Battery Storage Systems

An exploratory business model research for high power battery storage applications in the Netherlands

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Foreword

Imagine, would it not be fascinating to store electricity in a way that far exceeds the actual possibilities?! A range of new ideas would come up in our minds. Ideas that would fit in the need for smarter grids as a consequence of more decentralized power generation and the integration of renewables and e-Cars. This dream is not so far away when we look at recent developments in batteries with increasing energy density and lowering production costs. The number of students that is nowadays active in the further development of batteries, dominantly in China and the United States of America, is so big that successes cannot stay away in the coming decade.

This future perspective of electricity storage forms the bridge and loads the spirits to this thesis about Battery Storage Systems. In a phased structure this research project tries to find answers to what the most promising business model for Battery Storage Systems in the Dutch electricity system is. The expert interviews with the different main stakeholders gives a valuable snapshot in order to answer the related questions and to design the most likely business models. It also shows that the introduction of new technologies like Battery Storage Systems cannot always be successful without adaptation of existing regulation to the changing requirements. The output as presented is an in-depth piece of work with a number of valuable recommendations. If through further developments Battery Storage Systems would come available on a substantial scale we should embrace it and make full use out of it.

To the person Randolf, I must say that it was a pleasure to work with him during his graduation period. He is well-organized, dedicated and stands open for new ideas and new approaches. The meetings we had were well-prepared and constructive with a large input from his side. He is skilful in putting his research work in a structured and readable way on paper. Randolf behaves as a sincere interested person were a sound doses of humour is part of his interpersonal communication. With what he has shown to me during his graduation period I am convinced that he will be successful in his future career and wish him all the best with that.

Jan Langedijk, Division Manager Energy Transmission & Distribution, Siemens Netherlands N.V.,

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Randolf Weterings

Rotterdam, October 2010

Executive Summary

The expectation is that different socio-economic trends will have a significant impact on the technical, economic and institutional structures of the Dutch electricity system. As a result, different solutions, applications, technologies, etc. are popping up in the Dutch electricity sector, which support this development. Literature names several important upcoming developments of which “Battery Storage Systems” is one. Therefore, in this thesis the following main research question is answered: *What is the most promising future business model for Battery Storage Systems in the Dutch electricity system?*

In order to answer this research question, five sub research questions are defined and divided among three core research phases. The first phase deals with an extensive literature / desk research phase. During this phase the relevant scientific knowledge related to business models is gathered, which is used to carry out a solid scientifically proven business model research. The leading business model literature used in this thesis is related to the scientific research of Osterwalder. Next, this phase deals with the current Dutch electricity system and the environmental forces, in order to determine the current and future system requirements. By taking the total system requirements into account acceptable solutions for all relevant actors involved can be achieved. Thereafter, the Battery Storage Systems (BSS) technology itself is analyzed, in which the technology, applications and alternative technologies are a major issue. At last, this phase ends with a value assessment in which the (future) system requirements, BSS applications and alternative technologies are valuated. The results of this assessment, most promising applications and relevant actors, are used as the basis for the following research phases.

The second phase continues current scientific research by executing an extensive field study. During this field study, executing expert interviews was the core element to gather all the relevant data required. The required data consisted of two main elements, namely validating the data gathered during the previous phase and collecting additional data for covering all the business model issues. Validating the previous phase was required as most collected data is based on case studies carried out in different surroundings. Furthermore, the interviews were set up according and in order to cover the nine building blocks of Osterwalder’s business model framework. The interviews were hold among seventeen interviewees, with a response rate of 100%. All those interviewees had a great understanding about the specific case and shared relevant and interesting information.

During the last core research phase the three most promising business models (RGO, Private and Provider) were designed and evaluated. The main difference between those business models is the usage and ownership of the BSS technology. The evaluation existed of a feasibility assessment and a comparison in order to determine the strategic fit with the current business models of the relevant actors. From this assessment it is clear that the RGO model is the most valuable future model, as it provides the most benefits for the total Dutch electricity system and actors involved. Nevertheless, this assessment also concludes that all three business models encounter different resistance when implementing in practice. The RGO model will mainly encounter resistance from the current Dutch electricity law and regulation, as storage is still unknown in those rules and guidelines. Therefore, it is highly recommended to implement storage purposes in the Dutch electricity law and regulation in agreement with all relevant actors involved, which can be a long and intensive implementation process.

List of Abbreviations

AC	Alternating Current
ACER	Agency for the Coordination of Energy Regulators
APX	Amsterdam Power Exchange
BSS	Battery Storage Systems
CAES	Compressed Air Energy Storage
CHP	Combined Heat and Power
CO_2	Carbon dioxide
C-PCS	Control and Power Conditioning System
CSP	Concentrating Solar Power
DC	Direct Current
DG	Distributed Generation
EDV	Electric Drive Vehicle
EMA	Environmental Management Act
ENTSO-E	European Network of Transmission System Operators for Electricity
EUA	European Allowances
e-program	Electricity program
G2V	Grid-to-Vehicle
IT	Information Technology, in the Netherlands and some other countries also the term ICT (Information and Communication Technology) is used for the same purpose.
MRP	Metering Responsible Party
NEa	The Netherlands Emission Authority
NEC	Nederlands Elektrotechnisch Comité
NMa	Nederlandse Mededingingsautoriteit (The Netherlands Competition Autority)
OTC	Over-The-Counter
PEST	Political, Economical, Social-cultural and Technical
PRP	Programme Responsible Party
PSR	Performance Standard Rate
PTU	Programme Time Unit
RGO	Regional Grid Operator (also called DNO “Distributed Network Operator”)
RRP	Regulating and Reserve Power
SME	Small and Medium Enterprises
SMES	Superconducting Magnetic Energy Storage
TSO	Transport System Operator
VAS	Value Added Services
V2G	Vehicle-to-Grid

Table of Content

List of figures

List of Tables

1 Introduction

This chapter provides an introduction to the research undertaken. In Section 1.1 background information related to the research is included. Then in Section 1.2 the research problem is described, which gives the research motivation. Next, in Section 1.3, the research goal and questions are included. In Section 1.4 the research method is described and guidelines are given on how the research is approached. Section 1.5 describes the relevance of the research from a scientific and managerial point of view. The last Section, 1.6, describes the outline of this thesis.

1.1 Background

Climate and Energy issues have never been so high on the political agenda all around the world as they are today. Recent newspapers related to energy topics inform us about the dynamics of how energy markets and regulations are structured and how they will change over the cause of time. At the same time those newspapers inform us about how those structures, regulations and changes affect our society. An example of a recent issue is the arrival of new players on the local energy markets, due to the liberalization and privatization of the energy supply. One of the reasons behind this development is the willingness to introduce competition in this market in order to reduce energy prices (Weterings, 2008a; de Vries, et al., 2009).

International level, an important development in our society is the recognition of climate change and, as a result, increased environmental awareness. The recognition of climate change led in 1997 to an agreement between different countries all over the world, which came to be known as the Kyoto Protocol (UNFCCC, 1997). The aim of this agreement is to jointly tackle our global problem of climate change, by reducing greenhouse gas emissions, increasing the energy efficiency and increasing the use of renewable energy sources.

Power generation is one of the main factors responsible for the pollution of our world and therefore also for a large part of the anthropogenic CO_2 emissions (IEA, 2010). While looking at the global energy demand, electrical energy covers around fifty percent of our total energy demand and is even higher when we look at individual developed societies (International Energy Agency, 2010). For this reason many sustainable energy technologies related to electricity supply, transportation and distribution are under development (Hammons, 2005; Dehen, 2009). Examples of those developments are new types of wind turbines and photovoltaic systems, carbon capture systems, storage systems (for large power plants) and smart grids. Although almost all the examples explain themselves, smart grids need a little more explanation. The purpose of smart grids is to update our electricity network by making use of IT, in order to protect our power sources from blackouts or attacks, saving money for all actors involved in the electricity value chain and enabling clean/alternative forms of energy (Hargreaves, 2009). Therefore a smart grid is defined for this research project as "*An Electricity network that can intelligently integrate the behaviour and actions of all users connected to it (generators, consumers and those that do both) in order to efficiently ensure sustainable, economic and secure electricity supply*" (Netbeheer Nederland, 2010). The United States of America takes a leading role in the technological developments related to smart grids, which has mainly to do with the technical status of their current grids. Although America has a leading position in this development, Europe and Asia are also actively taking part in this development. As most technical solutions available and developments needed are still more expensive than conventional technologies government support is needed to make them feasible, which is highly recognized and supported by many countries in the world (Ummels, 2009; UNFCCC, 1997).

At European level, the aim is to develop one single energy market within the EU. This development started a few years ago and has so far resulted in different mergers and acquisitions within the energy sector. As a result, different regulatory mandates are proposed and accepted, which have to a large extent changed the energy landscape. Within the EU retail prices are bounded, while wholesale prices are increasing. This means that (profit) margins within this sector have been tightened and therefore that current strategies and business models should be revised (Veldhoven, 2007).

At national level, the Netherlands, in 2004 the Dutch energy market was liberalized and therefore consumers can now choose their own preferred energy supplier. From that moment on competition became possible within the energy market. In 2006 a legislative debate resulted in a Dutch law called the "Wet Onafhankelijk Netbeheer (WON)" ("Independent Grid Operator"), which had to be fully implemented in 2008 (Ministry of Economic Affairs, 2010). The WON required that the grid owner and the energy supplier should be two separate companies, but they could operate under the same holding. In the same year, the ministry of economic affairs was afraid that the Dutch electricity grid would be owned by foreign companies/investors, for which the function of the grid was less important than making money. This resulted, in 2007, in what we call in Dutch the "splitsingswet" ("Unbundling law"). This law realizes complete financial and legal separation between the activities associated with the supply of electricity and the transportation and distribution of electricity. In this law supplying energy is seen as a commercial activity, but the operation activities and owning the grids are tasks for the government. The process of separating those two companies is also called "the *unbundling of the physical and service functions*", and it has to be finished before January 1, 2011 (Weterings, 2008a; Veldhoven, 2007; Wijers, 1998).

Due to all those different power sources on international and national levels the Dutch energy sector will change significantly in the next few years. For this reason the Dutch grid operators asked TNO (independent Dutch research institute) to investigate the trends and drivers of the near future (in the coming 15 years) of the Dutch energy sector from political, economic, social-cultural and technical (PEST) points of view (Netbeheer Nederland, 2010). The PEST analysis used by TNO is visualized in Figure 1 and the main (combined) results of their research are enumerated below:

Figure 1: PEST analysis (provenmodels.com, 2010)

- Increasing dependency on electricity and therefore a greater certainty of supply;
- Increasing need for cost efficiency;
- Increasing need for energy savings;
- Increasing amount of renewable energy sources connected to the electricity grid (including decentralized) and becoming less dependent on fossil fuel sources;
- Providing of new services, due to the open energy market (including new business models);
- Managing the grid smarter (smart grids), due to the introducing of IT (but therefore increasing the complexity);
- Stimulating innovation;
- Entry of new players onto the market;
- Need for sustainable technologies;
- Aging of different physical parts of the electricity grids.

Within this changing environment, several innovative technologies, applications and services are emerging, that will contribute to the above trends. Examples are smart energy meters, electric drive vehicles, Graphical Information Systems, Battery Storage Systems, wireless services, etc. Due to all those changes and their uncertainties, the Dutch energy sector can be characterized as a dynamic market in which future responsibilities and the roles of all the actors involved are highly dynamic and uncertain.

Battery Storage Systems, which enable electricity storage to take place at almost every physical location, are considered to have a significant impact on the energy (electricity) sector and the large-scale implementation of renewable energy sources (Lindley, 2010; Xueqing, 2009). This technology enables a new service in which we can store electricity more easily and therefore can create flexibility in the electricity supply and demand. As the current strategies and business models of all actors involved in the energy value chain are designed for matching "real-time" electricity supply and demand, significant impacts on those strategies and business models are expected. The important question that arises is "*What is the most promising future business model for Battery Storage Systems in the Dutch electricity system, and what are the related implementation barriers?"*. From a governance point of view, the introduction of this (radical) technology has significant consequences for the current technical, economic and institutional structures.

Battery Storage Systems (BSS)

Battery Storage Systems (BSS) provide promising opportunities for the electricity sector, although it is still unclear who is going to benefit from this and who not. So far, it is expected that BSS can improve the performance and reliability of the power systems and to increase the profit margins of wind farm owners (Divya & Ostergaard, 2009). If we want to have a significant share of our energy sources completed with renewable energy sources, research indicates that storage is needed (Lindley, 2010; Divya & Ostergaard, 2009). Today, we are obligated to provide a steady supply for a constantly varying demand, due to the lack of good storage options. The supply has to be arranged by adjusting the output of coal and gas fired plants, which is very costly and inefficient. With the increasing need for renewable energy sources, for which their output is highly unpredictable, supply-based strategies have become less viable (Lindley, 2010).

A number of different energy storage technologies already exist, for which pumped storage hydroelectricity and compressed air are the two best known and most frequently applied storage technologies in the electricity sector. Those two technologies are very dependent on location and landscape and are therefore limited applicable. BSS has some unique features compared to the other storage technologies, for which the most important ones are the independency of location and landscape, the relative small size, low weight and high energy density. Due to the unique features of each storage technology there will not be one best technology, although the market for BSS technologies seems to be one of the largest (Lindley, 2010). Especially in the Netherlands where no high mountains for pumped storage hydroelectricity exist and where space is very limited for compressed air purposes.

Although the importance of BSS is recognized we still only find a limited amount of those installations in practice. There are two reasons for this, namely (1) lack of practical experience and (2) it is very difficult to distinguish the economic gains as current electricity generation (in current settings) can be adjusted relatively easily to the load demands. As already explained, this scenario is changing, due to the introduction of renewable energy sources on a large scale. As an example the goal in Denmark is to supply 50% of the total energy supply from wind power by 2025, which is an improvement of 30% compared to the situation in 2010 (Divya & Ostergaard, 2009). The Netherlands has the objective to decrease greenhouse gas emissions by 30% in 2020 and to increase the total amount of energy supply from renewable energy sources from 2% to 20% by 2020 (Ministry of Housing, 2010; Financieel Dagblad, 2010).

The challenge for (new) actors in the electricity sector lies in how to allow BSS to enter the current electricity value chain in order to gain a competitive advantage. A competitive advantage can be realized by using one of the three generic strategies, namely volume, efficiency (also called focus) and differentiation in order to enhance the value chain (Porter, 1985). The value creation model is visualized in Figure 2. Harrison (1999) describes the strategies of utility companies which can be divided into three main categories: (1) increasing operational efficiency and therefore reduce prices, (2) delivering unique value added services (VAS) and (3) being smarter than competitors in affinity marketing and branding (Harrison, 1999). Although Porter describes operational efficiency as a managerial task, which cannot be a strategy in itself, the purpose of reducing prices can be compared to strategy cost leadership (efficiency) (Porter, 1996). BSS technology provides the most opportunities to add value to the first two strategies of Harrison, which can be compared with the cost and differentiation strategies of Porter. The technology BSS in itself cannot provide a sustainable competitive advantage, but the service and the integration of this service into the business processes can, as explained in Chapter 2.

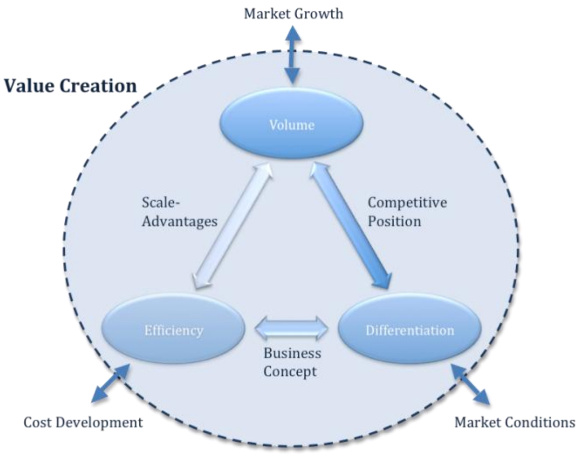

Figure 2: Value Creation (Hartigh, 2009)

Due to its great extent, the lack of electricity storage systems results in high costs for managing the electricity network. For this reason energy suppliers have laid down long-term (future or bilateral) contracts with energy producers in order to assure continuous supply. In the Netherlands since 1999, electricity can also be traded on a spot market (Wals, 2001). The spot market in the Netherlands is called the Amsterdam Power Exchange (APX). On the spot market energy suppliers can buy in or sell their electricity 24 hours in advance, as it is impossible to predict the precise amount of electricity that is needed. Selling and buying electricity on the spot market is significantly higher than what is agreed on in the long-term contract. Next to those expensive forecasting errors, reducing peak loads is also very attractive from a technical, economical and environmental point of view. From a technical point of view, the electricity grids should be designed to sustain the highest load that may occur. From an economical and environmental point of view, running on high or full capacity (energy providers) means that extra fuel or providers are needed in order to meet supply, which is very expensive and produces the most CO_2 pollution (Deconinck, 2010). The expectation is that managing the network load more efficiently by making use of storage, especially in combination with an increasing use of unpredictable renewable energy sources, significant savings can be made (Veldhoven, 2007; Lindley, 2010).

1.2 Research Problem

In connection with the environmental goals set by the government and the technical development of Battery Storage Systems (BSS), new opportunities are arising in the electricity sector. Despite all the environmental and economic benefits and the large amount of R&D (investments) that is still needed, a major concern is how this technology will affect the main actors in the electricity sector. As this technology and its value-added services (VAS) are still in the development phase, existing actors in the electricity sector are mainly concerned with how this technology and its services can increase their competitive advantage. A second concern is how this technology and its services will attract new competitors and therefore also a tougher competition.

Although the expectation is that BSS will provide several opportunities for feasible business cases, at first with subsidies as in the United States (Walawalkar & Dann, 2009), implementation is still limited due to the lack of practical experience and the difficulty in distinguishing economic gains (Divya & Ostergaard, 2009). A major difficulty lies in the fact that revenues, provided by the electricity storage services, are highly dependent on future developments and directions.

It is very difficult to predict the demand for BSS technology, as BSS can be defined as a High-Technology innovation. High-Technology innovation is defined as a high level of technological uncertainty, market uncertainty and competitive volatility (Mohr, et al., 2005), which is definitely the case for BSS. Furthermore, High-Technology innovation is mostly associated with a high level of up front investments. This hampers the development process, since economic gains are difficult to predict. It is therefore also difficult to predict how long the innovators and early adapter phases of the diffusion of innovation processes will take. After the early adaptors, but before the early majority phase, one of the most difficult questions arises, namely “Are we able to cross the chasm?”. Crossing the chasm is important if a majority needs to be achieved in order to recover up front investments, as visualized in Figure 3. Nevertheless, other countries such as the U.S. and Denmark already have some experience with defining the needs for BSS technology (Lindley, 2010; Divya & Ostergaard, 2009; Walawalkar, 2008; Gilmore, et al., 2010). From the experience gained by those countries lessons can be learned for the specific case of the Netherlands.

In scientific literature the success of a new technology is dependent on how technology and economics is brought together (Chesbrough, 2009; Magretta, 2002; Rosenbloom & Chesbrough, 2002; Gordijn & Akkermans, 2007; Rosenbloom & Chesbrough, 2002). Therefore business and technology aspects should be aligned. Understanding this, it is very important to tackle problems related to BSS with a multi-viewpoint approach with respect to technology, business and organizations. The success of the implementation of the BSS technology, in order to meet the requirements, is therefore mainly dependent on the business models and strategies of the actors involved. The structure between technology, strategy and business models will describe how actors can increase their competitive positions. As a result, the research problem outlined in this thesis focuses on adding value to the knowledge on how technology, strategy and business models should be intertwined in order to build a sustainable business or service for BSS in the Dutch electricity sector.

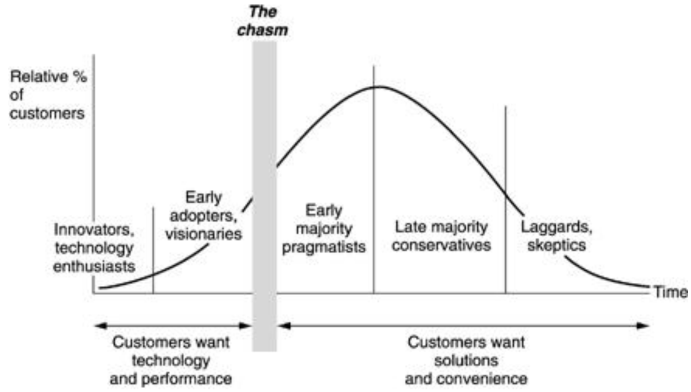

Figure 3: The change in customers as a technology matures (Massachusetts Institute of Technology, 2010)

1.3 Research goal and questions

The above introduction indicates that Battery Storage Systems (BSS) can provide very good solutions for the problems of the future Dutch electricity system. Although many discussions of decentralized solutions can be found in literature, the integration of technical, institutional and economic issues are often disregarded. Therefore, the aim of this research is to design and review the most promising business model for BSS in the Dutch electricity system, by taking technical, institutional and economic issues into account. With “most promising” we mean the business model that satisfies the (future) system requirements of the complete Dutch electricity system to a maximum extent, and therefore taking win-win situations of all relevant actors involved into account.

The main research question of this research project, in order to achieve the above goal, is formulated as follows:

What is the most promising future business model for Battery Storage Systems in the Dutch electricity system?

To achieve the research goal and therefore answer the main research question, five sub research questions are formulated and described below. The research framework is visualized in Figure 4, on page 8, for which each research question is linked to a chapter.

In the first stage, the target is to understand what competitive advantages are and how they can be realized by making use of technology development. The emphasis for answering the first sub-question is on existing, relevant and accepted scientific literature related to competitive advantages on a strategic and business model level. The answer on the first sub-question provides the fundamental knowledge needed for carrying out the research project and therefore understanding what to investigate. The first sub research question is formulated as follows:

Sub-question 1: *"What is the current available knowledge regarding business strategies and models, and what is the role of technology in this knowledge domain?*

Thereafter, the purpose is to get a clear overview of how the electricity sector in the Netherlands is organized and to gain knowledge about the environmental forces. The first step is defining the current Dutch electricity sector from a technical, institutional and economic perspective. An important element here is the understanding of the actors involved in the Dutch electricity system and which role they perform. Next, the environment needs to be investigated in order to understand which forces are pushing the current Dutch electricity system towards future developments. Based on this analysis the current and future system requirements can be determined. Therefore, the second sub research question is formulated as follows:

Sub-question 2: *"How is the current electricity system in the Netherlands organized, which forces are restructuring the system and what are the system requirements of the current and future Dutch electricity system?"*

The knowledge gained by answering this question gives insight in how Battery Storage Systems can provide value towards the actors involved and to the electricity system as a whole. In the next stage, the technology BSS will be investigated from a technical point of view. This will give a clear understanding of what the technology entails and which future developments are expected, in terms of opportunities. Thereafter, the applications that can be carried out with this technology will be investigated, as unique applications can result in competitive advantages. At last, the competitive technologies should be investigated in order to understand which applications could better be performed with other technologies. Based on this knowledge, a value assessment will be executed in order to determine the most promising applications and the related actors. Therefore, the third sub research question is formulated as follows:

Sub-question 3: *"What are Battery Storage Systems and what makes this technology unique and attractive for business purposes in the Dutch electricity system?"*

An important aspect of the success or failure of a new technology is how it supports or resists the strategies and business models of the strongest forces in the sector and its environment (Lewis & Seddon, 2003; Shafer, et al., 2005). As the available literature, related to BSS, is primary based on case studies carried out in Denmark and the United States of America, not all findings are valid in the Dutch electricity system. The primary reason is that the surrounding, the system itself, is organized completely different among those countries. Therefore, we should partly validate and collect the required data for the specific case in the Netherlands. As a result, the fourth sub research question is formulated as follows:

Sub-question 4: *"How does the Dutch electricity industry criticize this technology development and what are the critical business model design issues?*

On the basis of the information gained from the previous questions, the last sub research question aims at designing the possible business models. First, the current strategies and business models of the relevant actors needs to be analysed, in order to understand their current position in the market. Then, the new business models should be designed in which the most promising applications is the main focus. As the business model design does not take the current position of the actors involved into account, the last step must be a value assessment. This value assessment determines the potency and implementation barriers of each model in practice, in order to determine the strategic fit between the new business models and the current position and models of the actors involved. Therefore, the last sub research question is formulated as follows:

Sub-question 5: *"What are the possible business models, which one is the most promising from a technical, institutional and economic point of view and what are the related implementation barriers?*

Once all the answers to the sub research questions have been evaluated, we must then be able to answer the main research question. The research process, deliverables (chapters) and how the research questions are linked to each other is included in the research framework, given in Figure 4 below. An important aspect of this framework is that it supports the research structure, helps to establish a theoretical background and provides support by setting the boundaries of the research project. Furthermore, this framework serves as a communication tool for all parties involved in the research project and it breaks down the main research question in manageable pieces.

