affected by the problem or do not perceive the problem as immediately important or currently not worth their attention. Two types of classifications are used to classify the stakeholders, namely (1) the classification of critical and non-critical actors and (2) similar and conflicting interests and objectives. These classifications are used to provide a clear overview of the stakeholders involved. Table 26 shows the results of the stakeholder classification.

As can be seen in Table 27, a number of stakeholders are classified multiple times. For example the Ministry of EL&I has internally conflicting interests, on the one hand the Ministry wants to increase renewable energy in the Netherlands, and on the other hand the Ministry wants the Dutch energy infrastructure to remain affordable. Specifically solar PV lies at a crossroads here, because the Ministry of EL&I can work with or against the development of PV propositions. . A second example relates to members of parliament. Members of parliament are member of different political parties, with different interests and objectives. With regard to renewable energy there is for example a significant difference between members from the Christian Democratic Party CDA or from the leftist and greenest party GroenLinks. Due to the diverging interests and objectives of these parties, this stakeholder is classified in multiple classification boxes.

	Dedicated Actors		Non-Dedicated Actors	
	Critical Actors	**Non-Critical Actors**	**Critical Actors**	**Non-Critical Actors**
Similar / Supportive Interests and Objectives	– Eneco – DSO's (Stedin, Liander etc.) – PV system installers (GSU, Tempus, Green Spread, etc.) – PV system suppliers – Ministry of ELI *Actors that are likely to participate and are potentially strong allies*	– Consumers – Consumer Collectives – Holland Solar – Environmental Organisations – AgentschapNL – Financial Institutions (ASN Bank, Triodos) – Local government – ODE *Actors that probably will participate and are potentially weak allies*	– Ministry of IA – Consumer Association – Real Estate Developers – Members of Parliament – Consumers *Indispensable potential allies that are hard to activate*	– Scientific Institutions (ECN, TU Delft, etc.) – Members of Parliament *Actors that do not have to be involved initially*
Conflicting Interests and Objectives	– Ministry of EL&I *Potential blockers of certain changes (biting dogs)*	– Direct Competitors (Awizon, Greenchoice, etc.) – Other energy companies *Potential critics of certain changes (Barking dogs)*	– Ministry of Finance – Members of Parliament *Potential blockers that will not act immediately (sleeping dogs)*	– Members of Parliament *Actors that need little attention initially*

Table 26: Overview of the (inter)dependencies of the stakeholders involved (Adapted from: Enserink et al, 2010)

		Level of Interest	
		Low	**High**
Power	**Low**	**A** Real Estate Developers Building Inspectorate Consumers ***Minimal Effort***	**B** AgentschapNL Financial Institutions Competitors Energy Companies ECN ODE Consumers Consumer Association Consumer Collectives Environmental NGO's Holland Solar ***Keep Informed***
	High	**C** Ministry of IA Ministry of Finance Local Government ***Keep Satisfied***	**D** Ministry of ELI DSO Eneco PV system Suppliers PV system Installers ***Key Players***

Table 27: Overview of stakeholder dependencies (Adapted from Enserink et al, 2010)

From Table 26 and Table 27, the most important stakeholders can be identified. In Table 27, these are all the stakeholders on the right side of the figure. When Eneco is involved in a project concerning the large scale roll-out of PV for consumers in the Netherlands then these are the stakeholders to pay attention to. In Table 26 the most important stakeholders are positioned on the left side of the table. Some of the stakeholder depicted here are important because of their influence, but others are more important because of their skills, knowledge or other resources.

- Eneco
- Distribution System Operators
- PV system supplier
- PV system installers (including GSU, Metapart and Tempus)
- Financial Institutions (including ASN Bank)
- Ministry of Economic Affairs
- Consumers

The consumers in Table 27, have a low level of interest, because they are not that active in pursuing the installation of a PV system. Otherwise it is safe to assume that more PV systems would have been installed. They are included in the main stakeholders, because the proposition needs to be tailored to their needs.

Appendix G

Identified Stakeholder Barriers

The identified barriers have been categorised in the following four groups. The identified barriers are described in greater detail in this appendix.