The horizontal arrows indicate the step that has to be taken in order to answer the sub-research question and is discussed in a separate chapter. The vertical arrows indicate which knowledge is needed in order to fill the knowledge gap stated in the sub-research question and serves therefore as an input for the horizontal arrows. As a result, the blocks indicate the knowledge domain required for answering the sub-research question or indicates which knowledge is gained by answering the sub-research question. The blue arrows indicate the research phases described in the next section.

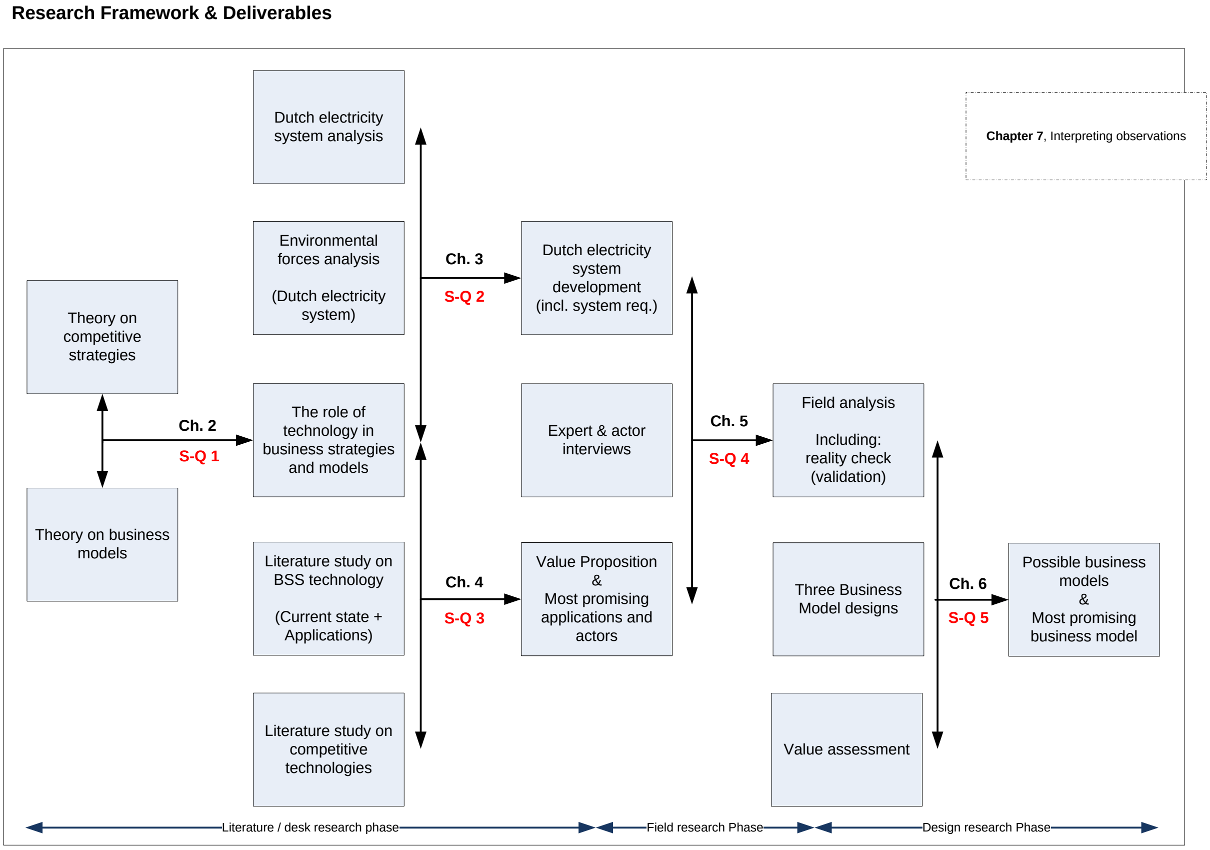

Figure 4: Research Framework & Deliverables

1.4 Research methods

The foundation of this research is based on exploratory research, which provides insights into and comprehension of a specific situation. Within this research, the specific situation is implementing Battery Storage Systems in the Dutch electricity system. Therefore, this research can be described as an intensive study within the total, natural surroundings, for which the appropriate research method is a case study (Velde, et al., 2004). Furthermore, it is important to understand that choosing a case study means that the research undertaken can only be generalizable to theoretical propositions and not to universes or populations. Therefore, the final conclusions are only valid within the determined natural surroundings, namely the Dutch electricity System (Yin, 2009). As a result, the conclusions drawn in this research are based on analytical generalization.

In order to get the most out of this case study research, this research project is divided into five logical research phases. Each phase is explained into more detail below and illustrated in Figure 5.

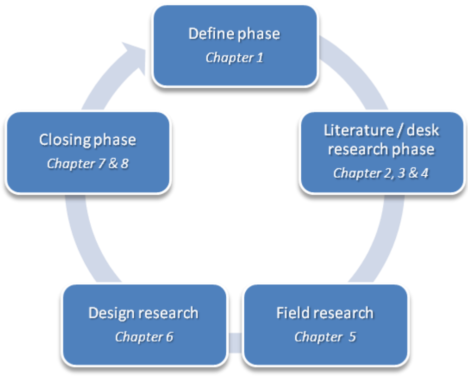

Figure 5: Methodology

1. Define phase

The first phase of this research project is defining the research project itself, which mainly consist of the research background, problem, goal, questions and methods. The research problem is based on a practical problem recognized by Siemens Nederland, who has indicated the need for a scientific approach. Therefore, the first step in this phase is to determine the scientific relevance and align the practical problem with the theoretical problems. The scientific fit of the practical problem is mainly determined by investigating accepted and relevant scientifically literature. As a result, the research questions are defined and the research is setup on the basis of scientifically proven research methods.

2. Literature / desk research phase

The second phase, answering sub research question 1, 2 and 3, is primary based on an extensive literature / desk research. The purpose of this phase is to collect all the relevant published knowledge, in order to expand this knowledge in the next phases. The type of literature used in this research phase depends on the knowledge domain and sub research questions that needs to be answered. For the first sub research question existing, relevant and accepted scientific literature related to competitive advantages on a strategic and business model level is used and validated with an interview with M. Zegveld (appendix B). For the second sub research question the primary information used is based on accepted scientific literature related the Dutch electricity system and supplemented with literature published by reputable organisations and professional magazines. The third research question is primary based on literature published by professional magazines and laboratories and supplemented with scientifically accepted literature related to the BSS technology. At last, this phase ends with three decision matrixes, which are filled in by the researcher on the basis of the knowledge gained during this phase. The decision matrixes are needed to narrow down the relevant business model input for the next phases.

3. Field research phase

As a large part of the primary information gathered in the previous phase is based on case studies carried out in different surroundings, this phase has two objectives. The first objective is to validate the collected data for the specific case in the Netherlands, which is not done before and therefore adds already a significant value to the scientific community. The second objective is to gather specific additional data, which is needed to cover all the business model design issues provided by Osterwalder (2010). This phase answers sub research question 4.

4. Design phase

The purpose of this phase is to design and review the actual business models, based on the deliverables and information gathered in the previous phases. Nevertheless, this phase starts with an analysis of the current business models and strategies used by the most important actors involved. For this analysis the only data source used are the latest annual reports of the relevant organisations. Next, the different business models are designed on the basis of the most promising applications of BSS. At last, this phase ends with a value assessment in which the different business model designs are reviewed in an extensive value assessment. As a result, this phase aims at answering sub-research question 5.

5. Closing phase

The last phase closes the research project, by providing conclusions (including answering the main research question), recommendations and a reflection. The main research question is answered with the answers provided by the five sub research questions. Furthermore, the aim of this phase is to hand over the main deliverable (thesis) and closing down the research project with a final presentation.

1.5 Research Relevance

The overall aim of this research is to add value to both the scientific community and to managerial knowledge that can be applied in practice. The scientific value of this research is mainly that technology (including its value added services), (corporate) strategy and business models should be intertwined in order to build a sustainable business or service in the electricity sector. By focussing on the electricity sector attention will be paid to the multi-actor context, which makes it extra attractive from a scientific point of view, due to its complexity. Next, the technology chosen for this research will pay attention to supporting renewable energy sources in the most efficient way, e.g. by storing electrical energy coming from renewable energy sources in the case of overcapacity. As a result, the energy consumption provided by fossil fuel sources can be reduced, which is good for society as that helps to reduce energy waste and CO_2 pollution. Furthermore, the research approach itself is also scientifically relevant, which provides guidelines for similar and further research.

Although the theories, frameworks, models and approach that are used for this research are derived from fundamental science, the deliverables are based on a practical case. The deliverables are presented in Figure 4 on page 8. On the basis of this specific case, the practical/managerial value of this thesis is supporting managers, leaders and entrepreneurs with their strategic decisions in relation to energy storage in the electricity sector and the usage for smart grids. This thesis will give those managers, leaders and entrepreneurs insights into technical, economic and institutional movements, due to the introduction of (small) energy storage in the Netherlands.

1.6 Report structure

The outline of this thesis is organized in order to study and answer the proposed main research question. The chapters are therefore linked to the deliverables, as illustrated in Figure 4 on page 8. This section provides a brief overview of the chapters and their context.

Chapter 1 gives an introduction to the research topic and the research approach. *Chapter 2* provides the fundamental strategic management knowledge needed for carrying out the research project and therefore understanding what to investigate. *Chapter 3* describes the Dutch electricity system and its environment from a technical, economic and institutional point of view. *Chapter 4* provides an in-depth overview about the technology Battery Storage Systems (BSS), its applications and the available alternative technologies. Next, a value assessment is included to determine the most promising applications and actors involved. *Chapter 5,* describes the field (interview) research approach and the main results of this field research. *Chapter 6* gives the designed business models and a value assessment in order to determine the most promising business model. *Chapter 7* provides the conclusions and recommendations in which the main research question is systematically answered and the main findings, research limitations and recommendations for further research are included. *Chapter 8* includes a reflection on the research undertaken and shares the main lessons learned with peers.

2 Literature review: The role of technology in business strategies and business models

The purpose of this chapter is to identify the role of technology in business strategies and business models, by making use of existing scientific literature. First, in Section 2.1, an introduction to the scientific literature related to competitive advantages and the position of strategy and business models in organizations are described. Next, in Section 2.2, the business evolution is described which distinguishes the importance of the environment. The primary literature used for this section is based on the research of Asseldonk (1998). Thereafter, in Section 2.3, the role of technology in business strategies is analysed. In this section, the four generic models related to strategic management are used as the basis of where strategy can consist of. The main literature used for this section is based on the scientific research of Zegveld (2006). Then in Section 2.4, business models and the role technology has in business models is analysed. For this section and thesis, a choice has been made for the generic business model of Osterwalder (2004), because this business model has a solid scientific foundation and is recognized by many experts in the professional and business environment. Finally in Section 2.5, the main findings and results of this chapter are summarized. Furthermore, in order to enhance the reliability and validity of this literature study, a validation has been executed by interviewing M. Zegveld. The validation interview is included in appendix B.

2.1 Introduction

The business landscape is changing rapidly and as a result companies cannot succeed anymore with only an outstanding technology. Technology should be integrated in the business strategies and models in order to become and stay successful in highly dynamic and tougher competitive markets. Rapidly changing environments have led to an increasing economic uncertainty, which make today's business decisions very difficult and complex. In this hostile business environment companies should be able to manage business uncertainty and react to rapidly changing markets. Courtney, Kirkland and Viguerie (1997) explain uncertainty by distinguishing four levels of uncertainty, which they relate to the level of complexity. Complexity is the level of diversity and interactions between human beings and their technologies (Hodgson, 2003). The four levels of uncertainty, including their explanation, are included in Figure 6 and should be taken into account when developing business strategies and models.

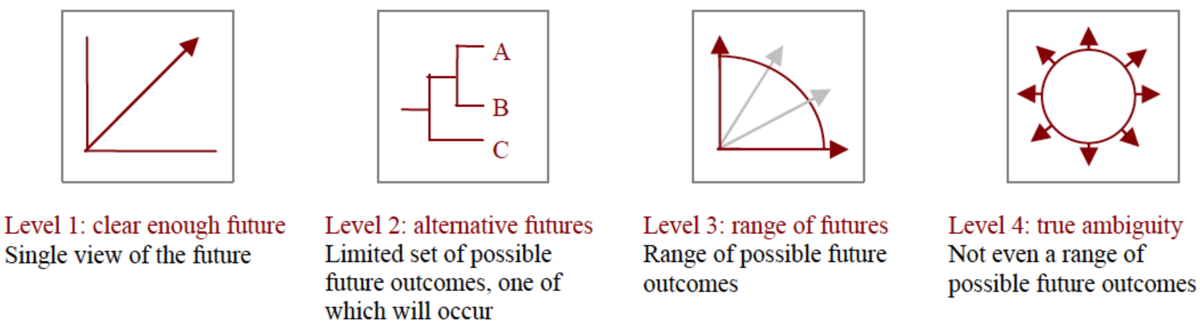

Figure 6: The four levels of uncertainty (Courtney, et al., 1997)

In the last decades technology and science have experienced an extraordinary progress and at the same time the need for services have increased significantly (Osterwalder, 2004). As a result innovations and technology changes have become a major issue in designing strategies and business models in order to gain competitive advantages. Nevertheless, rapidly changing environments, technology change and increased competition in many industries have led to shorter life cycles of products, processes, production, structural makeup's, etc. and therefore decreased the lifetime of competitive advantages. Next in today's climate, competition becomes more knowledgeable and therefore it is best to assume that most business models, even if they are highly successful, will gain only a short lifespan. Although technology change and its application(s) should be integrated in the strategy and business models of the organization, the opposite is also possible. In this case technology developments are organized in order to reach strategic goals. Therefore the success and acceptance of technology changes is highly dependent on strategic decisions related to business strategy and models.

A competitive advantage determines the position of a company in a competitive business landscape and allows the company to gain higher revenues than its costs (Investopedia, 2010). Gaining a competitive advantage can be realized by implementing a value creating strategy that is not being implemented by any competitor. In order to make this competitive advantage sustainable, it must be very difficult for competitors to copy this value creating strategy (Barney, 1991). In scientific literature (sustainable) competitive advantages are mainly explained by strategy and business model theories, for which the business model theory is a relatively new domain of study (Osterwalder, 2004; Porter, 1985). Although every organization has a strategy and business model, until recent years the complexity of doing business and the increased costs related to exclusive technology uses has increased the need of clear integration and understanding of technology, strategy and business models (Chesbrough, 2007; Osterwalder & Pigneur, 2010).

Figure 7: Business Layers (adapted from Osterwalder 2004)

In order to understand what the position of strategy and business models are in organizations a multi-layer approach provides more clarity. Osterwalder (2004) distinguishes three business layers, which are included in Figure 7. The top layer is the strategic layer and defines the planning level of an organization. On this level strategic decisions related to the planning of achieving business successes are made. The second (middle) layer is the business model layer, which translate the strategic decisions into money earning logic. This means that the output of strategy is defined as the input for business models and therefore business models can be described as a blue print of the business strategy (Lewis & Seddon, 2003; Shafer, et al., 2005). Defining strategies and business models should be an iterative and ongoing process, which is never complete. Therefore, the process of developing strategies towards business modelling can be recognized as the managerial equivalent of the scientific method. Based on the strategies, hypotheses should be designed and thereafter those hypotheses should be tested in practice. Next, the results should again be used as an input for strategic development (Shafer, et al., 2005; Magretta, 2002). Finally, the lowest layer is the process layer and defines the complete chain of all business related activities. In this layer the money earning logic is translated into business processes on an operational level.

2.2 Business evolution

An important element, that determines the design space for strategy and business model development, is the environmental forces. For this reason this section defines first the most important aspects of the environment related to strategic choices, before diving in depth into strategies and business models.

Hrebiniak and Joyce (1985) distinguished the relation between strategic choice and environmental determinism and concluded that each element is insufficient on its own. Choices should be a cause and consequence of environmental influences for which adaption determines the success of an organization. Although both elements are highly dependent on each other, the magnitude of each element determines the position and design space of an organization or industry (Hrebiniak & Joyce, 1985). The environmental determinism can result from different micro and macro environmental forces. Micro environmental forces include customers, competitors, suppliers, intermediaries, etc., while macro environmental forces include governments, cultures, technology changes, social and institutional environments, etc. Those different environmental forces have led to four different phases in the business evolution process (Asseldonk, 1998). Those different phases should determine the strategic direction an organization or industry should take.

Asseldonk (1998) explains the four phases of the business evolution process by a 3 x 3 matrix, which is in 2009 slightly adjusted by den Hartigh in a 4 x 4 matrix. The 4 x 4 matrix is included in Figure 8. The horizontal axis represents the different value drivers (see Section 2.3) of which a strategy can consist of and the vertical axis characterizes the different phases of the business evolution process. Each phase has different characteristics and therefore requires different strategies, business models and underlying business processes. The first phase in which an organisation (or industry) can position itself is the capacity phase. The capacity phase consists of organizations with the simplest organizational structures and therefore is resource-based only. Those organizations merely provide expertise, infrastructure capabilities or raw materials, without adding too much added value to those basic inputs. The only added value created by those organizations is the high volume, which they can retain as long as demand exceeds supply (e.g. for oil). At the moment in time when supply starts to exceed demand the organizations are forced to reduce their cost. Those forces result in a volume and efficiency focus, which drive an organization towards the industrial homogenous phase (started between 1820 and 1900). The characteristics of the industrial homogeneous phase enable organizations to re-use expensive parts of their value chain. This phase is therefore mainly driven by

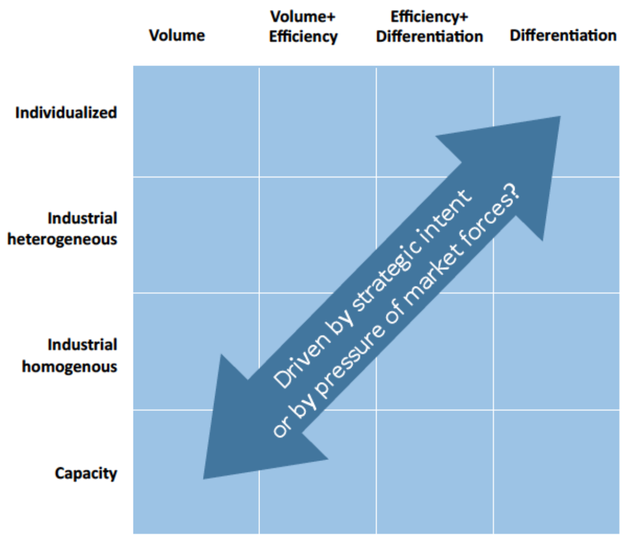

Figure 8: Business Evolution (Hartigh, 2009)

economies of scale, as large volumes quickly increase productivity. The organization in this phase is divided into different departments for which employees can focus themselves on their own expertise. The third phase of the business evolution is the industrial heterogeneous phase (started between 1930 and 1950). This phase combines the value drivers efficiency and differentiation. While looking at the car industry, in the previous phase it was only possible to produce one single product in mass production (cars in only in one colour, one motor type, etc). In this phase different products (cars in different colours, different motors, etc) can be produced with the same production facilities. Nevertheless, in this phase different settings follow a sequential process, e.g. producing only red cars the first week and the second week only blue cars, etc. In order not to lose economies of scale organizations in this phase integrate the whole variety of products into one production line, for which the production line is flexible (to some extent) in switching product series. The last phase of the business evolution process requires tailored products in mass production form and therefore satisfy a variety of different individual client needs on a large scale (e.g. the car industry of today). This phase is also called mass-individualization or mass-customization and is made possible mainly through IT. This phase started around 1990 and was recognized for the first time by Pine II in 1993 (Pine II, 2010). In order to fulfil the requirements of this phase a high level of innovation in all business activities is required. Although companies in this phase still gain advantages of economies of scale, the primary focus is on economies of scope. Advantages of economies of scope enable organizations to increase their prices, in order to recover the increased costs (as presented in Figure 9). During this phase, an organisation should switch its attitude from a "make-and-sell" attitude towards a "sell-and-respond" attitude. This attitude includes a switch in mindset, namely from product orientation towards service orientation. A service orientation enables companies to flexible adapt and respond to customer wishes (Asseldonk, 1998).

The business evolution theory defines the phases in which an organization or industry can or must position itself. The position or the evolution towards another phase in the business model evolution process can be driven by strategic intent, environmental forces, or by both. Understanding the phase in which a company or industry is positioned gives an important understanding about the environmental forces and the customer needs, wishes and expectations. Understanding external forces and the customers are two of the most important elements in developing and understanding strategies and business models.

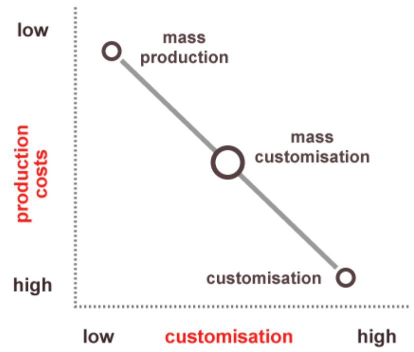

Figure 9: Mass customization (Pine II, 2010)

2.3 Strategy

Especially in the area of rapidly changing technology environments, technology and strategy should be intertwined. While looking at the business evolution theory, technology becomes increasingly important on a strategic level. Nevertheless, strategic management studies, related to corporate strategy, are very limited in approaching technology in strategic models (Zegveld, 2006). In this section the role of technology in (corporate) strategy models is explored, by focussing on the four dominant generic strategy perspectives recognized by Zegveld (2006). Those four generic perspectives are illustrated by Figure 11 and explained below after providing a definition for strategy.

Since strategy was defined for the first time the definition has changed a lot and even today a large number of different definitions of strategy are available (Zegveld, 2006). Although the existence of those different definitions, most definitions have in common the importance of the environment and how to deal with long-term survival (Romme, 1992). As a result corporate strategy is generally concerned with fitness, adaptability and vision of an organization, as given by Figure 10. Fitness (also called health) deals with different internal aspects as knowledge, competencies, resources, financial values, etc. for which a fit has to be found with the companies business. The second aspect, adaptability, deals with how companies adapt to internal and external forces and as a result the process of learning. The last aspect, vision, includes the long-term view of how the company should or must develop. In order to provide a definition for strategy, the definition provided by Scholten (2009) is chosen, as this definition is recognized and shared among different experts.

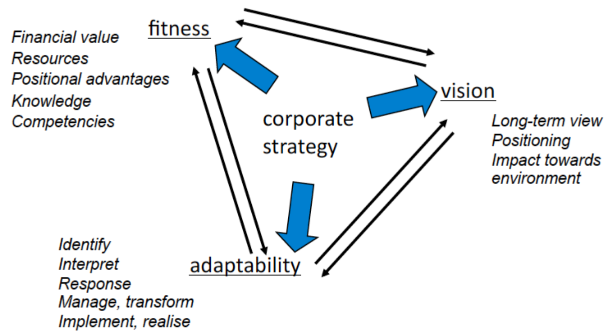

Figure 10: Corporate strategy (Scholten, 2009)

Strategy

"Strategy is about maintaining a dynamic strategic fit between the external environment, internal resources and capabilities in order to achieve a sustainable competitive advantage."

Scholten (2009)

The four generic strategy perspectives result from different schools that approach strategy differently. Although literature provides different perspectives, assumptions and views on strategic management, three clear reference points can be recognized. Those reference points are external (or outside-in approach), internal (or inside-out approach) and time (static or dynamic). As a result the four generic models are disposed against those three reference points in Figure 11. Although those perspectives provide a clear strategic development process in practice strategic decisions will never result from only one perspective (expert consultation, included in appendix B). Therefore it is important to understand what the role of technology is or can be in all four perspectives.

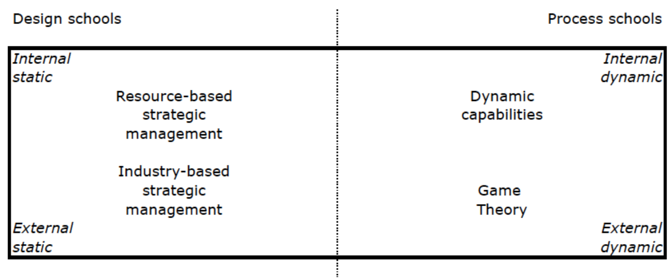

Figure 11: Position of the four generic perspectives of strategic management (adapted from Zegveld, 2006)

The outside-in orientation covers the Industry-based strategic management (external static) and game theory (external dynamic) perspectives. Those perspectives approaches strategy from the outside-in and therefore focuses on trends and industry, economic and market forces. Those external forces determine the attractiveness of the industry for long-term profitability and the relatively competitive position of the firm within that industry (Porter, 1981; Porter, 1985). The aim of this orientation is to establish a profitable position against the forces that determine the industry competition, by taking actions and reactions of all players into account. Within this orientation the profitable position is not a function of the organizations output (e.g. product, service, etc), but of the structure of the external environment. Therefore environmental determinism determines the strategic choices an organisation should take. Nevertheless, strategic decisions will influence the external environment as other players (e.g. competitors) will react on those decisions. According Brandenburger and Nalebuff (1995) strategic decisions should be made in order to realize win-win situations for all players included in their value net. Since a lack of trust, information, etc. influences strategic decisions the best outcome for all players is often not realized in practice (Brandenburger & Nalebuff, 1995). Within this orientation technology itself is treated as an unnecessary and incremental factor for successful strategy. Technology is always a consequence of business development and opportunities, which are driven by external forces. As a result, technology (development) is seen as a supporting factor that improves the competitiveness of the organization and is therefore limited and indirectly important (Zegveld, 2006).Within this orientation technology is a functional component that does not belong to the core of the strategy process itself.

The inside-out orientation includes the resource-based strategic management (internal static) and dynamic capabilities (internal dynamic) perspectives. Those perspectives stresses the firms resources as their key source for gaining (sustainable) competitive advantages. Therefore those resources determine the outstanding performance and performance difference between firms in the same industry. Those resources can be tangible, intangible or a combination of both (Barney, 1991). According Hamel and Prahalad (1993) the main source of gaining (sustainable) competitive advantages is the ability to bridge the gap between opportunities and performance. This includes the ability to develop skills and respond to changing opportunities. The firm's ability to build, integrate and reconfigure competences in order to adapt and respond to rapidly changing opportunities is called the dynamic capabilities of the firm (Teece, et al., 1997; Eisenhardt & Martin, 2000). The dynamic capabilities should be developed faster than the competition in order to sustain competitive advantages. Nevertheless, those perspectives describe that gaining competitive advantages can only be gained with strategies that are not being implemented by competitors and are extremely difficult to copy. Within this orientation, technology (development) itself can play a significant role in developing corporate strategies. Technology (development) is treated as a competence and capability in order to gain (sustainable) competitive advantages (Zegveld, 2006). Nevertheless this does not mean that all technological assets are automatically relevant on a strategic level.

Technology (development) is treated totally different between the outside-in and inside-out orientation. Within the outside-in orientation technology development or adaption is a cause of external forces, while within the inside-out orientation technology is treated as the basis of strategic decisions. Nevertheless, technology alone has in both orientations no value. The main value creation and capturing results from its applications and the context of those applications. Therefore the applications determines the possibilities and magnitude of gaining (sustainable) competitive advantages and not the technology itself (Zegveld, 2006). A more detailed description of all four perspectives is included in Appendix A on page 109.

2.4 Business models

The second business layer is the business model, which translates the strategic decisions into money earning logic. Business models can be described as the blueprint of the firm's corporate strategy, for which the development process should be an iterative process. The business model of a firm should adapt to strategic decisions and the corporate strategy should adapt to experiences of business models in practice. As a result, a strategy and business model development process is an ongoing and iterative process. Since the existence of organisations, business models are a key part of doing business, although the term business model is a relatively young phenomenon. The complexity of doing business has introduced the term "business model" and has become increasingly important during the Internet hype at the beginning of this millennium (Osterwalder, 2004). Before that time business models were also part of organisations, but the structure was relatively easy and therefore not worth describing in-depth. Figure 12 and Figure 13 gives an indication of the amount the term "business models" are used in news articles and scholarly journals during the past years and indicates the increasing interest of business models.

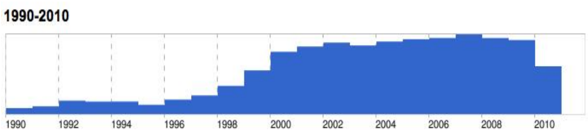

Figure 12: Google News Articles Search "Business Model" (02-05-2010)

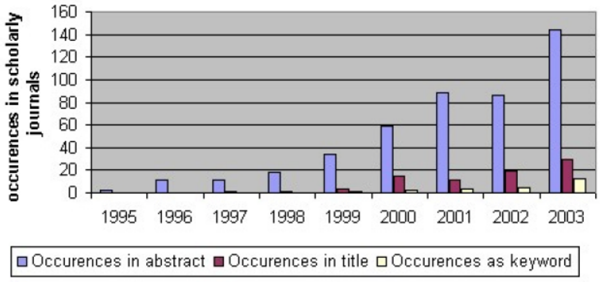

Figure 13: Occurrence "Business models" in scholarly journals (Osterwalder, 2004)

Although business models became increasingly important during the past years, the term business model was primary used by journalists, business people and academics. As a result different definitions can be found in scientific literature, e.g. (Applegate, 2001; Hawkins, 2001; Magretta, 2002; Timmers, 1998). Osterwalder (2004) recognized the problem of emerging business model definitions and started his PhD in understanding what business models are and developed the business model ontology. Nevertheless, Osterwalder was not the only academic who developed a business model theory (e.g. STOF-model (Haaker, et al., 2008)). As the business model ontology developed by Osterwalder is based on a solid scientific foundation, proven for the electricity market, suitable for multi-actor environments, universally applicable and is accepted by many scientists and business people in scientific and professional environments, for this thesis the business model theory of Osterwalder is chosen. Osterwalder (2010) defines a business model as follows:

> ***Business Model***
>
> *"A business model describes the rationale of how an organization creates, delivers and captures value."*
>
> Osterwalder (2010)

Business models are of primary interest for developing sustainable competitive advantages in today's (2010) complex business environments, in order to support the corporate strategy. This section provides an overview about the key elements of business models, for which the role of technology is of primary interest.

2.4.1 Business models from the outside-in orientation

By re-interpreting the outside-in strategy orientation through the business model lens, the outside-in approach determines mainly the environment in which a business model is positioned. Therefore, the structure of the business model should adapt to environmental changes. Due to the increasing complexity of doing business, e.g. changing economic landscapes, greater uncertainty, increasing market disruptions, etc, scanning the environment becomes increasingly important. Environmental changes should influence strategic decisions and therefore the environment influences the design space of the development process of business models. Osterwalder (2010) recognizes four main environmental forces that influence the business model design space, which is comparable with the environmental forces described by the STOF-model (Haaker, et al., 2008). The four environmental forces described by Osterwalder are included in Figure 14. As part of the key trends, technology development is a very important element of the environmental forces. The STOF-model even describe technology change as an independent force on its own, which highlights the importance of technology change even more. Business models should adept quickly to environmental forces, as a business model in today's environment can be a winning model, but obsolete or outdated tomorrow. For this reason evaluating business models should be a key management activity. Evaluating business models gives insight in the health of the firm's market position and enables managers, leaders and entrepreneurs to adapt quickly to environmental changes.

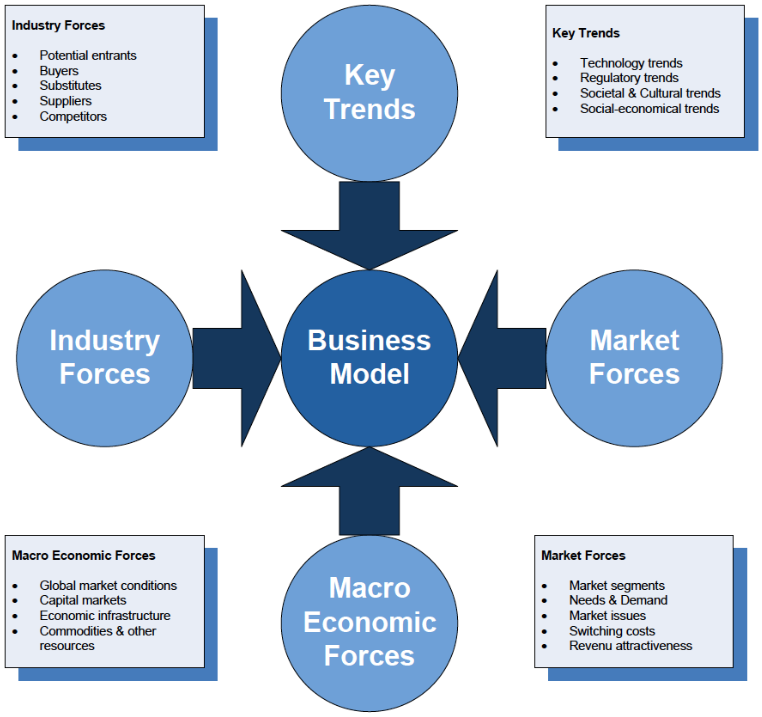

Figure 14: Environmental Forces (adapted from Osterwalder, 2010)

2.4.2 Business models from the inside-out orientation

Approaching the business model from the inside-out orientation, the business model itself is a key element of success. Business models describe the key elements of an organization in order to create, capture and deliver value to customers. Those key elements highlight the role and position of technology in the organisation. Osterwalder (2004) describes the business model through a decomposition of four domains and nine building blocks, which are given in Figure 15. Those four domains and nine building blocks explain and show how the organization intends to make money.

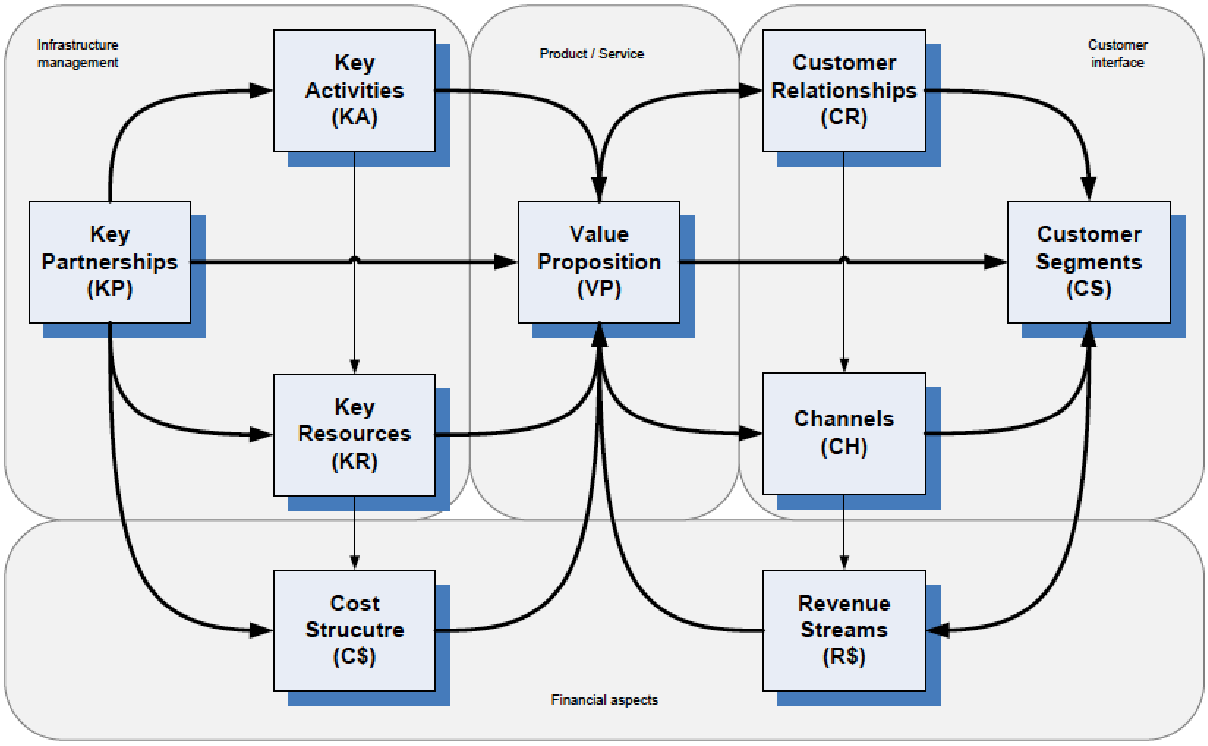

Figure 15: Osterwalder's nine blocks decomposition of a Business Model (adapted from Osterwalder, 2010)

The first domain, infrastructure management, contains the partnerships, resources (capabilities) and activities (value configuration), which determines the structure of the value network. A major issue here is which activities and resources are needed in order to execute the business model and create the required value for the customers. Furthermore, cooperation with partners is included to optimize processes, gaining external economies of scale, reducing risk and uncertainty or acquiring resources and activities. The second domain, product / service, focuses on the value proposition and therefore on the unique added value offered to potential value recipients. The value recipients can be described as a specific customer segment that is willing to pay for this value proposition. The value proposition can consist of a total range of products and services, which can again consist of qualitative (e.g. customer experience, design, etc.) or quantitative (e.g. speed of service, prices, etc) values. Nevertheless, the value proposition is mainly determined by the strategic position the organization wants or is forced to position itself in the market. The third domain, customer interface, contains the customer segments, channels and customer relationships. This domain focuses on reaching, serving and communicating with the preferred customer segment. The customer segment distinguishes the group of customers that is willing to pay for the value proposition. In order to enhance the customer experience, channels and relationships should be aligned with the customer segments and the rest of the business model. Customer experience determines a large part of the customer satisfaction and therefore the success of the value proposition. The last domain, financial aspects, includes the revenue streams and cost structures. The revenue streams are a result of successfully delivered value propositions. Revenue streams can be divided into two different types, namely; transaction revenues (single transactions) and recurring revenues. Those two types of revenues can result from fixed (static variables) and dynamic (market conditions) price mechanisms. By implementing a price mechanism switching costs should be taken into account in order to determine the optimal revenue streams. In order to generate profits, revenues should exceed costs. Costs structures can basically be divided into two broad categories, namely; cost driven and value driven cost structures. Although the drive to reduce costs is for cost driven organisations much higher, in both organisations cost efficiency is important. The three most implemented techniques to reduce costs and increase cost efficiency are: reducing transactions costs, economies of scale and economies of scope. Furthermore, cost structure can be divided into fixed and variable costs (Osterwalder & Pigneur, 2010).

Within the business model framework of Osterwalder three significant roles for technology can be recognized, which are:

- Supporting, in order to support the business model and therefore more important on the process layer;
- Key part of the infrastructure management, technology is a key resource of the organization or acquired through key partnerships in order to gain sustainable competitive advantages;
- Value proposition, the technology is offered to the customers.

More extensive information about the nine building blocks of the business model framework of Osterwalder and information about the most promising business model patterns are included in appendix A.

2.5 Conclusion

The business landscape is changing rapidly and as a result companies cannot succeed anymore with only an outstanding technology. Technology development should be integrated in the business processes in order to gain a (sustainable) competitive advantage. Sustainable competitive advantages can best be explained by business strategies and models, and therefore by the top two business layers of an organization. In order to create a sustainable competitive advantage the value-creating strategy developed by the organization must be very difficult to copy. An important issue in developing business strategies and models is the environment in which an organization operates. The business evolution process gives a clear understanding about the dynamics an organization can experience, due to environmental forces and strategic intent. The transformations towards the different phases in the business evolution process are primary made possible due to breakthrough technologies, which indicates the importance of technology development in rapidly changing business environments. The last and most recently developed phase in the business evolution process is the transformation towards service-oriented organizations, which is primary driven by IT technologies. This phase is called the mass-individualization phase, for which individual customer needs are fulfilled in mass-production environments.

The role of technology development in strategies in order to gain competitive advantages

Zegveld (2000) indicates that strategic management can be divided into four main generic perspectives. Those four perspectives are (1) Resource-based strategic management, (2) Industry-based strategic management, (3) Dynamic capabilities and (4) Game theory. Between those four different perspectives a clear distinction can be made between an outside-in and inside-out orientation. The outside-in orientation covers the Industry-based strategic management (2) and Game theory (4). This orientation domain treats technology as a functional component that only influences the companies activities and therefore does not belong to the core of the strategy process itself. From this perspective technology choice and development will be influenced by strategic decisions (and not vice versa), which are primary driven by environmental forces and strategic intent. On the other hand, the inside-out orientation covers the Resource-based strategic management (1) and Dynamic capabilities (3) perspectives. This orientation domain treats technology as itself as a competence and capability in order to gain sustainable competitive advantages. From this perspective the translation of technology into business is very important and therefore technology is recognized as a crucial component of the strategy process. As a result technology can be seen as a relevant aspect of corporate success and change. Nevertheless, technology alone has no value. The value of technology has mainly to do with its application and the context of this application, in order to gain a sustainable competitive advantage. Therefore, both orientation domains must be taken into account in order to develop sustainable, competitive and acceptable businesses.

The role of technology development in business models in order to gain competitive advantages

Scientific literature related to business models is a relatively "new" domain of study, which became important through the increasing complexity of doing business. Business models are described as the blue print of the corporate strategy, for which the focus is on creating, delivering and capturing value. The increasing need for business models have led to different business model frameworks and definitions. The business model theory developed by Osterwalder is based on a solid scientific foundation, proven for the electricity market, suitable for multi-actor environments, universally applicable and is accepted by many scientists and business people in scientific and professional environments. For this reason the business model framework of Osterwalder is used for this thesis as the foundation for business model related issues. Although the business model ontology of Osterwalder is used, the role technology gains in business models is common among different academics and business professionals. Business models bring technology and economics together which is an important design issue in today's complex business environment, for which technology can gain three main roles in the framework of Osterwalder:

- Supporting;
- Key part of the infrastructure management;
- Value proposition.

This chapter (literature study) clearly indicates that the next two steps in this research project should be analysing the Dutch electricity sector (outside-in) and the competitive BSS technology (inside-out). Based on those analyses the requirements and design variables should be determined, which will be used as the input for the interviews and the business model designs. Furthermore, this chapter will be used as a framework in the next chapters, which determines what to investigate or design.

3 Sector analysis: The Dutch electricity sector

In this chapter the second research question "*How is the current electricity system in the Netherlands organized, which forces are restructuring the system and what are the system requirements of the current and future Dutch electricity system?",* is answered. An important part of understanding and designing sustainable competitive advantages is to have an in-depth understanding about the environment in which the competitive advantage is or has to be realized (Osterwalder & Pigneur, 2010). The purpose of this chapter is therefore to get an overview and in-depth understanding about the sector and its environment in which the technology Battery Storage Systems (BSS) will be introduced. As this research is limited to the Netherlands, this chapter will focus only on the Dutch Electricity Sector and its environment. The analysis executed in this chapter determines the system requirements and the relevant actors involved, which are used for the selection procedure included in the next chapter.

Each section in this chapter describes one element of the environmental awareness model of Osterwalder (2010), which is included in Figure 14. The first section (3.1) starts with the core of the model, namely the Dutch electricity sector itself. In this section the Dutch electricity sector is analysed by making primary use of the scientific framework of de Vries (2009), which is given in Figure 16. Although this section is primary based on scientific literature, reports of reputable companies (e.g. TenneT) is used as a supplementation. The second section (3.2) describes the environment of the Dutch electricity sector and is primary based on reports published by reputable companies, as Siemens AG and EnergieNed. Finally, in Section 3.3 a conclusion is given in which the main findings of this chapter are included.

3.1 System analysis of the Dutch electricity sector

The first element of the domain research is to get a detailed overview about the market design of the current Dutch electricity sector. This section focuses on the technical (physical), economic and institutional (including juridical) market design aspects.

In this research, the Dutch electricity system is defined as the process of generation towards consumption, which is illustrated in Figure 16. De Vries (2009) divides the electricity system in a physical layer and an economic/institutional layer. The physical layer is divided into four blocks, namely generation, transmission, distribution and load, which distinguish the four main elements that makes the supply of electricity possible. The physical chain explains the main elements through which the electricity flows. Although new developments, like distributed electricity generation, disturb the one-directional process off the value chain, the largest part of the physical Dutch electricity system is still organized in this way. While the physical layer can be explained by the value chain theory, the economical/institutional layer is more complex and therefore a more system theory approach is needed. Due to the liberalization, the Dutch electricity value chain has attracted different actors that now control different parts of the Dutch electricity system. As a result, the complexity of the sector, mainly described in the economical/institutional layer, has increased significantly. Nevertheless, the overall purpose has remained the same, namely supplying electricity to consumers in a reliable, safe and economic way (Ummels, 2009).

Figure 16, gives a clear schematic overview about how the Dutch electricity system is organized. The double pointed arrows indicate the actor groups, described in the economical/institutional layer, that control the part of the physical layer. The single arrows indicate the direction in which electricity is traded.

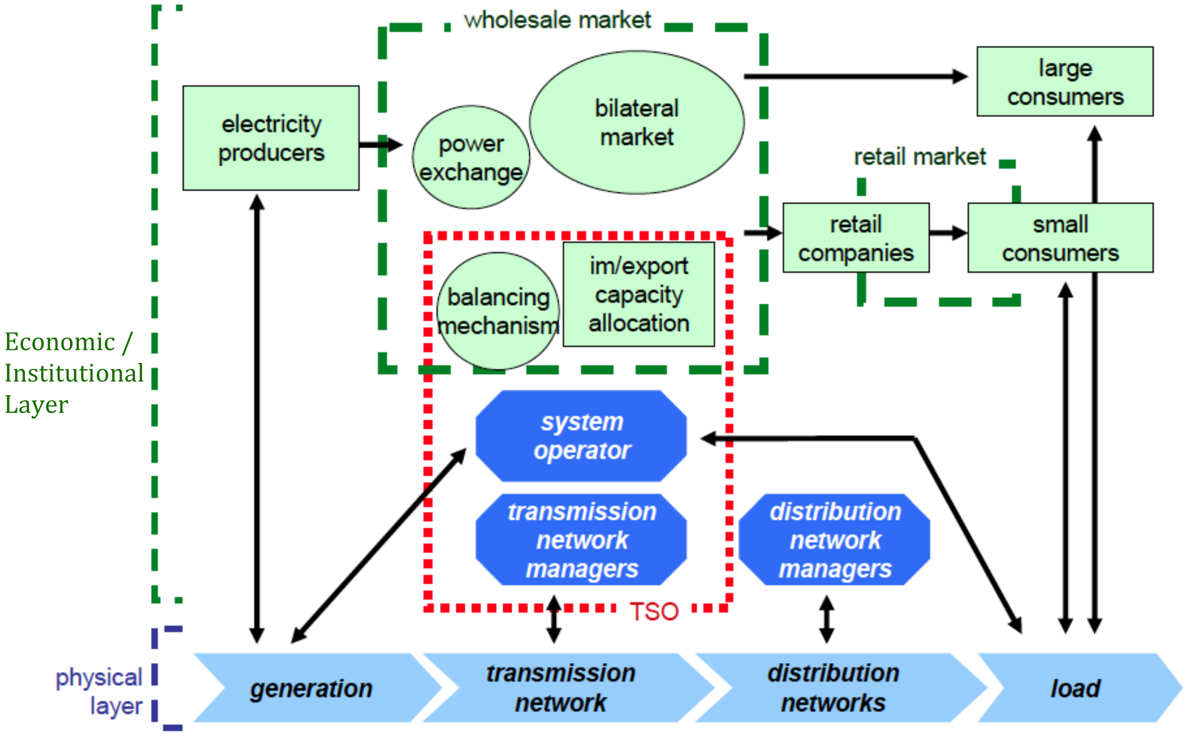

Figure 16: Dutch Electricity System (de Vries, et al., 2009)

In the following subsections the different elements of the Dutch electricity system, included in Figure 16, are shortly explained. This section provides an indication about the involved and relevant actors, the operation of the system and the current system requirements. A more extensive description of the elements is included in appendix C.