- Financial
- Technical
- Institutional
- Process

G.1. Financial Barriers

Table 28, presents the financial issues that interviewed stakeholders mentioned. During the interviews multiple stakeholders noted financial concerns related to PV.

G.1.1. Financial Barriers

G.1.3 provides a more elaborate description on the barriers identified in Table 28.

Financial Barrier	Explanation	Mentioned by stakeholder
Exchange Rate Risks	Fluctuations in the $ / € - exchange rates influence the profitability of PV investments. Strong $-exchange rates can make PV systems more expensive. Because a € is worth less when buying cargo in $'s. In Europe there are only a limited number of PV system suppliers that sell competitive products.	– Eneco BSH
Solar PV System Equilibrium	There is no stable equilibrium between the demand and supply of system components on the global market. When there is an oversupply of systems components prices drop. When there are PV system shortage prices will rise, as well as delivery times. These issues severely affect project profitability.	– Eneco BSH – Holland Solar
Financing of Project costs	Initiating and designing a collective project involves significant (project) costs. The main issue is that there are no stakeholders willing to finance these start-up costs.	– Bewonerscollectief Biesland
System Size	Consumers are often offered solar PV systems that are too large, resulting in high investment costs and a high degree of lock-in due to financial lease contracts. Moreover, this problem prevents consumers from expending their PV system at a later moment in time. This lack of system expansion and system	– Bewonerscollectief Biesland – GSU – PvdA – Holland Solar

Financial Barrier	Explanation	Mentioned by stakeholder
	updates leads to less business and lower profits. A final issue with large PV systems is that the upfront costs of these systems may provide a significant barrier for consumers investing in a PV system.	–
System Price Setting	Mono crystalline Silicium (m-Si) solar PV modules, are the benchmark in the PV sector. All new product prices are being compared against the prices of m-Si modules. New products that are cheap to produce, could thus become overpriced which slows down the development of PV systems and consumer buying	– Green Spread
Access to capital	There is no cheap capital available. Consumers and other investors issues with obtaining financing at favourable interest rates. Financial institutions on the other hand fear the risk of defaulting customers by higher interests rates. Capital thus remains difficult to obtain.	– ASN Bank – Holland Solar

Table 28: Financial barriers for the implementation of Solar PV in the Netherlands

G.1.2. Financial Barrier Scorecard

Table 29, shows the influence Eneco has over the mentioned financial issues and if that issue is seen as important by the stakeholders. The combined score of the influence Eneco has on the issue as well as the importance of the issue is taken to determine whether the issue is suited for further research. The issues that are not chosen for further research form criteria for the solutions that are developed. Solutions that are developed for the mains issues in Chapter 6 need to score positive on these criteria as well.

Financial Barrier	Influence Eneco	Stakeholder Importance	Total Score
Exchange Rate Risks	None (0)	1	1
Solar PV System Market Equilibrium	None (0)	2	2
Financing of Project costs	Medium (2)	1	3
System Size	High (3)	4	7
System Price Setting	None (0)	1	1
Access to Capital	Medium (2)	2	4

Table 29: Financial barrier selection for further research

G.1.3. Financial Barriers Explained

Exchange Rate Risks

The Exchange rate risk is not a critical issue, because Eneco is not able to influence exchange rates themselves. They can attempt to cover these exchange rate risks by financial instruments such as currency swaps and foreign exchange forwards (ITA, 2008). The underlying causes of the exchange

rate risks, cannot be influenced by Eneco. At the same time the risks of fluctuating exchange rates can be covered by financial instruments. These methods of dealing with exchange rate risks are described in multiple Economic textbooks. Therefore Exchange Rate Risks are not included in the further analysis.

Solar PV System Market Equilibrium

The control of Eneco on the PV system market equilibrium is very limited even though it creates a lot of uncertainty and instability. Since the start of the financial crisis and the cutbacks of subsidies by many governments there has been an oversupply of solar PV systems on the international market, coinciding with a large drop in prices (Stuart, 2010). Historically, when looking at graph 1, one can see that the price trend is downward, apart from a short period between 2003 – 2008 where there was a shortage of solar PV systems. But with large solar PV manufacturing capacity and large surplus inventories this is not likely to pose an issue in the near future. The control of Eneco on the prices of PV systems is very limited, because it does not own solar PV manufacturing facilities. Two other Dutch energy companies had large stakes in solar PV system manufacturers: Delta (Solland Solar) and Nuon (Helianthos). Both manufacturers have been operating at steady losses and have been sold. These two reasons, the steady decline of solar PV system prices, as well as the opinion that Eneco should not invest in the manufacturing process of PV systems leads to the conclusion that this issue should not be investigated further in this research.