3.1.1 Electricity Generation

In the Netherlands we can distinguish two sources of electricity generation, namely central and decentral. Central electricity generation produces the bulk amounts and is mainly based on coal and gas fuels. Central electricity generation is the traditional way of producing electricity and have been used already for decades. Technologies related to this type of generation are proven to be generally affordable and reliable, and are therefore difficult to replace for alternative sustainable energy sources. Although those two main advantages resulted in a very strong position of existence, technologies related to central electricity generation have also three main disadvantages that have resulted in the development of renewable energy sources. The three main disadvantages of central electricity generation are (Ummels, 2009):

- Unsustainable for the future, as fossil fuel reserves are finite;
- Fuels are unequally distributed between countries, which result very often in political disturbance;
- Emission of greenhouse gases, especially CO_2.

The second category in which electricity can be generated is decentral electricity generation, also called distributed generation (DG). DG generally means generating relatively small amounts of electrical energy on different widely spread places in the electricity grid. Today, DG is recognized as a trend in the energy sector, in the form of renewable / sustainable energy sources (Veldhoven, 2007). DG developments were stimulated first by the Dutch Electricity Act of 1989, which resulted in today's electricity generation in a share of around 30%. Nevertheless, renewable energy production is still only presented for 2% of the total amount of energy supply in the Netherlands. The goal of the Netherlands is to increase this amount to 20% in 2020 (Ministry of Housing, 2010). Although renewable energy sources are from an environmental point of view highly preferable, there are two main disadvantages recognized from an economic and institutional point of view, namely (Ummels, 2009):

- Technologies related to renewable electricity generation are still (far) more expensive compared to conventional technologies;
- The supply of renewable electricity generation is highly unpredictable and therefore less manageable.

The market for electricity generation is fully privatized and therefore accessible for commercial activities. In order to assure a continuous supply in this market, energy producers primary sell their electricity on a future or forward market (Kirschen & Strbac, 2004), which requires accurate forecasts and strict capacity planning and management. Furthermore, electricity providers provide three different products to the electricity market, namely electricity, operating reserves and capacity reserves.

3.1.2 Transmission network

The electricity grids can be divided into two categories, namely the transmission grid and distribution grid. The purpose of the transmission grid is to connect various power plants, distribution grids and cross-border grids and can be recognized as the backbone of the entire system. In the Netherlands the transmission grid is categorized as all power lines higher or equal to 110 kV and the distribution grids as all power lines lower or equal to 50 kV. The transmission grid is owned and managed by the Transmission System Operator (TSO), which is in the Netherlands the state owned company TenneT (TenneT, 2010b; TenneT, 2010d). The main managerial task of TenneT on a daily basis is safeguarding the continuity of the electricity supply, by balancing demand and supply. The payment for those services provided by TenneT is part of the grid fee, which is charged to all parties connected to the national high-voltage transmission grid. Part of this grid fee, TenneT charges three different serves, namely connection, transport and system services, which have their own tariffs. The structure of the tariffs is regulated by law, while the tariffs themselves are regulated by the Dutch government (Wijers, 1998).

TenneT has three main roles within the Dutch electricity system, namely managing the transmission grids, system operator and managing the import and export of electricity. Within those roles TenneT has a natural monopoly position, due to the physical constraint of electricity networks. Although natural monopolies are the most efficient when having only one network, they also have different drawbacks. Therefore the policy goals for the Office of Energy Regulation (Energiekamer) are as follows (de Vries, et al., 2009):

- Establish optimal tariffs;
- Ensure equal access for all;
- Obtain optimal quality of service.

Due to the liberalization and the stimulation of renewable energy sources, electricity producers can provide electricity on almost every physical location in the Netherlands. This has resulted in a high demand for connections on a few coastal sites and regions, due to the good environmental condition or other reasons to provide electricity. Although the building or placing process of new power plants, wind farms and CHP plants is going relatively fast, upgrading the transmission grids needs a significant more amount of time. This has resulted in areas in which more generating capacity is available than the transmission grids can handle, which result in congestion. TenneT has introduced an innovative system for this problem, named congestion management, which will in the end result in increasing prices for the end consumers. A more detailed description of congestion management is included in appendix C.

On international level, TenneT deals with the European Network of Transmission System Operators for Electricity (ENTSO-E) for European wide planning and operations, including the regulation for cross-border exchanges of electricity. The main purpose of ENTSO-E is stimulating the EU vision of an integrated European energy market (European Network of Transmission System Operations for Electricity, 2009).

Programme Responsible Party

An important actor related to the trade of electricity and the management tasks of TenneT is the Programme Responsible Party (PRP). This party is responsible for the purchases of electricity and therefore all the activities related to it, namely predicting, managing and administrating the expected electricity consumption using the electricity grid. This party is also the risk owner when imbalances occur, for which TenneT (TSO) will charge penalties (TenneT, 2010c). PRP's provide their individual electricity programs (e-programs) each day to TenneT. With this information TenneT will assure that the expected/demanded electricity flows can take place and measures the actual electricity production and consumption. When the actual electricity production and consumption does not match with the total sum of the electricity programs provided by the PRP's, TenneT will charge the imbalance to them, for every MWh of deviation. PRP's are not necessary the same actor as the electricity supplier. For the large electricity suppliers this is generally the case (e.g. Eneco, Essent, etc.), but for the small electricity suppliers this is generally not the case. Small electricity suppliers are mostly using one PRP together (e.g. PVNED). The ownership of the PRP is then shared among the different suppliers involved, which is allowed according Article 31 of the Dutch Electricity Act 1998.

PRP's can have two types of recognition, namely full recognition or trade recognition. Full recognition means that a recognised legal entity has program responsibility for grid connections, while trade recognition is limited to trading between PRP's.

3.1.3 Wholesale & Retail market

The Dutch wholesale market consists of four different market segments, namely Power exchange, bilateral market, balancing mechanism and import/export capacity allocation. The most important activity of the first market segment (power exchange) is the spot market, for which electricity is traded closely to the actual delivery. The second market segment (bilateral market) is to trade electricity directly between traders and therefore without the intervention of the trade market (also called over-the-counter (OTC)). This market segment includes also the option to produce the electricity yourself and therefore buying directly the electricity internally. The third market segment (balancing market) is a specific market in which only TenneT trades, in order to balance its transmission network. The last option is to import or export electricity from foreign countries, which is also operated by TenneT only. The Netherlands consist of four import/export connections, namely with Germany, Belgium, Norway and after finishing the BridNed project also the United Kingdom. The wholesale market in Europe and therefore also the Netherlands can be recognized as a decentralized market in which the system operator (TenneT) has only a technical function. Commercial activities related to the supply and demand of electricity is met somewhere else, primary described by the wholesale market.

Next to the wholesale market also a retail market exist in the Dutch electricity system. The retail market is the intervention between the wholesale market and small consumers. On the retail market energy retailers serve small consumers in order to prevent the necessity of all individual consumers on the wholesale market. Price settings within the retail market must satisfy the Dutch Electricity Act, article 95b, which means that if prices are unreasonable (difference between costs and price is too high) the Office of Energy Regulation (Energiekamer) can intervene by setting a maximum electricity price.

3.1.4 Distribution network

In contrast to the transmission grids, the Dutch distribution grids are owned and managed by several Regional Grid Operators (RGO's). In the Netherlands 8 RGO's are active and operate in total 27 distribution grids. The three largest RGO´s are ENEXIS, Liander N.V. and Stedin, which serve around 90% of the total market. The Dutch RGO's are owned by local governments and just like TenneT separated from all commercial activities, for which the unbundling process is currently (2010) in progress. The process of unbundling the physical and service functions on distribution level must be finished before January 1, 2011 (NMa Energiekamer, 2010; Weterings, 2008a; de Vries, et al., 2009). As part of the Dutch law, related to the unbundling process, RGO's should be juridical separated from the commercial activities (services) in a separate firm. This includes a separation of the location and identification of both organizations, in order to prevent unfair competitive advantages. However, according the latest developments (NOS, 2010), this law allows RGO's to be part of a larger energy firm. This larger firm can include other competitive activities provided by legal persons. In this way we can say that the larger company is split up into a monopoly and therefore un-risky part and a competitive risky part.

The main difference between a network manager on the transmission level and a network manager on the distribution level is the added task of system operator. In the current setting, the system operator task belongs to the TSO and can therefore not be performed on a distribution level (NMa Energiekamer, 2009). This means that the distribution operators are not allowed to perform any other task than managing the distribution networks. According the Dutch Electricity Act 1998 and the system code RGO's are not allowed to install energy storage solutions for peak shaving, contingency reserves, etc, as this can be seen as a service.

The main purpose of the distribution grids is to connect a large amount of customers to the electricity supply. Until recently distribution grids are not only important anymore for distributing electricity from transmission grids to end-users or customer, but also for connecting distributed electricity generators. This development has a significant impact on both the technical systems and managerial systems (Deconinck, 2010; Rodel, 2008). Distributed electricity generation enables the connection of small renewable energy sources to the electricity grid. Another important development in the distribution grids on the customer side is the development in which customers can manage their own demands (van Eck, 2007).

3.1.5 Consumption (load)

Within the Dutch electricity sector consumers are divided into two categories, namely small and large consumers. Large consumers are categorized as all connections higher then 3*80 A and small consumers lower or equal to 3*80 A. As large consumers are considered to have a good bargaining position and are trading electricity direct on the wholesale market, the Office of Energy Regulation (Energiekamer) does not monitor the prices for this group. Bargaining or trading good electricity prices is therefore their own responsibility. For small consumers, which are active on the retail market, the Office of Energy Regulation does monitor all prices and intervenes when necessary (NMa Energiekamer, 2010).

The Dutch government is stimulating sustainable developments for energy generation and energy savings (Ministry of Housing, 2010). At the consumer side this resulted in an increasing demand for distributed electricity generation, like solar panels, small wind turbines, micro-CHP's, etc. Although the demand for those technologies is increasing, without the (financial) incentives of the government, policy privileges and the rise of fossil fuel prices the changes of success would be relatively low (Foreest, 2008; Taylor & van Doren, 2002).

3.1.6 Regulation

The Dutch law that contains the guaranteeing of the existence of electricity is included in the Dutch Electricity Act 1998 (Wijers, 1998). This act is the end responsibility of the Ministry of Economic Affairs. The Ministry of Economic Affairs has charged the Office of Energy Regulation (Energiekamer) with regulating the Dutch Electricity Act 1998, as part of the Netherlands Competition Authority (NMa) (NMa Energiekamer, 2010). The Dutch Electricity Act 1998 is limited by regulating the monopoly activities only (such as network management for TSO and RGO) and therefore the free economic activities are no longer regulated by this law. This law also requires a legal separation between network managers and all commercial activities. Next to this law, network managers can together create codes as part of the Dutch electricity regulation system, which has to be officially approved by the director of the Office of Energy Regulation (Art. 31 and 36 of the Dutch Electricity Act. 1998).

The Dutch electricity regulation distinguishes three different types of codes, which are technical codes, tariff codes and information codes. The structure and the relation between those codes are illustrated in Figure 17. Those codes are designed to give substance to the Dutch Electricity Act 1998 and describe how network manager should act among other network managers and members connected to their networks. The technical codes consist of three sub-codes, namely network code, metering code and system code. The Network code describes how network managers should operate their grids. The metering code describes the conditions that have to be fulfilled in order to provide reliable metering of the electricity supply and demand (including the allocation of metering responsible parties). The last technical code, system code, describes how system services should be delivered. In the tariff codes the costs of the grids are determined, in order to distribute the costs among all network users. Within this code a distinction is made between transport, connection and system services. Finally, the information code describes which information should be shared among market parties. Although the Dutch Electricity Act 1998 requires the existence of those codes, the conditions included in those codes are not part of the legislation, but only part of the regulation (NMa Energiekamer, 2010).

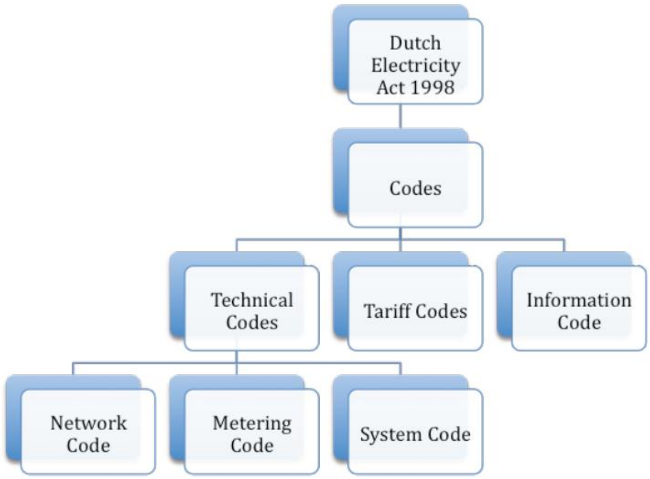

Figure 17: Code regulation structure

Due to the monopolistic nature of the network activities, (indirect) regulation is needed to guarantee the economic viability of the network business (Scheepers & Wals, 2007). In the Netherlands the indirect regulation for RGO's is provided with incentives in order to operate the network efficiently, while guaranteeing a certain quality level. The main purpose of this mechanism is to take the role of competition, which is missing in natural monopolies. The incentive mechanism used in the Netherlands is a price-gap regulation. This mechanism allows tariffs to increase with only a few percentages per year, which stimulates efficiency. The percentages the tariff can increase is calculated from the inflation factor plus the quality factor minus the efficiency factor (Meijer, 2009). This basically means that the higher the operational efficiency and quality of the networks, the higher the tariffs that can be charged by the RGO's. The efficiency factor is determined by the yard stick competition (benchmarking) principle, which compares the achievements made by the RGO with the sector average. The quality factor is determined by three main aspects, namely; continuity of supply, voltage (or power) quality and customer service quality. RGO's should find the best balance between those two factors, in order to optimize their profits. Furthermore, the wholesale and retail prices are regulated by price restrictions. For this mechanism a discussion is going on in which the question arises whether sufficient investments are made in price-restricted markets and if a capacity mechanism is not better for the consumer (de Vries, et al., 2009).

At European level, April 2009, a new package of regulations and directives were adopted by the European Union, called the Third Energy Package. The objective of this package was to strengthen the consumer rights, improving the security of supply and to create effective competition, in order to create a better integration of the European energy market and to maximize European welfare. In order to do so, a key goal was to remove the strategic advantage energy companies had from combining production and trade activities with network ownership. Therefore TSO's within the EU are now fully unbundled from competitive activities. As a result, a new established agency of the European Union was created on 13 July 2009, called the Agency for the Coordination of Energy Regulators (ACER). The main purpose of this agency is to improve and create harmony between the different regulations, executed by the national regulators (Pottering & Erlandsson, 2009).

3.2 Environment Analysis

Every organization, industry or sector is part of a larger environment. In order to develop a sustainable competitive advantage it is important to understand the design space available in this environment. As the external environment is changing rapidly, scanning and flexible adapting to this environment becomes more important than ever. Understanding the environment helps to effectively change and adapt strategies and business models to shifting external forces. In order to execute this environmental analysis the framework of Osterwalder is used as a foundation (Figure 14).

3.2.1 Industry forces

While taking the industry forces described by Porter (1985) into account, the industry profitability and therefore the attractiveness of the Dutch electricity industry is mainly determined by four forces. Those four forces are as follows:

- **Oil companies:** Over more than 85% of total amount of electricity is generated from fossil fuels, of which the primary fossil fuel used in the Netherlands is natural gas. The price of gas is highly dependent on the price of oil, which had a negative effect over the past years as oil prices increased very sharply and therefore also the cost of energy (de Vries, et al., 2009). As a result, Oil companies have in the current market setting a strong bargaining position.
- **Government:** Exclusive of taxes, the energy rates in the Netherlands are one of the lowest compared with other countries in Europe. However, as nearly 50% of the energy price for an average household consists of tax, energy in the Netherlands is comparatively expensive (EnergieNed, 2009a). As the energy price is mainly determined by tax, the government has a strong bargaining position, which they can use for stimulating renewable energy sources.
- **Consumer:** Since the liberalization of the electricity market in 2004 consumers are free in their choice of supplier, which enabled competition in this market. Electricity suppliers were forced to act more efficiently and adapt to customer needs and wishes. As a result, the electricity market is becoming more transparent and therefore consumers get more bargaining power. Transparency enables consumers to unbundle the services provided by electricity providers and bargain specific parts of the delivered services. Furthermore, transparency creates awareness, which consumers can use in order to become efficient users of electricity and therefore reduces the total demand for electricity.
- **Horizontal & vertical integration:** The most common self-reinforcing combination within the non-regulated part of the Dutch electricity system is the vertical integration of generation and retail activities, as this significantly reduces price risks for both actors. Vertical integration reduces the liquidity in the wholesale market (de Vries, et al., 2009). Next, in order to gain from advantages of scale, scope and learning different companies are increasingly active on the broader European market, which means integrating horizontally. Horizontal and vertical integration reinforces the market position and power, which creates a strong entry barrier for new entrants and forces smaller companies to find strategic partners (abroad).

3.2.2 Key Trends

Key trends recognized in modern society influences our design choices in order to develop innovative and competitive business models. Based on a recent market research of Siemens AG, four different key trends (also called mega trends) are recognized. Those trends are as follows:

- **Demographic change:** In 2050 the number of people over 60 years old will exceed the number of children and youth under 15 years old. The fastest growth rate will even be reached by elderly people above 80 years old, which will represent 4,1 % of the total population by the year 2050 (today 2010, 1,2%) (United Nations, 2010). This societal development creates bigger challenges to the energy supplies and enables new opportunities for "smart homes" (Kester J. , 2004). It is clear that demographic change will change the customer landscape and energy profile.
- **Urbanization:** The largest part of the world's population growth is taking place in cities. In 2007, for the first time in history, the number of people living in rural areas was less than the number of people who lived in cities. While following the trend, urbanization is accelerating and results in a share of 60% in 2025 and even 70% in 2050 of the worldwide population (United Nations, 2010). Urbanization will have a major impact on the electricity value chain. Energy reserves are mostly far from the consumer centres, requiring large amount of energy transported over long distance transmission grids. While challenges on distribution level are mainly related to the distribution of larger amounts of energy in local environments and decentralized power generation, for which smarter usage (smart grids) of the distribution grids is required.
- **Climate change:** Two-thirds of the total amount of greenhouse gas emissions worldwide is energy related (Siemens AG, 2009) and therefore this trend has a tremendous impact on the whole electricity system. The most important related generation technology developments can be divided into three main categories, namely: (1) improving the efficiency of fossil fuels, (2) renewable energy production and (3) nuclear power (currently in a political debate). As a result of the energy transition, the Dutch Ministry of Economic Affairs has setup a task force smart grids (Van der Hoeven, 2010). One of the deliverables of this task force was to come up with the possible energy transition scenarios, in order to understand the future. The final version of the three scenario's was not finished during the execution of this project, therefore this thesis takes the three scenario's included in appendix D into account.
- **Globalization:** Globalization provides companies to enlarge their markets and creates new opportunities, but it also increases international competition. Globalization means the integration of economic, political and cultural systems across the globe. Though the cross-border connections the physical part of the Dutch electricity system has become part of a larger physical system, while the privatization has opened the borders for parts of the economic and institutional systems. Globalization results in distributed political power in which decision-making processes becomes increasingly complex (Bruijn & Heuvelhof, 2008). Although Dutch laws regulate the largest part of the Dutch electricity system, European regulation and legislation becomes increasingly important.

3.2.3 Economic and market forces

In the current economic and market setting different forces are changing the economic and market landscape to a large extent. Those changes are mainly caused by the key trends described above. From an economic and market perspective two important forces can be distinguished, namely:

- **Implementation of the European directives:** The purpose of those directives is to create one competitive electricity market in Europe, for which the challenges can be divided into three obstacles. The first obstacle is related to the physical constrains that limits the trade between member states. As energy prices in neighbouring countries are still lower than in the Netherlands, import of electricity is highly demanded and as a result congestion occurs at the cross-border connections. Nevertheless, double transaction costs (cross-border costs and local transaction costs) are related to the import of electricity, which can make this development less attractive. The second challenge has to do with the availability and historical choices of primary fuels, which determines the electricity prices to a large extent. An example is that in the Netherlands a choice has been made for not choosing nuclear power as the primary fuel, although this fuel is cheaper. As a result, electricity in neighbouring countries can be cheaper, but do we want to import that energy? This result in the last constrain, which is related to the interconnection of market regulations. Market regulations should be aligned, with respect to taxes, environmental levies, etc, in order to enable fair competition.
- **Emission trading:** In the Netherlands two emissions trading programmes exist, a Dutch system for NOx emissions and an European system for trading greenhouse gas emissions (CO_2). In both trading systems the Dutch electricity system is involved, mainly through the high level of fossil fuel generators. In order to implement the NOx and the CO_2 emissions trading systems in the Dutch legislation, the Dutch environmental management Act was supplemented with a new chapter (16). The Dutch Emission Authority (NEa) has the responsibility to monitor the compliance of this law (Ministry of Housing, 2010; Ginjaar, 2010).

3.3 Conclusion

During recent years different forces has significantly changed the Dutch electricity system. As a result, the current Dutch electricity system can be characterized as increasingly complex and uncertain. The combination of being complex and uncertain (level 3-4, Figure 6) results in a system that is positioned in a dynamic business environment. In this environment it becomes increasingly important, but also more difficult, to create and capture sustainable competitive advantages.

The Dutch electricity system can be explained by dividing the system into two layers. The first layer distinguishes the technical system and consists of four main elements, which are (1) generation, (2) transmission network, (3) distribution network and (4) load. Although the purpose of this layer is already the same for many years an important change can be recognized. The technical system was designed for transporting electricity from central (bulk) electricity generators towards consumers and therefore electricity flew only in one direction. Since the increasing demand for distributed generation and renewable energy sources electricity started to flew in two directions. Current electricity grids are not designed for this purpose, which requires large investments in research and development and improving the currents grids. The second layer distinguishes the economic/institutional layer and can be divided into four main elements, which are (1) producing, (2) wholesale market, (3) retail market and (4) consuming. Especially this layer is becoming increasingly complex, because of the unbundling process, liberalization of the electricity market and the EU aim of an integrated electricity market. As a result, the actor network has expanded during the last years for which the decision making process has become increasingly complex. The actor network of the current Dutch electricity system, included in this chapter, is illustrated in Figure 18.