Financing Project Costs

The barrier of financing project costs arose from the Bewonerscollectief Biesland. They want to realize a solar PV project in their community, installing a large solar PV system on the local primary school and selling the electricity to that school and realizing a solar PV installation on the neighbouring farm. The preparations and planning of these projects caused high project costs. Project costs such as research, design and meetings with stakeholders. The chair of the collective found that this posed a barrier, which they would like to get financed. In the case that for example an energy company would take over the project and install operate and maintain the project they would have to do less work. In such a case the collective wants to be compensated for this. But this has not happened yet. The Bewonerscollectief Biesland wants to solve the issue by establishing a local energy company themselves (de Graaff, 2011).

The financing of project costs is not researched further, because one can argue that the project costs referred to by the Bewonerscollectief can be seen as a commercial risk. Second, if Eneco would become a project partner they could compensate the Bewonerscollectief Biesland. Eneco would have to ensure because they are a private company, that there is a positive business case.

Solar PV System Size

Solar PV Systems for consumers are often dimensioned too large. Because of their size they create large cost barriers for consumers and they prevent repeating business. In a majority of the cases the solar PV system, covers all of the suitable roof available, preventing a consumer from expanding the system at a later moment in time. For instance when solar PV becomes cheaper or if technological breakthroughs arise making systems more efficient (de Graaff, 2011; Morren, 2011; Saeijs, 2011). Therefore an improperly sized PV systems creates significant lock in effects. If in the past a consumer has invested in a large solar PV system, it will have less financial resources available, to reinvest or upgrade his existing system.

In the example given above, Eneco has a large degree of influence if they opt for the large scale roll-out of solar PV for consumers. They can opt to sell smaller PV systems to consumers, in order to generate repeated business in the future. Although this should be considered a trade-off for both Eneco and the consumer. The costs of a larger system are lower per W_p, than a smaller system, thus there are 'economies of scale', but the system is more expensive. When an energy company sells a large solar PV system his immediate profits are larger than when selling a smaller system. However, Eneco does miss out on the possibility of repeated business (Morren, 2011). Therefore this barrier is taken to the final barrier selection in paragraph 4.2

System Price Setting

According to Zwang (2011) PV system price setting is a barrier. Manufacturing process innovations are often marketed far above costs. The industry benchmark remains mono-crystalline Silicium panels. Any new innovation is marketed against the prices of these panels and this artificially inflates the component and system prices. Eneco has no influence over the price-setting of solar PV manufacturing companies. Additionally no other stakeholder mentioned this issue. Stakeholders emphasized the dropping prices of solar PV systems as a huge opportunity for the large scale roll-out of PV (Buddenbaum & Vrijmoed, 2011; Roesink, 2011; Schootstra , Holland Solar, 2011; Weeda, 2011). Therefore the issue of system price setting is not dismissed.

Access to Capital

The price of the average solar PV system is high and not all consumers have the funds available to finance these system. If they want to invest in a system, they have to obtain financing from a bank. Although banks charge lower interests rates because a solar PV system falls under the green financing scheme (Roesink, 2011), consumers find the financing conditions restrictive. The conditions are often set as high, so when one is eligible for financing you would not need a loan in the first place (Zwang, 2011). Multiple interviewees regarded this issue as prohibitive to the large scale roll-out of consumer PV. With regard to system financing, there are opportunities for Eneco to lower these barriers for consumers. Eneco could provide financing or lease the solar PV systems to consumers. Therefore the barrier access to capital is taken to the final barrier selection in paragraph 4.2

G.2. Technical Barriers

Table 30 shows the technical barriers to the large scale roll-out of solar PV for consumers. The technical issues concern the physical solar PV system itself. It includes system components as well as technological developments.

G.2.1. Technical Barriers

G.2.3 provides a more elaborate description on the barriers identified in Table 30

Technical Barrier	Explanation	Mentioned by stakeholder
Quality Uncertainty	Quality Uncertainty has two sources: – First there is the issue that market parties are at times uncertain of the quality delivered by the system components. – Second there is uncertainty about the quality delivered by the installation trade. Continuous education is needed for the installation trade to deliver the quality required for future system components. Both uncertainties can lead to a loss of confidence in PV systems as a means of generating renewable energy.	– ELI – Eneco BSH – Bewonerscollectief Biesland – GSU – PvdA
Standardization	Every roof is different: consumers have two general roof types, inclined and flat roofs. Even if these are south-facing then there are still a lot of technical obstructions, such as chimneys, guttering, etc. Standardization could solve a lot of these problems and lower costs of solar PV systems considerably. However it is difficult to develop a one size fits all. Additionally there is a problem that all solar panel manufactures use different module dimensions and the products are often not interchangeable.	– Eneco BSH – Holland Solar – ECN – Green Spread – AgentschapNL
PV system (component) lifetimes	Firstly, Solar panels usually have an economic lifetime in excess of 25 years. While the invertors needed to convert the DC generated electricity from the panels to AC used in domestic houses, have an economic lifetime of no longer than 10 years. Without the invertor PV systems do not generate electricity. In many business cases replacement of the inverter is often forgotten. Secondly, due to the developments in solar PV technology older systems become outdated. Shorter lifetimes in which the system pays itself back, could increase PV	– Eneco BSH – Green Spread – ASN Bank – AgentschapNL

Technical Barrier	Explanation	Mentioned by stakeholder
	business because after a number of years the consumer can reinvest in a new solar PV system (Saeijs, 2011).	
Alternating Current vs. Direct Current (AC vs DC)	Our electricity infrastructure is rolled out using alternating current. This creates increased solar PV system costs because an inverter is required to transform the DC output to AC. These conversion losses reduce the efficiency of a solar PV system.	– Bewonerscollectief Biesland – Green Spread,
Technology Development	The efficiency of the solar PV systems remains insufficient, compared to the fast paced development of the related personal electronics industry.	– Green Spread
Costs versus Quality	Competition on costs in some segments of PV panels is so severe, that solar PV panel manufacturers are sacrificing quality in order to sell cheaper panels.	– Eneco BSH – Green Spread – ASN Bank
Distribution Grid Stability	With higher penetrations of distributed generation such as solar PV, the likelihood that disturbances occur in the distribution grid is increased.	– PvdA
Sustainability Requirements	Although solar PV is attributed being a renewable technology, the environmental footprint of solar PV modules can be polluting depending on the production process. When offering a renewable product, one has to be sure that it is not damaging to the environment during the production.	– Saeijis 2011 – Greenpeace

Table 30: Technical barriers for the implementation of PV in the Netherlands

G.2.2. Technical Barrier Scorecard

Table 301 presents the score on the influence of Eneco on the issue as well as the stakeholder importance ranking. A number of issues, especially with regard to technical system components lie outside the influence sphere of Eneco. Therefore these are not taken into account, a well as a number of issues that are mentioned by a few stakeholder (less than three).

Technical Issues	Influence Eneco	Stakeholder Importance	Total Score
Quality Uncertainty	Medium (2)	5	7
Standardization	High (3)	5	8
PV system (component) lifetimes	Low (1)	4	5
Alternating Current vs. Direct Current (AC vs DC)	Low (1)	2	3
Technology Development	Low (1)	1	2
Costs versus Quality	Low (1)	3	4
Distribution Grid Stability	Medium (2)	1	3
Sustainability Requirements	Medium – High (2-3)	2	4-5

Table 31: Technical barrier selection for further research

G.2.3. Technical Barriers Explained

Quality Uncertainty

Quality Uncertainty as explained in Table 30, has two sides. On the one hand there is uncertainty about the system components such as the solar panels as well as the invertors, on the other hand the installed quality of the system is unknown. Eneco has some, albeit limited, influence over both issues. Eneco has however the means to obtain the knowledge necessary to discern between high and low quality systems. First they have the staff available that can discern between high and low quality components. Secondly, because Eneco has a number of installation companies (GSU, Metapart and Tempus), they can control the quality of the installed systems.