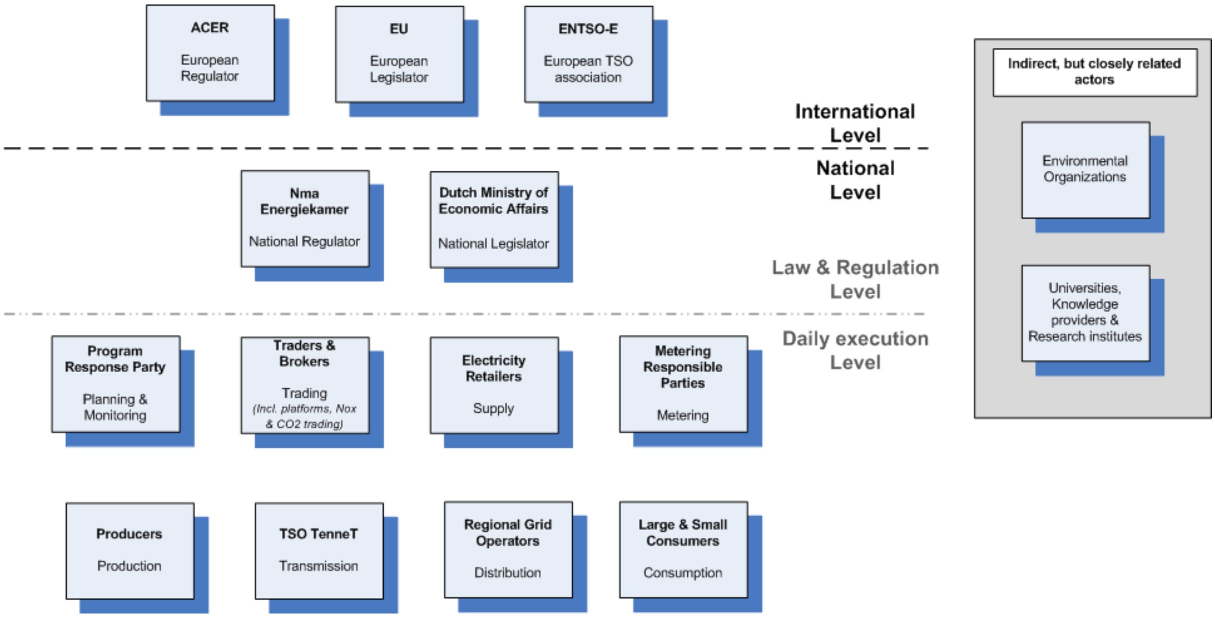

Figure 18: Actor network of the Dutch electricity system

Within the analysis of the Dutch electricity system an important focus was on the current system requirements. Those requirements are processed throughout this chapter and can be enumerated as follows:

- Reliability;
- Safety;
- Affordability;
- Economically;
- Quality;
- Security of supply;
- Accessibility.

Furthermore, business strategies and models are not only dependent on the system, but also on a larger environment. For this reason this chapter also distinguishes the external environment, by making use of the framework of Osterwalder (2010). Osterwalder describes the external environment by making use of four different forces, which are (1) industry forces, (2) key trends, (3) economic forces and (4) market forces. The result of the environmental analysis carried out in this chapter is illustrated in Figure 19, for which the economic and market forces are combined.

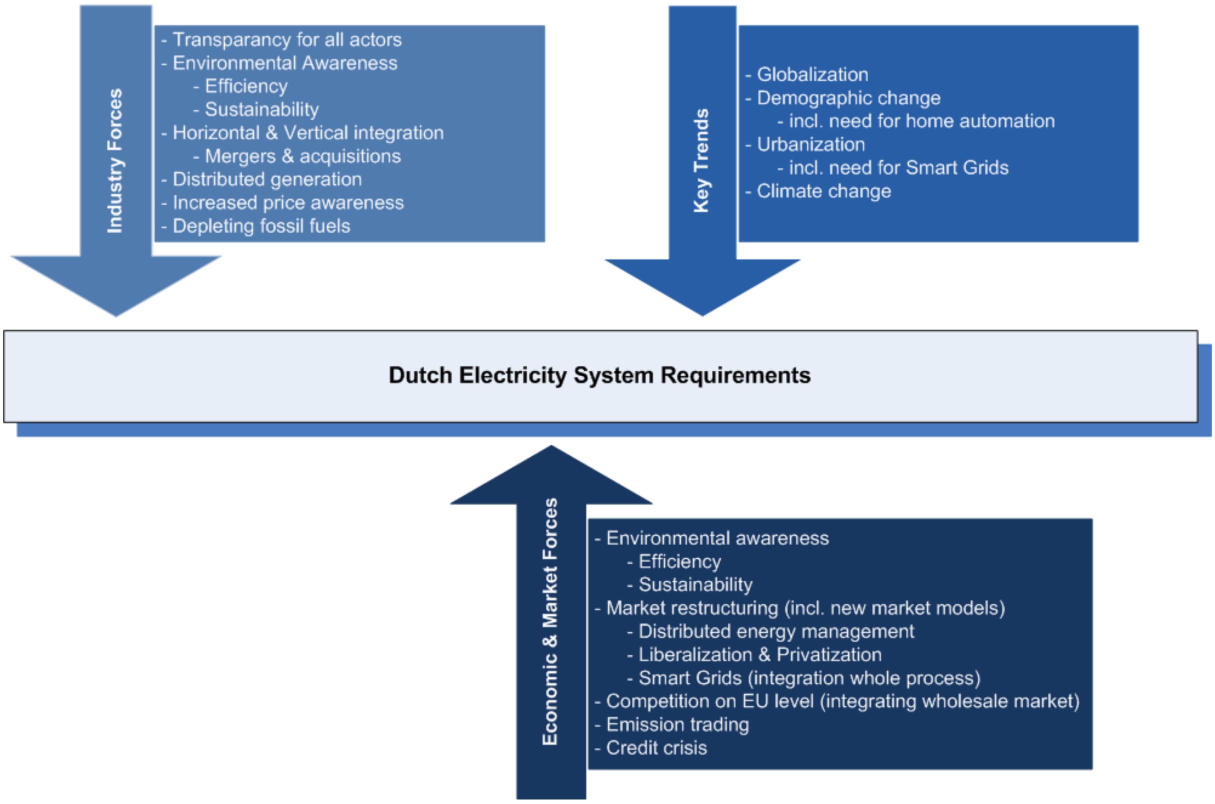

Figure 19: Environmental Forces that will change the system requirements

Due to pressure of the different environmental forces, the business environment is developing into a new stage described by the business evolution theory (Section 2.2). As the current stage of the Dutch electricity system can be described by the industrial heterogeneous stage, environmental forces are pushing the system towards the next stage, mass individualization. This stage requires fulfilling individual customer needs by making use of mass production, which requires a high level of flexibility. As a result, demand side management is required for which the consumers will get more managing power over their own energy usage, which requires a high level of communication. This development is called in the professional environment "Smart Grids". Furthermore environmental forces are performing pressure on developing towards a sustainable and efficient system. Renewable energy sources will become increasingly important and current fossil fuel generators must perform more efficiently. Nevertheless the increasing requirements will result in a need for efficient usage for all elements of the Dutch electricity system, as updating the system requires high level of investments. At last, transparency becomes increasingly important, as this is required for creating an optimal market operation, demanded by the government. As a result, the supplemented requirements can be enumerated as follows:

- Efficiency;
- Sustainability;
- Flexibility;
- Transparency.

The results of this chapter provides a clear understanding about how the Dutch electricity system is organized, which is required for designing reliable business models. Furthermore, the actor analysis and the recognized system requirements will be used in the next Chapter to determine the most promising applications and relevant actors involved, when implementing BSS. The requirements are validated in Chapter 5.

4 Technology analysis: "Battery Storage Systems"

Based on the analysis executed in the previous chapter, we understand the direction in which our electricity system is developing to. In order to enhance the success of new technologies, scientific literature related to strategic management theories describe that the applications belonging to those technologies should support this development. In this chapter the technology Battery Storage Systems (BSS) is analysed from different viewpoints in order to understand the uniqueness and competitive advantage of this technology. Those viewpoints are a result of the previous chapters. First, the BSS technology is analysed from a technical point of view, in order to understand the physical boundaries and future expectations of this technology. This analysis is done on the basis of an extensive scientific literature research. Thereafter in the next section, the applications that are made possible with this technology, described in scientific literature, are analysed. Although many applications exist in scientific literature related to energy storage, this section is limited to the applications of which BSS can provide a reasonable contribution. The main literature used for this section is scientific literature related to BSS case studies executed in the United States of America and Denmark, as those countries gain already some experience with this technology. The third section includes an analysis in which the alternative technologies and solutions are analysed, in order to understand the competition of BSS. This analysis is primary based on the scientific literature provided by Ibrahim, Ilinca and Perron (2008), who investigated different storage technologies. The fourth section of this chapter includes a value assessment, in which the primary focus of the business model design process is determined. The value assessment is supplemented with three decision matrixes, which are filled in by the researcher on the basis of the insight gained so far. The results of those three matrixes will be validated in the next chapter. Finally, this chapter ends with a conclusion that provides the main findings of this chapter, which will be used as an input for the next chapter.

4.1 Battery Storage Systems, a technology insight

Different developments, as well technology improvements as system changes, have increased the need and development of storage technologies. Battery Storage Systems are one of those developments that are supported by the discussion of electric drive vehicles and smart grid developments in the Netherlands (Divya & Ostergaard, 2009). As this technology is used as a reference point for this thesis, this section provides an in-depth understanding about the BSS technology.

Battery storage systems consist of three main elements, namely (1) the battery, (2) the control and power conditioning system (C-PCS) and (3) the protection equipment. The first element, the battery, contains two or more electrochemical cells. Those cells use chemical reaction(s) in order to create a flow of electrons (electric current) and as a result the stored chemical energy is converted into electrical energy. The three primary elements of a cell are (1) the container, (2) two electrodes (anode and cathode) and (3) electrolyte material. The electrolyte is constantly in contact with the electrodes, for which the current is created through the oxidation-reduction (chemical reactions) process.

When a battery provides energy through a connected load (discharging) the electrically charged ions supply electrons (oxidation), while ions near the other electrode accept electrons (reduction). When the BSS is in charging mode and therefore adopt energy the process is reversed, which entails ionizing of the electrolyte. However, some batteries (flow batteries) use electrolyte that is stored in a separate container outside the battery cell container. In this configuration the battery cells are said to be configured as a "stack" (Eyer & Corey, 2010). In the case of charging or discharging the electrolyte is transported between the cell stack and the electrolyte container.

The first element, the battery, determines the physical boundaries of the system, for which the most important features are (1) lifespan (number of cycles), (2) efficiency, (3) debt of discharge, (4) operating temperature, (5) energy density and (6) self-discharge. In appendix F the different battery technologies, including their characteristics, are included. Although the NiCd, Nas and Li-ion batteries are recognized as the leading technologies for power applications, the Li-ion battery has the highest future potential, due to its low weight, small size, high efficiency and high energy density (Divya & Ostergaard, 2009). The negative aspects of this technology are the high costs and the effect discharging has on its lifetime. Nevertheless, the expectations are that those disadvantages will improve due to heavy research and development. In order to understand for which application the different technologies are suitable the relation between rated power and discharge time is one the most important ratio's to know (ESA, 2009b). Figure 20 provides the relation between those different characteristics for several different (battery) storage technologies.

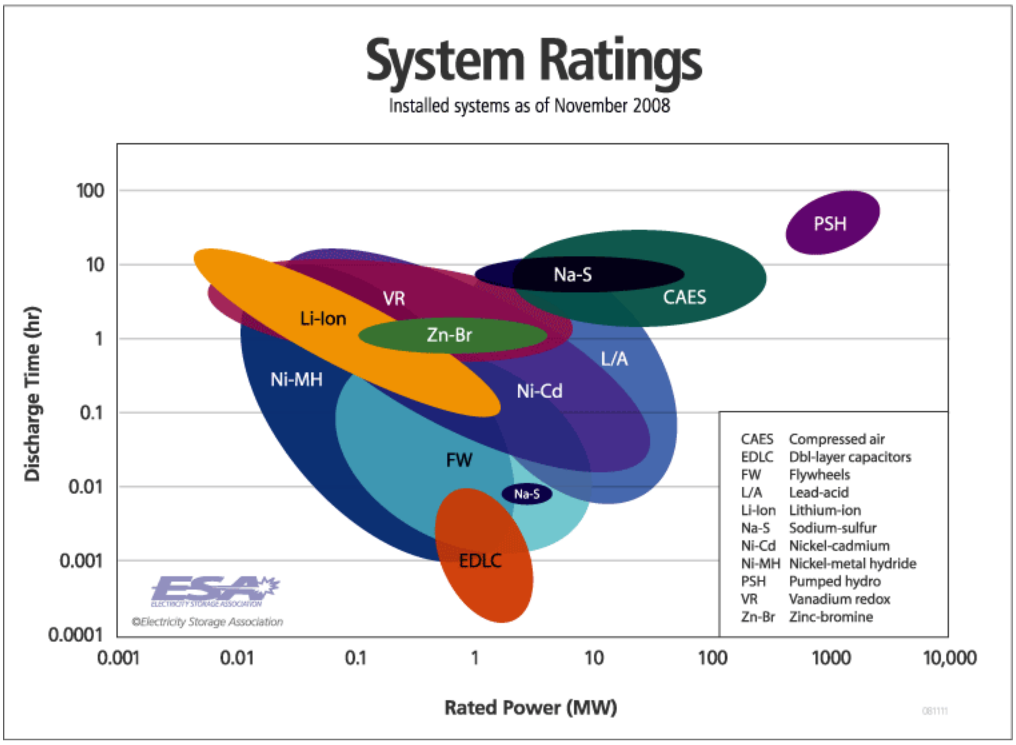

Figure 20: System Ratings (ESA, 2009b)

The figure above indicates that BSS is the most suitable for low voltage (230/400V) and medium voltage (distribution level) applications. Therefore, the next section includes only the applications on distribution and consumer level.

The second main element of BSS is the control and power conditioning system (C-PCS). This element includes all the equipment that interfaces the battery to the loads (utility and/or end-user), for which its function is to regulate the battery charging rate, charge/discharge, etc. This part of the system determines for which application(s) the system is made available. As an example to indicate the importance of this element, when we use this technology in order to support renewable energy sources Ummels (2008) indicates that without this element we will only provide more load to the system and therefore increases the CO_2 emissions. This is because batteries also allows to be charged from other (non-renewable) energy sources (Ummels, 2009), what it does if it doesn't react on fluctuating supply. Although this element is crucial when we use it for integrating renewables, communication (smart grids) with other units in the grid is needed for the best and most efficient solution. This part (C-PCS) of the system counts for a significant part of the total cost of the complete system, which can be greater than 25% of the total costs of BSS (Divya & Ostergaard, 2009).

The third element of BSS includes all the other parts that are needed to provide a solid protection for the C-PCS and the battery. This part is highly responsible for the safety aspect of the system (Divya & Ostergaard, 2009). Figure 21 provides a diagram of BSS and Figure 22 provides a simplified diagram of BSS.

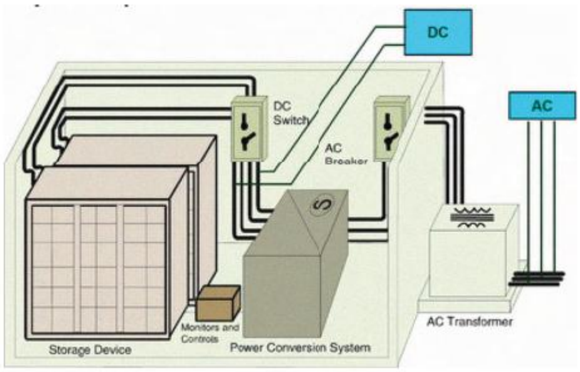

Figure 21: Diagram of BSS (Xueqing, 2009)

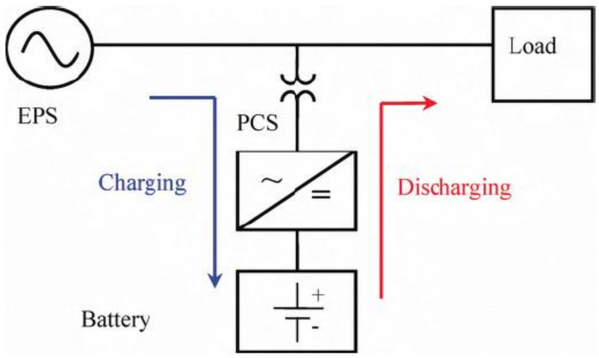

Figure 22: Simplified Diagram of BSS (Xueqing, 2009)

As already mentioned above the Li-ion battery has the highest future potential, due to its favourable characteristics. As a result, this technology is used as the primary battery in the electric drive vehicles (EDV), which will boost the research and development of this technology even more. According Divya and Ostergaard (2009) EDV's will become economically viable and attractive by 2025 and therefore the expectation is that the high costs will decrease tremendously, due to the increasing demand and supply (economic law). At the same time the lifetime will increase due to the high investments in research and development. Secondly, Divya and Ostergaard (2009) indicate that BSS will become increasingly important in the economic operation and reliability of smart grids, in which a significant amount of decentralized renewable power is assumed. This assumption is in line with the two decentralized scenarios of the energy transition scenarios included in appendix D. Nevertheless, the expectation is that not one of those three scenarios will give the perfect representation of how the future will look like, as a combination of those scenarios is expected. As a result, the future role and development of battery storage technologies in the Dutch electricity system is highly dependent on the development of the whole electricity system and the mixture of those three scenarios. However, wind and solar energy is increasing in the Netherlands and therefore the fluctuating output becomes increasingly challenging. Especially in relation with the high prices for spikes in liberalized markets, which have raised the potential rewards for storage technologies and therefore research continues (de Vries, et al., 2009).

4.2 Applications, determining the value proposition

One of the main findings of Chapter 2 is that the technology itself has no value, but that it is all about the applications that are made available through this technology. As a result, the applications will have the biggest share in creating competitive advantages, by making use of the BSS technology. Although BSS can only store energy the trigger to start charging or discharging determines the application. In this section the applications that are recognized in scientific literature as promising and valuable applications for distributed storage technologies are included. Nevertheless, the value of those applications is highly dependent on the electricity system that is used per country. As most literature used in this thesis, related to distributed storage technologies, comes from scientific articles based on case studies performed in the United States of America and Denmark, which uses a different electricity system, we have to value each application for the specific case in the Netherlands. This value assessment is done later on in Section 4.4, after we have recognized the different alternative technologies that can be used to provide the same applications or at least the purpose of those applications. For this thesis eight promising applications are recognized, of which the names and definitions provided by Sandia National Laboratories are used, namely:

1. **Electric energy time shift:** This application focuses on purchasing inexpensive electric energy during periods when the price is relatively low (mostly off-peak periods), so it can be sold or used during expensive periods (mostly on-peak periods) when the price is relatively high (Eyer & Corey, 2010). The primary goal of this application is therefore reducing energy costs. An secondary advantage of this application is that it indirectly support the integration of renewable energy on a large scale. If our renewable energy sources provides large amounts of energy the price is relatively low and when we have a shortage of energy the price is relatively high, so indirectly we stimulate storing energy and therefore renewables.
2. **Ancillary services:** Ancillary services are necessary in order to support the delivery of electricity from supplier to customer, while maintaining the reliability and integrity of the transmission and distribution network. Ancillary services are in this thesis seen as one application, but includes more sub-applications that can be combined to some extent. The different sub-applications are included in appendix E on page 142.
3. **Congestion management (distribution level):** The demand for electricity increases, which results in a continuous building process of new energy production facilities. For these facilities the electricity grid needs to be aggravated and expanded. As the construction of production facilities is much faster than upgrading the electricity grid, congestion may occur (Ministry of General Affairs, 2010). BSS can provide support for congestion management on a distribution level by increasing the efficiency of the grid usage.
4. **Distribution upgrade deferral:** This application involves delaying and preferable avoiding entirely utility investments in distribution system upgrades. As the maximum peak load determines the system's load carrying capacity and therefore the design rating, peak shaving by making use of small amounts of storage is the key theme for this application. The total amount of small storage facilities can be used in order to provide enough incremental capacity to defer large amounts of utility investments in the distribution systems (Eyer & Corey, 2010).
5. **Electric service power quality:** The fifth application adds value to the power quality delivered to the load, by protecting the load from short-duration events that

influences the quality of power. This means that this application, and therefore also the supported technology, should supply power to the system for just a few seconds to about one minute (Eyer & Corey, 2010).

6. **Balancing forecast errors:** The disadvantage of most renewable energy sources (e.g. wind power) is that the output is unpredictable to some extent. In the Netherlands, 24 hours before the actually production of the energy the programme responsible parties have to hand in their energy programs, which they can change until one hour before the actual delivery. At 24 hours before the actual delivery the forecast error standard deviation is around 13% and 1 hour before the actual delivery around 5% for wind power (Ummels, 2009). As the spot market closes one hour before the actual delivery, the remaining forecast errors must be solved on the balancing market. This BSS application can reduce the costs for a renewable energy producer, by balancing the unpredictable forecast errors.
7. **Micro/independent grid:** Micro-grids are relatively small local grids that can function for a certain time period independently from the public electricity grid. The advantage of such a grids is that specific local goals can be achieved, e.g. reliability, cost reduction, carbon emission reduction, diversification of energy sources, power quality, etc. In those micro-grids electricity storage is seen as an essential element for the feasibility (Netbeheer Nederland, 2009).
8. **Demand charge management (incl. Community storage):** This application focuses on BSS technologies installed at the customer or end user side, in order to reduce their overall electricity costs. This cost reduction is made available due to reducing demand charges, which means that electricity demand is reduced during specific periods (time shift), normally during expensive peak periods. Demand charged management enables customers to individually manage their own electricity needs (ESA, 2009a).

A more extensive description of each application is included in appendix E on page 142.

4.3 Alternative technologies, understanding the competition

In order to gain a competitive advantage, with a specific technology, it is important that the most valuable applications can best be supported with that specific technology. In this section the alternative technologies that are available in order to support the same applications, listed in the previous section, or to reach the same purpose of those applications are enumerated. Those alternative technologies are discussed in the next section for determining the unique value of the BSS technology in relation to the different applications listed in the previous section. Note that only the storage technologies are taken into account which can work in both directions (store and release). For this thesis the following alternative technologies are taken in to account:

- **Centralized / Bulk storage:** In order to store large amount of energy for longer periods in time, we use centralized / bulk storage facilities. Those technologies are on average cheaper than decentralized storage facilities, but heavily dependent on the available space and environmental conditions. As a result, those technologies are mainly connected to the transmission grid and are therefore less feasible for balancing the distribution grids. Nevertheless, two different types of technologies exist for centralized/bulk storage, namely *pumped hydroelectricity* and *compressed air* (Ibrahim, et al., 2008).