From the interviews with stakeholders it is clear that quality is very relevant to all parties involved. A high level of quality is needed to ensure a high level of customer satisfaction and to generate more business. Because of the fact that Eneco can control the quality and that quality that is so important to all the stakeholders involved, it is taken into account in the further analysis in paragraph 4.2.

Standardization

Standardization is an important barrier, almost every roof in the Netherlands is different. The roofs differ by means of their orientation towards the sun, the gradient of the roof, the obstruction on the roof, surrounding shading, etc. In order to stimulate the large scale roll-out of PV it is required that a standardized product can be installed on all the roofs. A standardized product keeps costs down.

Second, standardization keeps the maintenance costs low as well, if a component breaks down, it can be replaced easily, because the specifications of the product are known. When every roof has a customized installation with different parts, for instance the dimensions can differ and finding a replacement component can become troublesome. Eneco influences the level of standardization, it can make rational choices about what components should be used to build the PV system. Therefore standardization is taken into account in paragraph 4.2.

PV system component lifetimes

A number of stakeholders mentioned that one of the problems with PV systems is that, when calculating the business case, replacement investments need to be done. The solar PV modules have an economic lifetime of 25 years or more, looking at the performance guarantees given by solar PV module manufacturers (Zweibel, 2010; Zeman, 2010). However, the invertors, a critical component in a PV system that converts the DC electricity to AC, has an economic lifetime between 7 to 10 years. This means that when calculating a project, with a duration of 20 years, one or two inverters need to be replaced (Weeda, 2011; Zwang, 2011). First of all not all parties involved, include these necessary replacement investments.

A second issue is the development of new solar PV components. These new components are of better quality and performance wise than the previous generation. The problem is that because solar PV systems have relatively long payback times, PV systems are almost impossible to upgrade profitable. First Eneco has influence over the first argument it does not have as much influence over the second argument. Secondly only a limited number of stakeholders see this as a problem. Therefore this barrier is not taken into account.

AC vs. DC

Solar PV systems generate Direct Current instead of the alternating current on which our electricity infrastructure is based. Although a DC infrastructure would mean that costly inverters would be obsolete it would involve a complete overhaul of our electricity system. The cost of replacing our current AC infrastructure does not outweigh the costs of buying a DC/AC inverter for a solar PV system. Eneco has limited influence on the standards used in our electricity infrastructure, and only two stakeholder considered this an important issue, therefore this barrier is not taken into account.

Limited Technological Development

It is interesting to note that during the interviews one stakeholder mentioned that the development of solar PV systems is progressing slowly. Arguing that when looking at the efficiency of solar panels, ranging between 8 – 22 % (depending on module type a-Si through m-Si) that the efficiencies are only improving very slow. However the technological limits of the technology suggest otherwise (Zeman, 2010). A solar PV system can only use a fraction of the available light and convert it to energy, as well as other theoretical limits. In that regard the efficiency improvements are progressing rapidly (Zeman, 2010). The other stakeholders mentioned the technological improvements of PV systems as a major opportunity. Therefore this barrier is not taken into account.

Costs versus Quality

At the moment there is severe competition between solar PV module manufacturers, squeezing their margins (Stuart, 2010). As a result, according to Weeda (2011), Zwang (2011) and Roesink (2011), quality suffers. According to them companies compete first on price and second on quality. This leads to bad quality solar PV modules on the market. Although the barrier is significant for the large scale roll-out of solar PV, there is little that Eneco can do about it. They can ensure that they buy only the high qualitative solar modules, but that is as much as they can. Even though three stakeholders found this barrier to be important, it is not taken into account because of the low level of influence Eneco can exert.

Distribution Grid Stability

According to Member of Parliament Samsom, a high penetration of renewables may lead to concerns about our distribution grid. It could lead to large peaks in the infrastructure with which it is unable to cope. However Wijgerse (2011) from Stedin, argues they can cope with large penetrations of renewables on the distribution grid without experiencing problems. Therefore this barrier is not taken into account.

Sustainability Requirements

Although solar PV is deemed as a renewable source of electricity there are some drawbacks. The materials used during the production may be hazardous to the environment (Alsema, 2012; A.T. Kearney, 2009). It is important therefore that the solar panels do not contribute to environmental pollution during its entire lifetime. In the industry however important steps are taken to reduce the use of hazardous materials[48]. Although this is an important issue which Eneco can influence by buying products from certified manufacturers, only a limited number of stakeholders expressed this as important. Therefore it is not taken into account

[48] http://solarplaza.com/pressrelease/solar-frontier-sets-higher-environmental-standards last queried 01-11-2011

G.3. Institutional Barriers

Table 32 shows the institutional barriers for PV. Institutional issues are barriers regarding policy, contracting and arrangements between stakeholders.

G.3.1. Institutional Barriers

A more detailed description of the issues is provided in paragraph G.3.3.

Institutional Barrier	Explanation	Mentioned by Stakeholder
Contracting / Warranty Issue	Arrangements between market parties could be improved. These arrangements include warranties, product performance guarantees, etc. The performance of a product is guaranteed for a period of often 25 years, while the product guarantee lasts around 5 years. This mismatch creates contracting issues to parties involved.	– ELI – Eneco BSH
Policy (in)Consistency	Dutch energy policy has been inconsistent with regard to renewable energy incentives. The policy time frame does not correspond to the timespan used when calculating investment decision. Increasing the institutional risk of investments.	– ELI – Eneco BSH – Holland Solar – Green Spread – ASN Bank – ECN – AgentschapNL
Permit Requirements	In the future an increased penetration of solar PV in the built environment may cause that building permit requirements are introduced. These should guarantee the (aesthetic) quality of the build environment and of the PV systems. In certain cases building permits need to be applied for, these requirements should be made uniform between municipalities to keep the application process efficient.	– ELI – Holland Solar – AgentschapNL
Grid Connection	There is no uniform standard for connecting PV installations to the distribution grid, different distribution grid operators use different standards. This creates confusion amongst PV installation companies.	– Holland Solar – GSU
No Domestic Market	Because of a lack of a stable stimulus package, no domestic market has developed in the Netherlands. This causes Dutch upstream companies to be competed out of the market place by foreign companies.	– Holland Solar
Vague Legislation	Sometimes it is not exactly clear when a project structure is eligible for net metering as referred to in Appendix B..	– ASN Bank – AgentschapNL

Institutional Barrier	Explanation	Mentioned by Stakeholder
Contracting / Costs and Benefits Allocation	As with Smart Grids there is an issue with the allocations of costs and benefits attributed to the installation of PV systems. Clear and fair arrangements have to be made between market parties including consumers about allocating costs.	– Stedin – Eneco SBH – ASN Bank – Green Spread – AgentschapNL
Net Metering	At the moment net metering is the only stimulation policy available to consumers. The market for solar PV systems could be increased further by increasing the applicability of this policy to VvE's etc.	– Holland Solar – Eneco SBH – Green Spread – PvdA – Stedin

Table 32: Institutional barriers for the implementation of PV in the Netherlands

G.3.2. Institutional Barrier Scorecard

Table 33, shows the scores attributed to the issues. It is interesting to see that there are many institutional issues identified by the interviewed stakeholders. However many issues are not shared among a broader group of stakeholders.

Institutional Barrier	Influence Eneco	Stakeholder Importance	Total Score
Contracting / Warranty Issue	Medium – High (2-3)	2	4-5
Policy (in)Consistency	Low (1)	7	8
Permit Requirements	Low – Medium (1-2)	3	4-5
Grid Connection	Medium (2)	2	4
No Domestic Market	Low (1)	1	3
Vague legislation	Medium (2)	2	4
Contracting / Costs and Benefits Allocation	High (3)	5	8
Net Metering	Low – Medium (1-2)	5	6-7

Table 33: Institutional barrier selection for further research

G.3.3. Institutional Barriers Explained

Contracting / Warranty Issue

This barrier comes forth from the issue between the economic lifetime of the solar PV modules and the inverter. The solar PV modules have a product guarantee for 5 years and a performance guarantee up to 25 years. However it is often unclear what the performance guarantee involves: does it mean that the panel will get replaced if its performance is less specified? This is also the case with the invertor where the warranty and sometimes the insurances cover different timespans. These two issues create confusion amongst consumers.