- **Thermal Energy Storage:** Thermal Energy Storage refers to a number of different technologies that store energy in thermal reservoirs, which can be used later on for generating energy. We can recognize two different types of thermal reservoirs, the first is being maintained at lower temperatures, and the second is maintained at higher temperatures. The technology behind the storage of thermal energies is the ability of water to store large amounts of cold or heat, also called the heat of fusion.
- **Fuel Cell – Hydrogen energy storage:** The fuel cell storage system consists of three main elements. The first element is the electrolyzer, which consumes electricity (off-peak or in the case of renewables at overcapacity) in order to produce hydrogen through water electrolysis. The second element is the hydrogen buffer tank in order to store the produced hydrogen. The third element is the fuel cell that uses the stored hydrogen and the oxygen from the air to generate electricity (Ibrahim, et al., 2008).
- **Flywheels:** Flywheel energy accumulators consist of a massive flywheel connected to a generator and special (mostly magnetic) brackets, placed inside a housing at low vacuum or at very low pressure to reduce self-discharge losses. The generator/motor is connected to the utility grid, in order to store or produce electricity (ESA, 2009b; Ibrahim, et al., 2008).
- **Super capacitor:** The super capacitor is a combination of a normal capacitor and an electrochemical battery, although in this device no chemical reaction will take place. As no chemical reaction takes place, the cycling capacity is increased enormously compared to that of batteries. As a result, this device works the same as a normal capacitor, but against much better performance (ESA, 2009b).
- **Superconducting magnetic energy storage (SMES):** SMES systems store energy in a magnetic field by inducing direct current (DC) into a coil made of superconducting cables. Those cables have a resistance of almost zero, which must operate under its superconducting critical temperature. This technology is ideal for regulating network stability.
- **Other non-storage alternatives:** Next to the different alternative storage technologies also two other solutions can provide or disable the need for some applications mentioned in the previous section. Those two solutions are:
    - ***Demand side management****:* This alternative creates flexibility is adapting demand to supply, which is against the thought of how the electricity market is organized nowadays. In the current market setting supply is following demand, while in the case of demand side management demand will follow supply. The reason behind this is the thought that due to an increasing amount of renewable energy sources demand will become increasingly difficult to control, as renewables are mainly dependent on weather conditions. Nevertheless, the consumer demand can be controlled to some extent by fluctuating energy prices or regulation.
    - ***Grid reinforcement****:* The conventional way of solving transport problems is grid reinforcement, e.g. “heavier” grid components and thicker or parallel cables. Current grids are designed for handling the maximum peak load that may occur, which is very often 10 times higher than the average load (Ibrahim, et al., 2008). As this peak load only occurs a few times per year, this investment is quite inefficient. Nevertheless, as the life expectancy of grid reinforcements is over 40 years, the resulting net present value of this alternative is quite good, including relatively low risks (Meijer, 2009).

A more extensive description of each application is included in appendix E on page 142.

4.4 Value Assessment

In the previous three sections we have analysed the technology, its applications and the available alternatives. In this section those three variables and the results of the previous chapters are compared in order to determine the value proposition of Battery Storage Systems (BSS), understanding the main competition and determining the actors involved. The result of this comparison will be used as an input for the field analysis and the business models of the next chapters. In order to gain a solid foundation three decision matrixes are used in this section, which are filled in (by the researcher) on the basis of the insight gained by the previous chapters.

4.4.1 First comparison

The first comparison made is between the three variables analysed in the previous three sections. The results of this comparison are included in Table 1. This table mainly indicates which technologies or alternative solutions can be used for providing the different applications. Furthermore, this table also indicates the competition between those different technologies and alternative solutions. In this table the Fuel Cell technology is included as an unknown technology, because current public available literature related to this technology is very limited. Therefore determining the future expectations of this technology is a study on its own, which is out of scope for this research. Nevertheless, we should keep in mind that this technology will probably become more important in the future.

Table 1: Applications vs. Technologies / Alternatives

Nr.	Applications	Technologies / Alternatives									
		BSS	Pumped hydroelectricity	CAES	Thermal Energy Storage	Fuel Cell	Flywheels	Super capacitor	SMES	Demand side Management	Grid reinforcement
1	Electric Energy Time Shift	++	++	++	++	?	+	-	-	++	-
2	Ancillary Services										
2.1	Load Following	+	+	+	+	?	+	-	0	+	-
2.2	Area Regulation	++	0	0	0	?	++	+	++	0	-
2.3	Regulation, Reserve and emergency power	+	++	++	0	?	0	-	-	+	-
2.4	Voltage Support	+	++	++	0	?	+	0	+	0	-
2.5	Spinning Reserve	0	++	++	0	?	-	-	-	-	-
2.6	Black Start	++	0	0	+	?	-	-	-	-	-
2.7	Frequency Control	0	++	++	-	?	+	-	+	-	-
2.8	Intra PTU	+	0	0	0	?	-	-	-	0	-
3	Congestion Management	++	0	0	0	?	-	-	-	++	++
4	Distribution upgrade deferral	++	-	-	0	?	-	-	-	++	++
5	Electric service power quality	+	+	+	0	?	++	++	++	0	-
6	Balancing forecast errors	++	+	+	++	?	0	-	-	+	-
7	Micro/independent grid	++	-	-	0	?	+	-	-	++	-
8	Demand charge management	++	-	-	-	?	-	-	-	-	-

BSS: Battery Storage System	++	:	Fully capable and reasonable
CAES: Compressed Air Energy Storage	+	:	Reasonable for this applictation
SMES: Superconducting magnetic energy storage	0	:	(Maybe) Feasible but not quite practical or economical
	-	:	Not feasible or economical

One of the main disadvantages of BSS is that the lifetime of the battery is mainly dependent on the charge/discharge cycles. For this reason the applications with a high frequency in occurrence are less feasible with BSS. Those applications are usually characterized with short discharge times and limited power ratings. For those applications super capacitors, SMES and flywheels are more feasible. For the applications with a medium discharge time and a medium power rating (see Figure 20), preferable in distribution (medium and low voltage) grids, BSS is one of preferable storage technologies. The main competition on this level is between BSS, thermal energy storage, demand side management and grid reinforcement. Dependent on the specific case one of these technologies will gain the highest value, for which in some cases a combination is required. Thermal energy storage will for example be the preferable energy storage technology in the case in which companies have a large refrigerator, produces heat as a by-product, etc. Demand side management is recognized in the energy industry as a cheap solution to many problems, although the bandwidth that can be controlled is highly dependent on the consumers profile and his need/urgency for energy. For this reason many experts expect that demand side management will be the first priority and that storage will be used as a supplement (see Chapter 5). The last competitive alternative is the current way of working, namely grid reinforcement. This alternative is mainly in competition in the case of congestion management and distribution grid deferral. The primary focus of those two applications is cost savings, which means that BSS should be cheaper than this alternative.

4.4.2 Second comparison

The second comparison focuses on the applications in relation to the system requirements determined in the previous chapter. The results of this comparison are included in Table 2, which indicates the value of each application. Although the different requirements can have different weight factors, for this comparison all requirements are treated as evenly important.

As Table 2 concludes, the electric energy time shift application adds the most value to the Dutch electricity system as a whole. This application adds value to the reliability for several reasons, e.g. overloading the system will become more difficult when we are able to shift peak loads. The next requirement for which this application adds value to is affordability. One of the main purposes of this application is to shift the expensive peak demands to the cheap time periods, which must result in cheaper average energy prices, but also in cheaper grid fees. The third requirement where this application adds a significant value to is economically. This is mainly because this application enables grid operators to use their equipment more efficiently. Next, this application also adds value to the security of supply. When we have stored energy, we can use this energy in the case an error occurs. While looking also at the "new" system requirements, which are becoming more important due to external forces as explained in the previous chapter, this application adds value to three of the four requirements. The first requirement is efficiency, as equipment does not have to be engineered for the heaviest load, but for the average load. Next, this application also adds value to the requirement sustainability, because this application allows a further integration of renewable energy sources (storing in case of overcapacity and discharging in case of undercapacity). The last requirement where this application adds value to is flexibility. As the expectation is that both demand and supply will fluctuate more and will become less controllable in the future, flexibility is needed in the system. On distribution level, this application enables flexibility to a certain extent by filling the gap between electricity demand and supply.

Table 2: Applications vs. System requirements

Nr.	Applications	System requirements: Current: Reliability	Safety	Affordability	Economically	Quality	Security of Supply	Accessibility	New: Efficiency	Sustainability	Flexibility	Transparency	Total
1	Electric Energy Time Shift	+	0	++	++	0	+	0	++	+	++	0	**55**
2	Ancillary Services												
2.1	Load Following	0	0	0	0	++	0	0	0	0	0	0	**10**
2.2	Area Regulation	0	0	0	0	++	0	0	0	0	0	0	**10**
2.3	Regulation, Reserve and emergency power	++	+	0	0	++	++	0	0	0	0	0	**35**
2.4	Voltage Support	0	0	0	0	++	0	0	0	0	0	0	**10**
2.5	Spinning Reserve	+	+	0	0	++	++	0	0	0	0	0	**30**
2.6	Black Start	+	0	0	0	++	++	0	0	0	0	0	**25**
2.7	Frequency Control	0	0	0	0	++	0	0	0	0	0	0	**10**
2.8	Intra PTU	0	0	0	0	++	0	0	0	0	0	0	**10**
3	Congestion Management	+	0	+	++	0	+	+	+	0	+	0	**40**
4	Distribution upgrade deferral	0	0	++	++	0	0	0	++	+	+	0	**40**
5	Electric service power quality	0	0	0	0	++	0	0	0	0	0	0	**10**
6	Balancing forecast errors	+	0	+	++	0	+	0	+	++	++	0	**50**
7	Micro/independent grid	+	0	0	+	0	++	0	0	0	++	0	**30**
8	Demand charge management	+	0	+	+	0	++	0	+	+	++	0	**45**

Assumption: all requirements are evenly important

		Value of indicator
++	: Add good value to requirement	10
+	: Add reasonable value to requirement	5
0	: Does not add extra value to requirement	0
-	: Has negative effect on requirement	-5

The second promising application focuses on balancing forecast errors, which are primary caused by renewable sources and secondary by shifting demands. As this application has some similarities with the application electric energy time shift, the requirements where this application adds value to are also comparable. The main difference between those two applications is that electric energy time shift is primary driven by price incentives, while this application is primary driven by balancing renewables for system operating purposes. Nevertheless, indirectly this application also reduces costs, as imbalances are currently solved with an expensive imbalance market (see Chapter 3). In practice a combination of those two applications is feasible and can therefore be very valuable. The first two requirements this application adds value to is reliability and security of supply, e.g. when the prediction of wind power is higher than the actual wind power this application can supplement the difference and therefore improve the reliability of integrating renewable energy sources. The second requirement is economically. As we have learned from the case in Denmark, but also from the business cases of renewable integration in the Netherlands, unpredictable and uncontrollable energy sources have some negative effects. In the case of overproduction energy should be sold for extreme low or even negative energy prices, while in the case of underproduction energy should be bought for extreme high prices. As a result, it becomes very difficult to come up with a positive business case for renewable energy production facilities. Next, this application also adds a significant value to the "new" requirements. At first, this applications adds value to the requirement efficiency, because it enables efficient usages of renewable energy sources, as selling energy for negative prices is not quite efficient. The second requirement is sustainability, which is quite obvious because of the further integration of renewables on an efficient manner. The last requirement this application adds a significant value to is flexibility, which is primary done by filling the gap between the actual and forecasted electricity supply.

The third most valuable application, considering the requirements of the Dutch electricity system, is the demand charge management application. Although this application focuses on individual consumer needs, implementing this application on a large scale will result in benefits for the whole system. The first requirements this application adds value to are reliability and security of supply, which is because of the possibility of providing electricity supply in the case of interruptions. The second requirement is affordability, which can be realized by buying cheap electricity off-peak and using the cheap energy when the electricity prices are high (on-peak). The second advantage for large-scale consumers can be to reduce the capacity tariffs, which means also a shift in risks. When the consumer decides to reduce capacity tariffs the risk of being able to cover the peak load will shift to the consumer, as the supplier and the grid operator will in that case only be responsible for the contracted capacity. Therefore this solution can be less attractive for consumers that are highly dependent on electricity, e.g. companies performing accurate chemical processes or hospitals. The next requirement is economically, because in the case of large scale introduction the electricity system will be optimized for all users active in the Dutch electricity system. This application also adds value to the “new” Dutch electricity system requirements. At first this application stimulates to efficiently leverage the individual consumer requirements and therefore stimulates the mass-individualisation effect explained in Section 3.3. As the government currently stimulates sustainability for households, e.g. subsidy for implementing photovoltaic solar panels on rooftops, this application enables consumers to be less dependent on the electricity grid and provides solutions for integrating large amounts of decentralized production facilities. As a result, this application contributes to the requirement sustainability. The last requirement, flexibility, will be supplemented with this application, as we are able to shift demand in time.

The fourth interesting and valuable application is the congestion management (distribution grid) application. The reason why this application is of high value is because grid operators are not able, due to the Dutch Electricity Act 1998, to block any electricity generators to the grid. As a result, because of some environmental compositions, many generators pop-up in the same area, which result in congestion. The first requirement, reliability, will be completed by levelling the energy that needs to be transferred over the power cables. Therefore, we are able to handle more energy with the same equipment, which increases the reliability from at least a producers point of view. The second requirement where this application will adds value to is affordability. The primary reason is that congestion management, which cost extra unnecessary costs, will be limited to the maximum. Furthermore, this application adds a significant value to the requirement economically, because of the optimal usage of equipment (cables, trafo’s, etc) and the unnecessary investments needed for congestion management. Another disadvantage of congestion management, as it is implemented nowadays in the Dutch electricity system, is that in the case of congestion somewhere else in the grid electricity should be generated. This means that we are in the case of congestion dependent on other parties in the grid, which can have a negative effect on the security of supply. With this application this negative effect can be reduced to the limit, which means that this application adds value to the requirement security of supply. Although the Dutch Electricity Act 1998 disallow grid operators to block generators by not connecting them to the grid, without this BSS application the accessibility requirement can still be disturbed. E.g. when a significant amount of renewable energy sources is connected to a congestion area, we must shut down some renewable energy sources in the case of congestion. In this case the accessibility to renewable energy from other parts of the country becomes more difficult. Therefore, this application adds value to the accessibility requirement. Nevertheless, this application adds also value to the “new” requirements. At first, our equipment and energy sources will be used more efficient than allowing congestion, as explained before. While secondly, we create flexibility for producers to generate their energy at different points in time, which enables them to produce the contracted amount of energy.

The fifth application that is quite attractive from a system requirements point of view is distribution upgrade deferral. This application adds value to five requirements given in Table 2. The first requirement for which this application adds a significant value to is affordability, which is the main purpose of this application. This application enables an increased efficiency usage of the distribution grids and therefore deferring the investments that are needed. Although this application is to make the grid more affordable the main challenge here is to find technologies that are significantly cheaper than performing grid upgrades. The second requirement is economically, which can be realized by significantly increasing the efficiency of the current equipment installed. E.g. the current cables are engineered for peak loads that only occur a few times per year, for which the peak load is mostly 10 times higher than the average load (Ibrahim, et al., 2008). As a result, this application also adds value to the “new” requirements. At first, the efficiency requirement is supplemented, by improving the efficiency of current equipment installed, in order to defer distribution upgrades. Secondly, the sustainability of the system increases, e.g. because this application enables the introduction of renewables without the direct need for high distribution upgrades. At last, this application adds value to the flexibility requirement, because it provides flexibility in the time of transferring energy over the currently available equipment.

The other applications listed in Table 2 are less interesting from the Dutch electricity system requirements point of view, because those applications only provide some value to one or a few requirements. The second reason why those other applications are less interesting is that those applications can better be performed by alternative technologies instead of BSS, determined by Table 1.

4.4.3 Third comparison

The third comparison, included in Table 3, assess the value of each application per actor. Note that the value of each application in Table 3 is the value determined by Table 2. The first important insight this table provides is that three of the ten actors involved in the Dutch electricity sector will not gain any significant benefit from one of the applications. Therefore, those three actors will be ignored during the design process in Chapter 6. Secondly, the regional grid operators seem to benefit the most. Therefore one of the business models designs in Chapter 6 will primary focus on the regional grid operator as the owner of this technology, in order to provide the most interesting applications. The second actor in the list who benefits the most of those applications is TSO TenneT. As Table 3 does not include any technology restrictions, this table should be compared with the technology comparison made in Table 1. While comparing both tables it becomes clear that the technology BSS is not able to cover any of those applications on the voltage level were TenneT is operating on. BSS is only applicable on distribution (medium and low voltage) level, while TenneT is operating on transmission (high voltage) level. If we would like to provide those applications on a transmission level, Table 1 indicates the technologies that are the most feasible, namely Pumped hydroelectricity and CAES. TenneT is therefore not recognized as a key actor for the business model design in Chapter 6.

Table 3: Applications vs. Actors

Nr.	Applications	Value	Actors of the Dutch Electricity System: Office of Energy Regulation	Dutch Ministry of Economic Affairs	Program Responsible Party	Traders & Brokers	Retailers	Metering Responsible Paries	Producers	TSO TenneT	Regional Grid Operators	Large & Small Consumers
1	Electric Energy Time Shift	55	0	0	++	+	++	0	++	++	+	0
2	Ancillary Services											
2.1	Load Following	10	0	0	0	0	0	0	0	+	+	0
2.2	Area Regulation	10	0	0	0	0	0	0	0	+	+	0
2.3	Regulation, Reserve and emergency power	35	0	0	0	0	0	0	+	++	+	0
2.4	Voltage Support	10	0	0	0	0	0	0	0	+	+	0
2.5	Spinning Reserve	30	0	0	0	0	0	0	+	0	+	0
2.6	Black Start	25	0	0	0	0	0	0	+	+	+	0
2.7	Frequency Control	10	0	0	0	0	0	0	+	+	+	0
2.8	Intra PTU	10	0	0	0	0	0	0	+	++	0	0
3	Congestion Management	40	0	0	0	0	0	0	0	0	++	0
4	Distribution upgrade deferral	40	0	0	0	0	0	0	0	0	++	0
5	Electric service power quality	10	0	0	0	0	0	0	0	+	+	0
6	Balancing forecast errors	50	0	0	+	+	+	0	++	+	+	++
7	Micro/independent grid	30	0	0	0	0	0	0	0	0	++	++
8	Demand charge management	45	0	0	0	+	+	0	0	0	0	++
	Total		**0**	**0**	**800**	**750**	**1025**	**0**	**1600**	**1625**	**2325**	**1250**

		Value of indicator
++	: Add good value to actor	10
+	: Add reasonable value to actor	5
0	: Does not add extra value to actor	0
-	: Has negative effect for actor	-5

The third actor that is of primary interest is the producer. As a result of the vertical unbundling process, explained in Section 3.2.1, commercial energy providers in the Netherlands mostly integrate the following actors into one single company:

- Producer;
- Programme Responsible Party;
- Trader & Broker;
- Retailer.

Although this integration is not obligated and therefore is not the only structure that can be found in the Dutch electricity market, the largest companies do integrate those four actors. As a result, those four actors will be combined into one actor group in Chapter 6.

The last important actor is the large and small consumer (or prosumer). Although this actor only includes plusses for three applications, the indirect objective of the other applications is also based on adding benefits to the end consumer. Nevertheless, those benefits will be realized indirectly and are therefore not included in the column of the consumer. The consumer/prosumer will be the main focus for the third business model design in Chapter 6.

4.5 Conclusion

Battery Storage Systems consist of three main elements. The first element is the battery itself, for which this chapter takes the characteristics of nine batteries into account. Although those nine batteries are taken into account, scientific literature concludes that the lithium-ion battery has the highest future potential. The second element is the Control and Power Conditioning System (C-PCS), which includes all the equipment that interfaces the battery to the load(s). The third element is the protection equipment that protects the battery and the C-PCS from any damage. As a result of the technology analysis, we can conclude that Battery Storage Systems are only feasible on a distribution (medium and low voltage) level. Consequently, eight applications, for which the application ancillary services is divided into eight sub-applications, are chosen in order to study into more depth in this chapter. Thereafter, the alternative technologies and solutions that can provide the same applications are analysed. In total nine alternatives are researched into more depth in this chapter.

Next, a value assessment is executed by the researcher in order to determine the basic inputs for the interview and business model design process, namely the most promising applications and actors. In order to provide a solid foundation for the choices that has to be made three decision matrixes are used. The conclusion of the first and second matrix together is that the primary focus should be on the following applications:

- Electric Energy Time Shift;
- Balancing forecast errors;
- Demand charge management;
- Congestion management;
- Distribution upgrade deferral.

For which the main competitive alternatives are:

- Thermal Energy Storage;
- Demand side management;
- Grid reinforcement.

Nevertheless, this research does not exclude that a combination of the alternatives can lead to better total solutions. At last, in this chapter the different actors involved in the Dutch electricity system are compared with the applications in order to determine the key actors. The result of this comparison is that the focus should be on the following three actors (groups):

- Regional grid operator;
- Electricity provider, includes: producer, programme responsible party, trader & broker and retailer;
- Consumer (or prosumer).

In order to enhance the reliability and validity of the research done in this and the previous chapters, part of the interviews executed in the next chapter is validating the results of those chapters. This includes the results of the three decision matrixes. Thereafter, the results of those chapters are used as an input for the business model designs in Chapter 6.

5 Field analysis, an expert consultation

In this chapter the results of the previous chapters are evaluated on their requirements and target values. This means that all the decisions taken and choices made during this research project so far are evaluated in practice and that the collected case study results are tested for the specific case in the Netherlands, which provides an extensive reality check. Furthermore, this field analysis provides extra information regarding the required business model inputs, which are not yet included in (scientific) literature. Those "new" insights are used in the design process of the next chapter. As a result, this chapter includes the data collection plan / protocol (Section 5.1) and the results of the collected data (Section 5.2). The collected data itself is not included in this chapter, but in appendix H. The conclusion, Section 5.3, of this chapter provides the transition towards the design process, which is provided by the next chapter.

5.1 Data collection plan / protocol

This section includes the fundamental procedure that is used to collect the required data for this field analysis. Therefore this section deals with administrative and management issues, in order to collect and monitor the data efficient and accurate and to ensure the required quality.

5.1.1 Operationalizing

The first step in the data collection protocol is determining which research questions we need to answer in order to have a valid validation review and to collect the additional business model data required. Therefore, this section makes the process and results measurable for testing and data collecting purposes, for which the book "Guide to management research methods" provides the guidelines (Velde, et al., 2004). Based on the research questions that are determined in this section the data collection process, instruments, etc can be designed in order to get the most optimal results. The validation part should be based on testing all the important decisions and choices made during the project process. Furthermore, this part should validate the collected data of the previous chapters, as a large part is based on case studies carried out in different surroundings (mostly in Denmark and the United States of America). In order to get valid results Balsters (2008) advises two validation processes, namely the flowdown and flowup validation process. The flowdown process starts the validation process with testing the first decision made and goes on in a sequential process towards the last decision. The flowup process does the validation process in the reverse sequence. As not one of the two validation processes has a clear preference the researcher is free to choose his or her preferable process, as long as the researcher sticks to the right sequential flow (Balsters, 2008). For this research the flowdown process is chosen. The second part of the research questions aims at collecting the required business model input, which covers all the business model issues provided by the framework of Osterwalder, included in Chapter 2. The research questions are included in the right order in Figure 23.