Eneco can take-up a large role, by for instance taking over the product guarantees or to conclude additional product insurances. However most stakeholders do not find this barrier prohibitive to the penetration of solar PV in the Netherlands. Therefore this issue is not taken into account.

Policy (in)Consistency

Many stakeholders have mentioned that policy inconsistency creates a lot of problems for the penetration of solar PV in the Netherlands. On the one hand this problem creates a situation in which consumers postpone investements and wait for better market opportunities. At the same time it prevents market parties from investing and taking risks to sell products to the market (Negro, Vasseur, van Sark, & Hekkert, 2009). Although many stakeholders perceive the current policy inconsistency as frustrating, there is little the market parties can do on a short notice. However this issue is taken further to paragraph 4.2.

Permit Requirements

In the future permit requirements may be introduced to guard, among others, the aesthetic qualities of solar PV systems. These permit requirements could pose a barrier to the penetration of solar PV. because consumers would have to apply for a building permit to install a solar PV system on their roof. Eneco can influence this by ensuring that the solar PV systems Eneco proposes are of a high aesthetic quality. At the same time, if the permit requirements are introduced Eneco can take over the permit application. Although Eneco can influence the barrier by making it less problematic for consumers in the future, they cannot influence whether or not permit requirements are introduced. Only three stakeholders have mentioned this barrier and therefore the issue is not taken into account for further research.

Grid Connection

According to the installation trade companies there are no uniform connection requirement for solar PV systems. Different DSO's utilize different standards for the connection of solar PV installations. There are some requirements that are uniform between DSO's: for example that a 600W_p installation can be connected without installing a new electricity net group. However the lack of clear standards creates higher costs for these companies. Whereas this issue is important, Eneco has little influence over the setting of standards, therefore the barriers is not taken into account.

No domestic market

Upstream companies, such as solar PV module manufacturers, have almost been competed out of the Dutch market because of the inconsistent policy, referred to earlier. This means that there are no local produced cheap solar PV systems available. This situation leads to increasing costs and a lack of certain chains in the value chain of solar PV.

Eneco has little influence over this barrier. Furthermore, whereas this issue was only mentioned by Holland Solar, the barrier is not included in the further analysis.

Vague Legislation

At the moment it is unclear between all the market parties what is allowed by law and what is not. Although the law does see explicit on certain issues, at times some project could be seen as eligible for net metering. For further analysis on this subject consult Appendix H. Examples of this vagueness is backed-up by various news articles of Energeia about net metering projects[49].

[49] A selection of these news articles can be found at: www.energeia.nl/dossier.php?DossierID=30 last queried: 1-11-2011

Only two stakeholders have brought up this issue, however Eneco can exert some influence on the matter. Eneco can exert some influence by, for example, setting up pilot project and forcing the legislator to judge whether or not this is permissible and otherwise bringing it up in court.

Contracting / Costs and Benefits Allocation

A large number of stakeholders have expressed that, in case of a solar PV proposition, the costs and benefits and responsibilities are clearly laid out in contracts. The establishment of these contracts is however a long process in which agreements and coalitions need to be forged. An important aspect is that the costs of these contracts need to be as low as possible in order to have a profitable proposition. In other words, the transaction costs need to be as low as possible (Roesink, 2011). Eneco has a substantial influence in this process, because of their current relation with the future customer as well as their information about the electricity market. Therefore, in combination with the stakeholders expressing this barrier, this issue is taken for final selection in paragraph 4.2.

Net metering

Net metering at the moment is the only stimulation measure for small consumers. A majority of the market parties opt for additional measures that stimulate the consumer market. At this moment, due to the current climate, it is however unlikely that lobbying for new stimulation measures will be successful for Eneco.

Although there are many stakeholders that want additional stimulation measures besides net metering, Eneco has little influence over this process. Although some stakeholders said (Buddenbaum & Vrijmoed, 2011; Samsom D. 2011) that they are open for suggestions on expansion of the stimulation package, this issue is not taken into account.