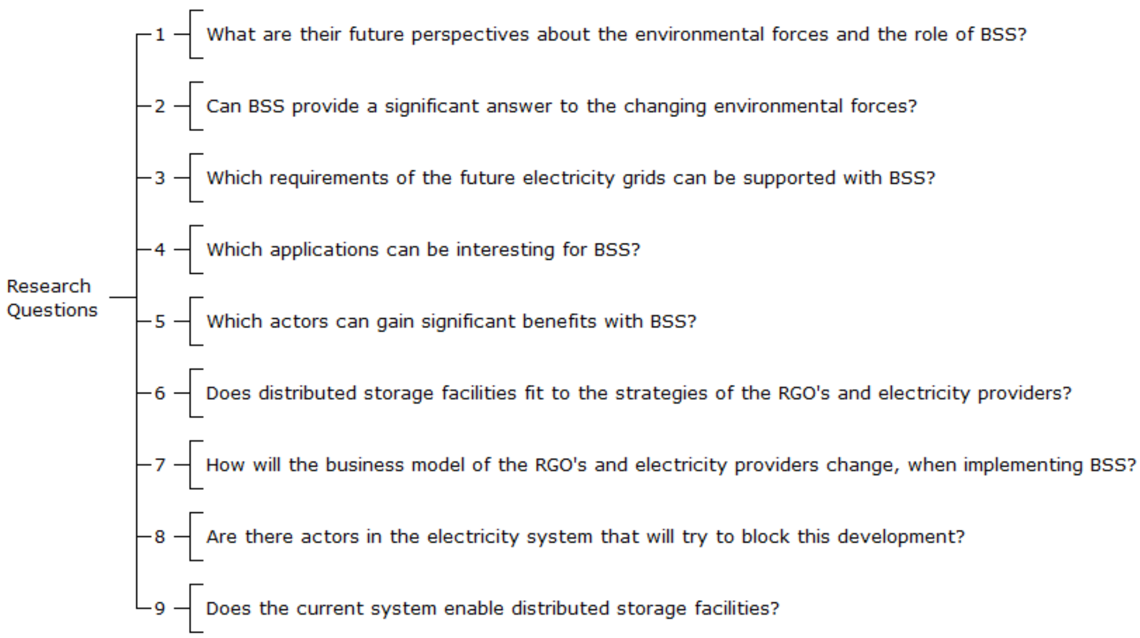

Figure 23: Research questions for collecting the required data

5.1.2 Measurement instrument

In order to collect the data that is needed for this research a measurement instrument is required. Based on the previous section, in which the research questions are designed, the choice has been made for interviews. According to Van der Velde, Jansen and Anderson (2004) interviews are the most suitable measurement instruments when the research concerns knowledge, opinion/attitudes and facts of individuals, which is the case for this research. Nevertheless, Van der Velde, Jansen and Anderson (2004) also describe that questionnaires can be a valid measurement instrument in this case. For this research the following tradeoffs has been made that lead to the measurement instruments interviews instead of questionnaires:

- Due to the specific sample made in the following section a high response rate was required, as only a few people satisfy the sample requirements. The response rate for interviews is generally higher than for questionnaires (Velde, et al., 2004).
- Direct interaction with the respondents will provide the intention behind the answer.
- More topics can be addressed than in questionnaires.
- Smaller risk that questions will be skipped, because the researcher can monitor and restore any omissions if necessary.
- In the case of unclear questions or ambiguities the researcher can explain the question by providing additional information.
- Time consuming, so less people can be reached compared to questionnaires. This is not a primary issue for this research as the total amount of people that fulfil the sample requirements is limited.
- More difficult to analyse and generalize the results, which is solved by using a semi-structured interview, explained below.
- The chance that the sample is too small, in such a way that it does not represent the total population, is more likely for interviews. This problem is limited to the

maximum, explained in Section 5.1.3, 5.1.4 and 5.1.5. Nevertheless, the remaining risk related to this problem is taken for this research.

In order to get the intention behind the answers and to make the interview easier to generalize a semi-structured interview form is designed, explained in Section 5.1.6. Most questions that are asked during the interview started with a closed question on a linkert scale in order to let the interviewee think about the direction of his or her answer, which is easy to generalize. After the interviewee had answered the closed question an open question followed to give his or her explanation, which focuses on the intention behind the answers. As a result, two measurement types are used for this data collection method. The open questions are primary based on a qualitative research, which uses a nominal scale. The closed questions are based on a linkert scale, which is a quantitative measurement type, based on an interval scale.

5.1.3 Population and Sampling

The population of this research project are all the actors involved in the Dutch electricity system, which are included in Figure 18 on page 33. As those actors consist of many different organizations a sample that will represent those actors is needed. In order to interview the right representatives the following (semi-random) selection process has led to the 14 different interviews performed for this research:

Selection step 1, reducing actors

Figure 18 consist of different actors that are active in the Dutch electricity system, but not all of them will be affected by the implementation of BSS. As a result, the first selection is on an actor level, in which only the affected and related actors are involved. The following selection has been made:

- National regulator;
- Producers;
- Regional Grid Operators;
- TSO TenneT;
- Traders and brokers
- Retailers;
- Programme responsible parties;
- Knowledge and technology providers;
- Local government.

Selection step 2, combining actors

In the Netherlands many actors implement a horizontal and vertical integration strategy, which causes organisations that includes more actors. As this is a common composition the second selection has brought different actors together into one actor group. As a result, the following actors are brought together in the actors group “electricity providers”:

- Producers;
- Traders and brokers;
- Retailers;
- Programme responsible parties.

Selection step 3, Selecting companies

The third selection step determines the companies/organisations that will represent each residual actor. For those residual actors the following selection, including the motivation, is made:

- **National regulator:** This actor consists of only one organisation, namely the Office of Energy Regulation (in Dutch NMa Energiekamer);
- **Regional Grid Operators:** This actor consists of eight different companies, of which three companies dominate the market, as explained in Chapter 3. Those three companies together own over 90% of the total Dutch distribution market. As a result, those three companies are selected. The three companies are Eneco, Liander (which is part of Alliander) and Enexis. Nevertheless, also the foundation e-laad is added to those three representatives, as this foundation is an alliance between the eight RGO's within the Netherlands that work together on making electric drive vehicles possible. This foundation is therefore closely involved with storage issues related to distribution grids.
- **Transmission System Operator (TSO):** This actor consists of only one organisation, namely TSO TenneT;
- **Electricity providers:** In consensus with experts of the Delft University of Technology and Siemens Nederland, a random selection between electricity providers has been made. Nevertheless, the random selection was made out of a pool of electricity providers, which were known at the Delft University of Technology and Siemens Nederland for their good previous experiences and their current involvement in storage pilots. As a result, of the semi-random selection, the electricity providers Eneco and Essent are chosen for this sample.
- **Knowledge and technology providers:** In consensus with the Delft University of Technology and Siemens Nederland four different companies are selected. Those four companies are within and outside the Netherlands active in storage projects related to smart grids and distributed storage. Those four organisations are TNO, Cofely, ECN and KEMA.
- **Government:** For this actor the municipality of Rotterdam is selected, which is chosen based on the knowledge that the responsible person is also involved in the Taskforce Smart Grids (Van der Hoeven, 2010).

Selection step 4, Function profile required

The last selection step determines the function profile of the interviewee that is required within the selected companies / organisations. The interviewee should have the following characteristics:

- Great knowledge about the electricity market, which should be part of his or her daily job.
- Familiar with Smart Grids and preferable with distributed storage.
- Should have decision making power or have a consultant role within the company / organisation.
- Should have or work at least on a higher education level.

This function profile has resulted in the interviewee list included below in Table 4.

Table 4: Interviewee list

Nr.	Actor	Company / Organisation	Function
1	TSO	TenneT	Business Planner
2	RGO	Enexis	Innovation Manager
3	RGO	Stedin	Innovation Specialist Smart Grids
4	RGO	Alliander	- Innovation Manager - Graduate Student TU/e (E-storage)
5	RGO	E-laad	R&D Manager
6	Electricity provider	Eneco	Strategy Consultant
7	Electricity provider	Eneco	Senior Innovation Manager
8	Electricity provider	Essent	Manager Electric Transportation
9	Knowledge & technology provider	Cofely	Business Developer Smart Grids
10	Knowledge & technology provider	ECN	Program Manager Smart Grids
11	Knowledge & technology provider	TNO	Senior Business Consultant
12	Knowledge & technology provider	KEMA	- Principal Consultant Energy Storage - Consultant
13	National Regulator	Office of Energy Regulation	Senior Member of Staff
14	Government	Municipality of Rotterdam	- Alderman for Sustainable Development, Inner City and Public Spaces - Project leader Sustainable Mobility

The interviews number 4, 12 and 14 consisted of two interviewees, which were interviewed at the same time. A more extensive list is included in Appendix H. Furthermore, a 100% response rate was obtained.

5.1.4 Reliability

The reliability can be made concrete in term of repeatability (Velde, et al., 2004). As a result, the reliability of the interview is evaluated and guaranteed by taking the following four issues into account:

- The questions are designed on the basis of a solid business model framework, which guarantees that all the important questions related to the business model design issues are covered.
- Extensive selection of interviewees performed, which guarantees the reliability of the answers given.
- Questions are reviewed by professionals of the Delft University of Technology and Siemens Nederland.
- Test-retest method is used. This means that a test interview is executed with a colleague student and repeated the next week. The colleague student answered the questions with the same answers, which indicate the quality of repeatability.

5.1.5 Validity

The validity determines the extent to which the interview measures what we want to measure. Although the general characteristic of interviews is that they already have a good and positive effect on the validity of the research (Andriessen, 2009), for this research we have taken the following four issues extra into account to guarantee the validity:

- The data collection process follows a proven methodology, described by Van der Velde, Jansen and Anderson (2004).
- Research questions are reviewed by professionals of the Delft University of Technology and Siemens Nederland.
- The validity of Chapter 2 is confirmed with an interview included in Appendix B.
- The external validity (generalization) is confirmed by focussing on an actor level.

5.1.6 Data collection process

The last part of the data collection plan / protocol is concerned about the interview itself. This includes the preparation for the interview, the process during the interview, the structure of the interview and the analysis process of the data afterwards.

An interview requires a significant time period of the interviewee. Therefore, we are limited in the questions that can be asked during the interview. Based on the sample determined in Section 5.1.3, the time frame needed for the interviews was on average between 1 and 1,5 hours. Since the full agenda's of the interviewees and to let them speak in familiar surroundings, the interviews were carried out at the interviewees' side. During the interviews a voice recorder is used in order to make the interview more personal, as the interviewer does not have to write the whole time. Furthermore, the recorded interviews are used during the data processing to ensure that important details are included. This enhances the reliability and validity as well. Nevertheless, the recorded interviews and the answers on the questions were used confidentially. This means that only the interviewer used the recorded interviews and that the answers could be checked first by the interviewee before including it in this report. Furthermore, the interviewees required anonymity and therefore the answers and the names are disconnected from each other in this report. The results of the interviews are included in Appendix F.

The interview process itself started one week before the first interview was carried out, by sending the interview protocol (appendix G) to all the interviewees. Having the interview protocol at least one week before the execution of the interview itself was experienced pleasant by the interviewees, although most of the interviewees had no time to read it on beforehand. During the interview itself the interview procedure included in Table 5 was used to ensure a smooth process.

The collected data is summarized per actor group in appendix F, which makes it easy to compare and to draw the conclusions per research question, included in the next section. In order to create the maximum required anonymity, three actor groups are defined, which are:

- Electricity providers (key actor);
- Grid Operators (Key actor);
- Other actors (all non-key actors).

Table 5: Interview procedure

<table>
<tr><th>Nr.</th><th>Name step</th><th>Content / Comments</th></tr>
<tr><td>1</td><td>Introduction</td><td>Introducing each other and informal talk</td></tr>
<tr><td>2</td><td>Explanation</td><td>Explain the research and the reason for the interview</td></tr>
<tr><td>3</td><td>Building trust</td><td>Explain how to deal with the answers: voice recorder only for own use, confidential information will not included in the thesis, possibility to review the answers first and create anonymity by disconnecting the names from the answers.</td></tr>
<tr><td>4</td><td>Discuss the plan</td><td>Discuss the outline of the interview and the time available for the interview</td></tr>
<tr><td>5</td><td>Executing questions</td><td>Executing the interview questions in order to collect the data required to answer the research questions included in Section 5.1.1. The interview questions (included in appendix G) are related as follows to the research questions:
<table>
<tr><th>Research questions (Section 5.1.1)</th><th>Interview questions (appendix G)</th></tr>
<tr><td>1</td><td>1, 2, 19, 20</td></tr>
<tr><td>2</td><td>3, 4, 5</td></tr>
<tr><td>3</td><td>16</td></tr>
<tr><td>4</td><td>6, 7</td></tr>
<tr><td>5</td><td>8, (17)</td></tr>
<tr><td>6</td><td>9, 10</td></tr>
<tr><td>7</td><td>11, 12, 13, 14, 15</td></tr>
<tr><td>8</td><td>17</td></tr>
<tr><td>9</td><td>18</td></tr>
</table>
</td></tr>
<tr><td>6</td><td>Evaluate</td><td>Evaluate each answer, but also the interview in total, in terms of completeness of the answer, relevance and validity.</td></tr>
<tr><td>7</td><td>Close</td><td>Thank the interviewee for his or her time and explain what the further procedure will be (close smoothly).</td></tr>
</table>

5.2 Interview results, a field research

This section provides the main results of the interviews. The complete data is included in Appendix H. Although the main purpose of the interviews was to provide answers on the research questions (Section 5.1.1), the interview questions itself were not directly formulated like this. The interview questions were indirectly linked to the research questions, in order to get the most information out of the interviewees and to indirectly link the questions to the scientific framework used for this research project. Nevertheless, this section will provide the outcome of the nine research questions, on the basis of the fourteen interviews performed.

5.2.1 Research question 1

The first research question validates the second part of Chapter 3, namely the environmental forces, and provides additional information which is not included in scientific literature. The aim of this question is to understand how the involved actors expect that the electricity sector will change and how they will react on this development. Secondly, the role of BSS is tested in order to understand the need for this technology. To give this forecast more value the timeframe and the chance of having a significant role in the Dutch electricity sector is added. This first research question is formulated as follows:

"What are their future perspectives about the environmental forces and the role of BSS?"

All interviewees (100%) expect that BSS will become increasingly important in the future Dutch electricity system. The only question that arises is what the magnitude of this technology will be, compared to the complete system. The magnitude will determine the level of significance and the value of BSS within this system. The level of significance will therefore determine of this technology will get a crucial role, which is answered differently among the interviewees. Around 70% of the interviewees expect that the role of BSS will become important, but not crucial. The expectation is that compared to the total value of the Dutch electricity system, BSS will add only a small contribution. Furthermore, the expectation is that this technology will first be implemented for power applications and after a significant improvement also for energy applications.

A significant part of the interviewees expect that the success of BSS will mainly be determined by the penetration level of decentralized (renewable) generation and the success of its competition, namely demand side management. The expectation of the penetration level of decentralized (renewable) generation is widely spread over the interviewees, which indicates the high level of uncertainty. Half of the interviewees believe that the largest share of our electricity will be generated centrally, while the other half believe more in decentralized generation. Nevertheless, both groups believe that not one of the outlined scenario's will pure and only become the future, but that it will become a mixture of both. Therefore, the penetration level of decentralized generation is uncertain, which is indirectly related to the uncertainty level of BSS. The second uncertainty for BSS is the success rate of demand side management. As the expectation is that demand side management is much cheaper than storage technologies and will more or less create the same flexibility level, most interviewees indicate that this technology has their highest priority. This means that BSS will be implemented only for the parts that cannot be solved with demand side management, which indicates the high-risk level for investing in this technology. Nevertheless, we should keep in mind that demand side management creates more power at the actors involved, while storage on local level can create more power for the consumers. Therefore, choosing for demand side management can also be a strategic choice for creating lock-in effects.

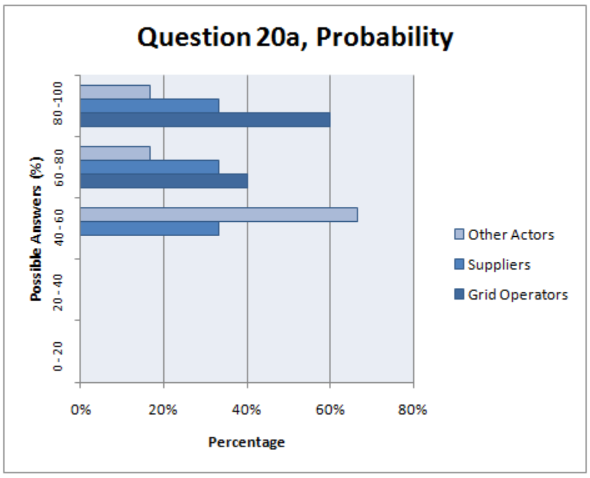

Figure 24: Result interview question 20a: "*What is the probability that BSS will become part of our electricity system?*"

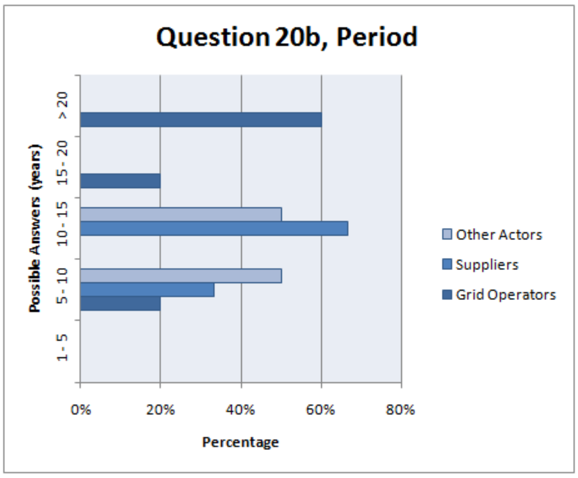

Figure 25: Result interview question 20b: "*When do you expect that BSS will become part of our electricity system?*"

In order to understand the potency of BSS the question is asked how the interviewee should categorize BSS, radical or incremental. More than 70% of the interviewees characterize this technology as incremental at the moment of speaking, which can become radical if large technological discoveries or inventions are made or pop-up in the future. 50% of the interviewees expect that such a discovery or invention will pop-up in the future and will significantly change our electricity system.

The chance that BSS will become part of our electricity system is estimated between 40% and 100%, whereof grid operators are the most positive actor. 60% of the grid operators predict the chance between 80% and 100%, while for the “other actors” group 65% predict the chance of around 50%. The electricity providers are somewhere in the middle, which is given by Figure 24. Furthermore, the grid operators expect a significant share for BSS in the Dutch electricity system later than 2030, while the other actors expect this to be happening already over 5 – 15 years (included in Figure 25). Nevertheless, the grid operators expect that BSS will become increasingly important in following years.

5.2.2 Research question 2

The second research question continues validating and enriching Chapter 3, by focussing on the critical success factors and drivers of the BSS technology. Next, this question touches different environmental forces recognized in Chapter 3 and determines the impact of those forces. This second research question is formulated as follows:

“Can BSS provide a significant answer to the changing environmental forces?”

The transition of our electricity system towards a (more) sustainable construction is seen as the most important driver behind the development of BSS. Integrating more renewable energy sources will lead to a system in which supply will not follow demand anymore. The magnitude of this problem is highly dependent on the political choices, related to stimulating renewable energy sources in the future. As a result of this development, flexibility will become increasingly important on each transport level in the Dutch electricity grids. Flexibility can be provided by BSS, but also with demand side management and interconnections, dependent on which transport level the flexibility is needed. All interviewees expect that a combination of all three technologies will be the future, but only the magnitude of all three technologies is highly uncertain. Furthermore, most interviewees expect that the electric drive vehicles will stimulate the BSS technology. The high demand for those vehicles will drive the prices of the batteries down, following the economic laws. Secondly, this development can be interesting for using the batteries of the vehicles by giving them a second life. The expectation, currently tested, is that when the battery is not good anymore for driving purposes it can still be used in the electricity grid. Therefore, the lifetime of the battery can be expanded.

Since, BSS is still in the research and development phase all interviewees indicate that the performance of the batteries must increase first before they can use it commercially. The price of the BSS system is still too high, compared to its performance. Nevertheless, they also indicate that BSS can be attractive when the value of the flexibility or the energy prices increases significantly.

Furthermore, with interview question number 5 the different (mega) trends recognized in this thesis are tested on their contribution towards the success of BSS (and vice versa). The result of this question is that BSS can significantly support or positively affect the climate change, smart grids, smart homes and mass individualization trend, but is less certain for the other trends. The other trends, as financial crisis and globalisation, can even have a negative effect on the success or introduction of BSS, e.g. globalisation requires more interconnections and therefore creates (more) flexibility on a transmission level.

5.2.3 Research question 3

The third research question validates and supplement Table 2 (part of Chapter 4), by determining which system requirements can be supported with BSS. The result of this question is used for determining the value proposition of the business model, included in the next chapter. Therefore, this research question is formulated as follows:

"Which requirements of the future electricity grids can be supported with BSS?"

According the interviewees, BSS can add a significant contribution towards the requirements reliability & accessibility, quality, security of supply, sustainability and flexibility. As a result of the energy transition, the interviewees expect that those requirements will become increasingly difficult to manage and sustain. BSS can provide a solution, together with demand side management and interconnections, which is in line with the answers on the previous two research questions. Since the future prices of BSS, the future performance of BSS, the future energy prices and the future structure of the electricity system are highly uncertain, it is also uncertain if BSS can add a significant value to the following system requirements: affordability, economically, efficiency and transparency. The answers on those requirements were widely spread, which indicates the high level of uncertainty. At last, the expectation is that this technology will have a negative effect on the safety requirement. This technology increases the chance for mechanics that parts of the electricity grid are still active when an error occurs, increases the chance of exploding elements, etc. The positive effect can be that sudden interruptions can lead to safety issues for other components in the grid, which can be solved with BSS. Nevertheless, the interviewees indicate that those answers are generally spoken and can differ among the different applications.

5.2.4 Research question 4

The fourth research question validates and supplement Table 1 (part of Chapter 4), by determining the applications that are the most interesting ones in combination with the BSS technology. The result of this question is again used for determining the value proposition of the business model, included in the next chapter. Therefore this research question is formulated as follows:

"Which applications can be interesting for BSS?"

The list of promising applications provided by the interviewees is identical to the list that follows from the first value assessment, included in Chapter 4, with only one addition. This addition is the "regulation, reserve and emergency power" application, which has to do with their believes about local or distributed management services in the future. Therefore, most interviewees indicated that this application is not the logical application to start with. The list of promising application provided by the interviewees is as follows:

- Electric Energy Time Shift;
- Area regulation;
- Black start;
- Congestion management, on distribution level;
- Distribution upgrade deferral;
- Micro / independent grids;
- Demand charge management;

- Balancing forecast errors (renewable integration);
- Regulation, Reserve and Emergency power.

The other applications listed in interview question 6 are less interesting for purposes in the Dutch electricity grid. The interviewees provided two main reasons for this outcome. (1) The other applications are mainly for quality purposes, which is already more than good enough in the Netherlands. Those applications will have probably more value in some other countries were they are dealing with quality issues. (2) Some applications should be arranged on a high voltage level, which is too high for BSS.

Furthermore, the question was asked if the list provided in interview question 6 is complete. Three interesting applications popped-up:

- Electric drive vehicles applications (V2G & G2V);
- Innovative retail applications, related to the “new energy services”;
- Applications related to smart homes.

Although those applications are out of scope for this research project, those applications are interesting to mention for further research.

5.2.5 Research question 5

The fifth research question validates and supplement the last part of Chapter 4, Table 3, by determining which actor will benefit the most of the BSS technology and the related applications included in the previous question. Therefore, this research question is formulated as follows:

“Which actors can gain significant benefits with BSS?”

According the interviewees, the actor that can benefit the most of all actors from this technology is the regional grid operator. Followed by the consumer, the producer, programme responsible party and TSO TenneT. The consumer must directly or indirectly benefit from this development, otherwise it will not be introduced in the first place. TSO TenneT can only indirect benefit from this technology, as its imbalance management can become more manageable. The producer can benefit from this technology by balancing forecast errors in the case of renewable integration on distribution level and by ballasting its fossil fuel generators more constantly (increasing efficiency). The programme responsible party will benefit from this technology as his work can become better manageable, by balancing the forecast errors. Furthermore, the traders, brokers and retailers are less likely to benefit from this technology, as this imbalance is one of their main revenue streams. Nevertheless, the interviewees indicate that when traders, broker and retailers are combined with other actors into one company they can benefit as well from this technology. Combinations can result in totally different benefit levels for all actors involved in that company, which mostly result in positive effects. As a result, designing business models for the RGO’s, prosumers and electricity providers is a logical decision and therefore the next step in this research project.

5.2.6 Research question 6

The sixth research question aims at gathering information about the strategic fit of this technology in the Dutch electricity system, by taking primary the strategies of the grid operators and electricity providers into account. Therefore this research question is formulated as follows:

"Does distributed storage facilities fit to the strategies of the RGO's and electricity providers?"