G.4. Process Barriers

Table 34 shows the identified process issues from the stakeholder interviews.

G.4.1. Process Barriers

In paragraph G.4.3. the issues are explained in greater detail

Process Barrier	Explanation	Mentioned by Stakeholder
Traditional Companies	Traditional (energy) companies have the issue that they are internally often slow to react to new and fast paced developments. This implies that traditional companies can miss the boat, due to internal struggle. On the other hand there is the issue that new companies are often to small and fragmented to act decisively (Arcadis, 2011)	– Eneco SBH – Green Spread
Knowledge of the Consumer and Market Parties	Consumers and at times stakeholders involved, have a limited understanding of solar PV. This means that they lack the capacity to compare quotes, have no information on market developments or they have no proper knowledge of legislation. The consumer cannot comprehend the complexity of the PV market because of conflicting opinions and various offers from multiple market parties.	– ELI – Eneco SBH – Holland Solar – Green Spread – ASN Bank – ECN – AgentschapNL
Lack of Cooperation	Cooperation between stakeholders is progressing with some difficulty. According to the ASN Bank for instance, stakeholders are concerned too much with their own benefits rather than with the benefits of the group as a whole. Better cooperation between market parties could generate large market opportunities. In a report by Arcadis (2011), it is noted that it is difficult to convince stakeholders to participate and contribute to innovative new concepts.	– ELI – Eneco BSH – Green Spread – ASN Bank – ECN – *Stedin* – AgentschapNL

Table 34: Process barriers for the implementation of PV in the Netherlands

G.4.2. Process Barrier Scorecard

Table 35, shows the scores attributed to the identified process issues. It is surprising to see that Eneco has a high level of influence on the identified process issues when compared to the financial, technical and institutional issues.

Proces Barrier	Influence Eneco	Stakeholder Importance	Total Score
Traditional Companies	High	2	5
Knowledge of the Consumer and Market Parties	High	7	10
Lack of Cooperation	Medium	7	9

Table 35: Process barrier selection for further research

G.4.3. Process Barriers Explained

Traditional Companies

Eneco and Green Spread both acknowledge that incumbent companies such as Eneco are generally slow in adapting to changing and new market conditions (Weeda, 2011; Zwang, 2011). Eneco has a lot of influence in changing the company structure to become more flexible in anticipating new opportunities. However, only two stakeholders mentioned this issue and therefore this barrier is not taken further into account in this thesis.

Knowledge of the consumer and market parties

Stakeholder have expressed to AgentschapNL on multiple occasions that they, at times, lack important information about the marketplace for solar PV in the Netherlands. They have difficulties in obtaining unbiased information about, among others, technological and institutional developments (Janson, 2011; Schootstra, Holland Solar, 2011). However, information on the solar PV market in the Netherlands is highly fragmented, looking at competition and companies active in the market (Janson, 2011). AgentschapNL attempts to solve these issues by finding ways to supply unbiased information.

Consumers face similar issues as companies do: there is too much complexity for a regular consumer to comprehend. This problem is caused by the complex business case, the coloured information available to consumers and conflicting information. The consumer is unable to judge a proposition on its merit (de Graaff, 2011; Morren, 2011; Weeda, 2011; Zwang, 2011).

Eneco can influence information provisions, because the company is seen as a large and reliable institution. Eneco can use their position in the stakeholder network to inform consumers as well as helping other stakeholders in getting a clearer picture. Interviewed stakeholders, like Weeda (2011) argued that Eneco can take an important role in this issue. Therefore, this issue is analysed further in paragraph 4.2

Lack of cooperation

Cooperation between stakeholders is difficult. According to the ASN Bank (Roesink, 2011), stakeholders are more preoccupied with realising their own benefits than with the benefits of other stakeholders. Improved cooperation between market parties could generate larger market opportunities (Roesink, 2011; Wijgerse, 2011).

By taking up a process facilitating role, Eneco can exert a lot of influence on these matters, (De Bruijn & Ten Heuvelhof, 2008). Therefore this issue is taken into account and analysed further in paragraph 4.2.