At first, with interview question 9, the direction is determined by taking the three generic strategies of Porter (1985) into account (the three strategies are included in Figure 2 on page 4). This direction provides an indication of the companies that can benefit from this technology. It is clear that companies that only focus on increasing volumes will not benefit from this technology as intended. Secondly, companies that primary focus on cost reduction should also not be the primary focus for this technology, as price developments of BSS are still too uncertain. Nevertheless, the focus should be on companies or organisations that use a differentiation strategy. All the interviewees saw the potential to differentiate from the competition, by implementing BSS. Although grid operators do not have any "real" competitors, performing better than their colleagues in the same market is a strategic objective for RGO's. furthermore, the speed of introduction (first movers advantage) will result in the largest advantage that can be gained, as the electricity market is defined as a "copy market".

Secondly, with interview question 10, BSS is tested on the current grid operators' and electricity providers' strategic intent. From the collected data, closed question is included in Figure 26, we can clearly distinguish the fit of BSS between RGO's and electricity providers. The RGO's indicate that this technology has almost a perfect fit, because it can support the strategic goals, e.g. reducing the downtime minutes. While the electricity providers indicate that this technology has only a limited fit, as they are not primary an asset owner. This technology will only fit to them if they own decentralized production facilities and if it supports the new energy services they provide, e.g. providing renewables for households in combination with a BSS. The data collected from the other actors support the above conclusion. From a strategic view, the regional grid operators seems to be the most important actor for implementing BSS.

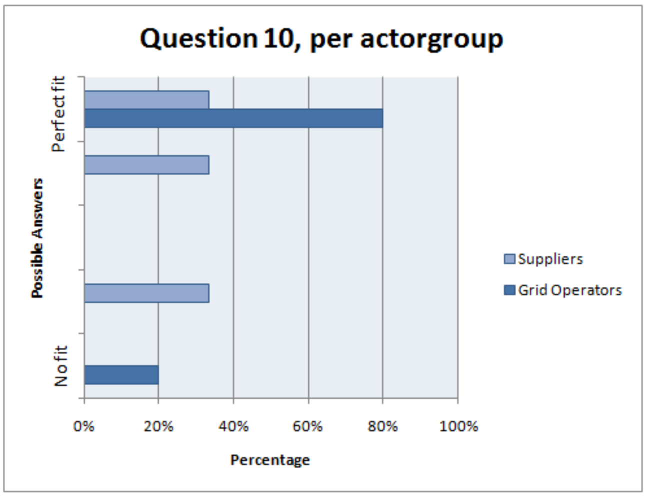

Figure 26: Result interview question 10: *"Does BSS fit to the corporate strategy of your company?"*

5.2.7 Research question 7

The seventh research question continues the previous question by focussing on the second strategic management layer, namely the business model layer. For this analysis the framework of Osterwalder (Chapter 2) is used as the basis. Therefore this research question is formulated as follows:

"How will the business model of the RGO's and electricity providers change, when implementing BSS?"

The value proposition is already included in the previous questions, therefore this research question only includes the other parts of a business model. Furthermore, this question is limited to the two most important actors, which are the RGO's and electricity providers.

The first interview question (11) is related to the key activities of the grid operators and electricity providers. The expectation of the interviewees is that this technology (including the applications) will add new important activities to the already existing activities of the actors involved. This primary means for the RGO's that they have to manage the storage facilities and probably trading in electricity as well. For the electricity providers this means that storing electricity will be added to their current electricity portfolio. Nevertheless, the interviewees believe that it is more likely that the activities related to BSS will become part of the RGO's business model instead of the electricity providers business model. Figure 27 indicates the effect BSS will have on the key activities of the grid operators and electricity providers.

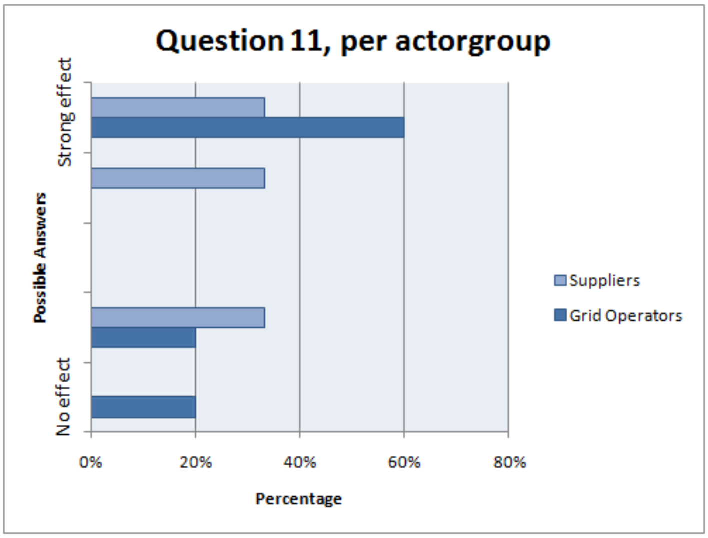

Figure 27: Result interview question 11: *"Do you expect that BSS will have a significant effect on your companies key activities?"*

The second interview question (12) is related to the key resources of the grid operators and electricity providers. The results of this question (closed part only) is included in Figure 28. All interviewees believe that this technology should be a key resource of the regional grid operator, because this technology fits good to their role. Only on a limited scale, for integrating renewable energy sources, this technology can be expected at the electricity providers side. If it becomes a resource of the electricity provider it is more likely for supporting the new energy services, which is rather a product or service belonging to the value proposition element of a business model instead of a key resource.

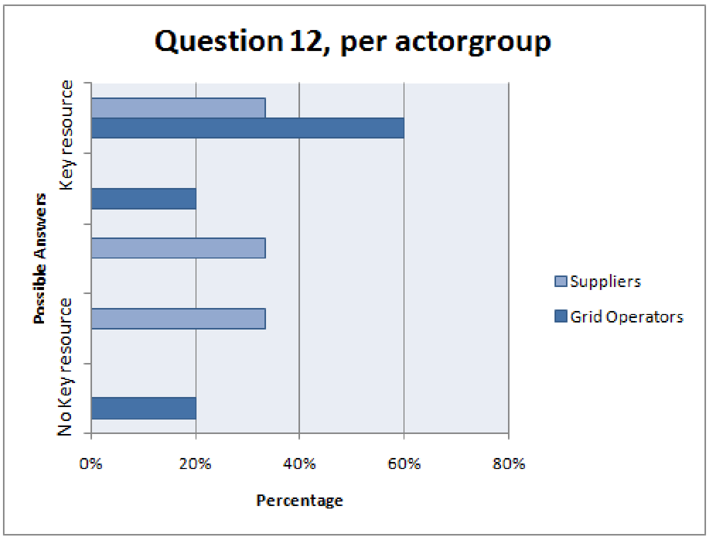

Figure 28: Result interview question 12: *"Do you see BSS in the future as a key resource of you company?"*

Next, interview question 13, determines the effect on the key partnerships element of the business model. 100% of all interviewees expect that this technology will introduce new or more extensive relationships with other actors. The most frequently mentioned example is the one between RGO's and electricity providers. In this case, the electricity provider will pay the RGO for its storage services, which he uses for integrating its renewable energy sources. Nevertheless, this can also lead to a new actor, namely Energy Service Companies (ESCO's), who will operate as an intermediary or agent. The results of the closed part of interview question 13 is given in Figure 29.

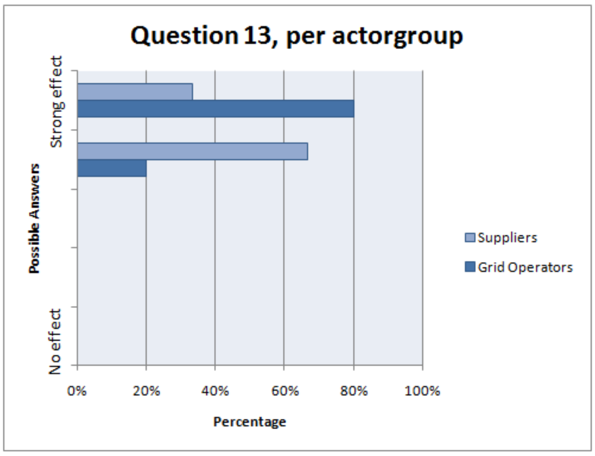

Figure 29: Result interview question 13: "*Do you expect that BSS will have effect on your companies key partnerships?*"

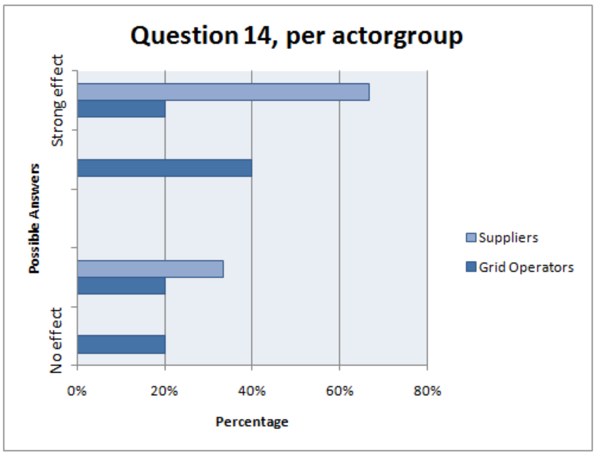

Figure 30: Result interview question 14: "*Do you expect any effect on the customer interface of your company?*"

Interview question 14 determines the effect of BSS and its applications on the customer interface. The customer interface includes the customer relationships, customer segments and channels, explained in Chapter 2. The overall thought of the interviewees is that this element will change as well, both for the RGO's as for the electricity providers. The RGO's will get new customers by introducing this technology (e.g. traders or programme responsible parties) or current customers will need an extensive relationship because more dynamic services are offered. Furthermore, this shift in customer segments is highly dependent on the future energy transition. For the electricity providers this means that other services (new energy services) can be provided. This will not necessarily result in new customers due to differentiation, but more to other relationships and channels. Nevertheless this shift in relationships and channels will not come from only this technology, but from a whole bundle of technologies / services of which BSS can become part of. The results of the closed part of interview question 14 is given in Figure 30.

The last interview question, which is part of research question 7, is related to the financial aspects of the business model. As the technological development is highly uncertain and BSS needs for some applications a change in the electricity system setup, cost reductions and increasing revenues are difficult to predict. Nevertheless, most interviewees expect that this technology will be used in the future by RGO's for grid efficiency purposes, which will not result in cost reductions but in less sharp increasing costs. Therefore the expectation is that the primary cost advantage is for the RGO's. Furthermore, this technology will not lead to increasing revenues for RGO's, because they are non-profit organisations, but can lead in increasing revenues for electricity providers. Electricity providers can use this technology for offering their new energy services. But as those new energy services are related to the energy transition, the answers provided to this question were widely spread over the possible answers. This indicates the uncertainty of the future energy transition and the uncertainty of the new energy service that will be provided by electricity providers in the future.

As a final conclusion to this question, all the interviewees believe that this technology needs a restructure of the current business models of both the RGO's and the electricity providers. Nevertheless, the business model of the asset owner, probably the RGO, will be affected the most. The level of importance to change those business models will follow automatically from the energy transition.

5.2.8 Research question 8

The eighth research question provides insight in the possible resistance of different actors on the introduction of the BSS technology. This research question is formulated as follows:

"Are there actors in the electricity system that will try to block this development?"

The general feeling among the interviewees is that none of the actors will perform a real resistance against this technology. This technology and its applications can only be experienced unpleasant, because it is against our normal way of working. Nevertheless, it is possible that required changes in the current market model could result in some resistance from different actors, which highly dependent on the recommended model.

5.2.9 Research question 9

The last research question is about gaining insights about the feasibility of introducing BSS in the Dutch electricity system, with emphasis on the market facilitation and law & regulation. Therefore this research question is formulated as follows:

"Does the current system enable distributed storage facilities?"

All interviewees recognize problems in the current law and regulation and in the current market model. The problems in the current law and regulation mainly arise if we would like to implement this technology in the regulated part of the Dutch electricity system, e.g. at the RGO's side. Storage is completely unknown in the current law and regulation and is due to the unbundling law increasingly difficult to implement. Nevertheless, storage can be installed in the non-regulated part of the electricity system, but then not all applications (as mentioned in Chapter 4) can be carried out as intended. Furthermore, the current market model does not included storage, which should be changed in order to determine the cash flow allocation.

5.3 Conclusion

This chapter includes an extensive interview research, in order to validate the decisions taken and choices made in the previous chapters, validate the collected case study results for the specific case in the Netherlands and to collect the required additional business model input. This chapter aims at providing a solid transition towards the business model design phase, in order to gain the highest reliability and validity as possible. Therefore, nine research questions are designed at the beginning of this chapter. Based on those nine questions the measurement instrument is chosen, which is interviews for this research. In agreement with the Delft University of Technology and Siemens Nederland 14 interviews (17 interviewees) are determined for the research sample. This sample is partly based on their previous experiences with those interviewees and their involvement in storage projects. Next, the research process protocol and interview protocol (appendix G) are designed.

The collected data is included in appendix H, but the results are included in this chapter. The results include answers on all nine research questions prepared at the beginning of this chapter. When comparing the nine answers with the decisions taken and choices made during this research project we can conclude that the research undertaken so far is valid, as the answers are in line with the decisions taken and choices made. Furthermore, we can easily conclude that BSS has a significant different value in the Netherlands then in Denmark or in the United States of America, which has to do with the different set up of the electricity systems, historical choices in primary fuels, different landscapes and different national resources. At last, this interview research has resulted in new insights, included per answer in this chapter, which will be used as an important input for the business model design phase. With the information gathered in this chapter all the relevant information is collected to design the new business models, according the business model framework of Osterwalder (2010).

The result of this chapter clearly indicates the need to design and valuate three different business models. The difference between those models is that each model takes a different actor as “key actor”. The three key actors are:

- Regional Grid Operator;
- Electricity provider;
- Consumer (or prosumer).

The designed and valuated business models are included in detail in the next chapter.

6 Business model design analysis

On the basis of the insight we have gained from the previous chapters, the aim of this chapter is to design the most promising business models related to BSS. Based on those business models the feasibility of this technology can be determined, in order to understand the potency and possible implementation barriers. Furthermore, this chapter indicates the strategic fit of BSS with the relevant actors involved. First, in Section 6.1, an in-depth analysis of the current strategies and business models of the RGO's and electricity providers is carried out. The foundation of this analysis is the framework of Osterwalder (2010) and the data is based on the latest annual reports of the sample companies determined in the previous chapter. Thereafter, in Section 6.2, the most promising business models, based on the applications and actors determined in the previous chapters, are designed. The data used for this section is the collected data provided in the previous chapters. Next, in Section 6.3, a value assessment is carried out to understand the strategic fit of those promising business models in practice, by comparing the new business models with the currently used business models. Secondly, a feasibility assessment is carried out, in order to provide insights in the potency of this technology in the Dutch electricity market and the barriers that need to be conquered. Both the value and feasibility assessment is carried out by the researcher on the basis of the knowledge gained from this research project. At last, this chapter ends with a conclusion that provides the main findings of this chapter.

6.1 Current business models of the most important actors

The first part of the business model design analysis is an in-depth analysis of how the current strategies and business models of the two most important actors, RGO's and electricity providers, are structured. This analysis is needed in order to determine the strategic fit further in this chapter. The third most important actor, consumer (or prosumer), is not included in this analysis, because within this actor every individual has its own strategy and business model and is therefore not possible to generalize. The data used in this section is based on the latest annual reports of the sample companies selected in the previous chapter. Furthermore, the framework of Osterwalder is used as an foundation for this analysis.

6.1.1 Strategies and the general business model of the Dutch grid operators (RGO's)

In order to determine the general strategies and business model of the RGO's, the annual reports of the three sample companies (determined in Chapter 5), Stedin, Liander (which is part of Alliander) and Enexis, are analysed. The results of this analysis is included in Figure 31.

RGO's in the Netherlands have a natural monopoly position, because of the physical limitations of their assets. Although this means that they have no competition, the Office of Energy Regulation challenges them to perform better than their partners in the same market, explained in Chapter 3. As a result, the strategies of those actors deviate from competitive companies. While looking at the strategies of the three RGO's included in Figure 31, it is clear that none of them is using a cost leadership strategy. Nevertheless, all three RGO's note in their annual reports that they are focussing on cost efficiency. While studying their annual reports into more detail, it is clear that when a trade of has to be made between quality or cost efficiency, their preference will go out to quality. As a result, their main focus is on quality in the form of differentiation, for which satisfying changing market conditions is a primary issue. According Porter (1985), a third generic strategy, namely volume, exists, which is also not interesting for those three RGO's. The reason for that is that they all have a fixed area to operate in and within that area nobody can choose for another RGO. Therefore, it is not possible to enlarge their volume, as there is a natural equilibrium. Furthermore, there are some significant differences between those RGO's on a strategic level, which is their expectation about the future development of the electricity system as a whole. Stedin for example has the vision that decentralized (sustainable) generation will become increasingly important and probably the dominant future perspective. As a result, their strategy supports this development completely. At the same time, Alliander and Enexis are more focussing on a combination between centralized and decentralized generation, which is supported by their strategy. However, when large technology changes or innovations should be adapted by RGO's, mostly collaborations between RGO's are set up, in order to adapt this development, e.g. e-laad.nl or Netbeheer Nederland.

Figure 31 provides the general business model used by RGO's in the Netherlands. The first element of the business model is the key partnerships. This element indicates that ten key partnerships can be recognized. The purpose of those relationships are optimising the core processes carried out by the RGO's and optimizing the Dutch electricity system as a whole. As a result, the main types of partnerships that can be recognized are buyer-supplier relationships and a combination between coopetition and strategic alliances.

The second element provides all the key activities that are carried out by this actor. The most important activity listed in this element, is asset management, which is the primary regulated task of this actor. The next three activities enable RGO's to improve their assets and adapt their assets to environmental forces / changes. The last activity is a special activity that is not carried out by all RGO's. During the unbundling process, explained in Section 3.1.6, RGO's had the strategic choice to include this activity or not. If they had chosen for including this activity, they could only perform this activity for their own assets. If they had chosen for unbundling, this task shifted within the company towards the key partnerships (contractors).

The third element of the business model are the key resources. As part of this element three important resources can be recognized. The first resource is the physical resource, which is the complete electricity infrastructure that is needed to provide the value proposition. The second important resource is the tacit knowledge, which is included in the heads of the employees. The last resource, which is probably the most important resource for the RGO's, is the monopoly position. This monopoly position enables the RGO's to gain a sustainable competitive advantage. As this sustainable competitive advantage is gained by the RGO's resources, the inside-out strategy perspectives are the most likely perspectives to build up the companies strategy. Nevertheless, the outside-in strategy should not be ignored, as the electricity infrastructures should also adapt to environmental forces, e.g. the demand for decentralized generation.

Actor Regional Grid Operator

Strategy

Stedin	Alliander	Enexis
- Safe and continuous energy transport through our grids - Enabling decentralized energy generation (incl. prosumers) - Leader in safety, quality and cost efficiency - Differentiate from E and G, by transporting other products e.g. CO2, hydrogen,Steam, etc - Enable a sustainable energy supply - Brand reputation - Being a professional company towards third companies	- Focus on reliability (being a reliable service provider) - Performing the full asset management in house - Performing and facilitate R&D related to our core business - High customer focus - Providing services and products that will strengthen our core business In order to decrease customer costs	- Our society will become increasingly dependent on energy - Customers will become more critical about our performance - Respond to new technology developments and changing market conditions - Leading position in facilitating a sustainable energy supply - Companies core value: together, decisiveness, responsibility, future-oriented

Business Model

Infrastructure management

Key Partnerships (KP)
- Suppliers
- Contractors
- Project developers
- Municipal authorities
- Universities
- Knowledge institutes TNO, ECN, KEMA, etc.
- TSO TenneT
- Office of Energy Regulation
- Shareholders
- RGO's

Key activities (KA)
- Asset Management
- Infra / Energy services
- Projects: Management / Engineering / etc
- R&D, current focus: (Mobile) Smart grids & smart meters; Decentral energy production (2-way); Efficiency
- Infra products[1]

Key Resources (KR)
- Electricity grid (assets) Cables, Trafo's, etc
- People (tacit knowledge)
- Natural monopoly position Fully responsible for restricted area

Product / Service

Value Proposition (VP)
- Connect consumers and producers to the public electricity grid
- Distribute electricity

Focus on:
- Accessibility
- Cost efficiency
- Performance

Custumer interface

Customer relationship (CR)
- Accountmanagers
- Personal assistance: Call center; Information desk
- Self-service: Online
- News letters (E-mail)

Channels (CH)
- Accountmanagers
- Energy suppliers mostly for small consumers
- Call centers
- Information desks

Customer segments (CS)
- Large customers: Companies; Government
- Small customers: Individuals

Focus on:
- Mass market within own region

Financial aspects

Cost Structure (C$)
- People / man power (intern and extern)
- R&D costs
- Costs transportation TenneT
- Financial compensation for distribution errors which takes more then 4 hours
- Purchases (raw material, grid assets, etc) + outsourcing
- Depreciation assets
- Other asset management and maintenance costs
- Less important: Grid losses and Fraud

Revenue Streams (R$)
- Transport: changed in capacity tariffs: Large customers; Small customers (day and night tariff possible)
- Fixed fee (regular connection and transport fee)
- Renting fee for the electricity meters
- System services TSO TenneT

Note: Information is gained from the annual reports of the companies
Assumption: Models are based on only their electricity part

[1] Different among grid operators (in Dutch we call this "vette of slanke netbeheerder")

Figure 31: Strategies and the general business model of the Dutch RGO's (Stedin, 2009; Alliander, 2010; Enexis, 2010)

The forth element of the RGO's business model is the value proposition, which consist of two important services. The first service is connecting consumers, producers and prosumers to the public electricity grid, in order to use, offer or exchange electricity. The second value proposition is the distribution of electricity, between the transmission level and their members connected to their distribution grid.

The fifth element is the customer relationship. Depending on the customer segment (next element of the business model) different relationships are used. For the large customers all four types of relationships are used, while for the small customers only the last three relationships are used.

The sixth part of the business model provides the customer segments, which focuses on a mass market within their specific region. Although the business model is focussing on one single customer segment, namely customers that would like to be connected to the electricity grid, two different customers are recognized within this segment. Those two customers are divided into small customers (households) and large customers (industry/companies and government). The reason for this distinction is because all households needs more or less the same product/service, while for the large customers a standard connection does not fit all. As a result, standard services and products are offered to small customers, while custom made services and products are offered to large customers.

The seventh element, channels, provides the communication channels used to reach and communicate with the customers. In order to reach both customer groups, distinguished in the previous element, different channels are used. To communicate with the small customers the following three channels are used; energy suppliers, call centres and information desks. While for communicating with the large customers the communication channels accountmanagers, call centres and information desks are used.

The last two elements are concerning the financial aspects of the RGO's. The first element is about the main cost structure, which consist of eight different types of costs. From those eight different types of costs the depreciation of assets is the most striking one. The main reason for this is that investments made in the electricity system have a lifetime of around 40 years. As a result, those relatively high investments are depreciated also over 40 years, which is not done by any commercial company. Therefore, RGO's are non-profit organisations owned by the government, as explained in Section 3.1.4. Furthermore, those costs should be covered by the last element, namely the revenue streams, which consist of four different types of revenues.

6.1.2 Strategies and the general business model of the Dutch electricity providers

The Dutch electricity providers are defined in this thesis as the integration of four different actors, namely producers, programme responsible parties, traders & brokers and retailers. This combination is for the large energy companies in the Netherlands a common composition, caused by the horizontal and vertical integration, in order to reduce risks and lower transaction costs. Due to the Dutch Electricity Act 1998 and the effect of creating competition in the non-regulated part of the system, the number of electricity providers active on the Dutch electricity market is still increasing. As a result and because of time limitations, a sample for representing the total population was needed for this research. The sample is determined in the previous chapter and consist of Eneco and Essent. The result of the annual report analysis is included in Figure 32.

Actor Energy (Electricity) Provider, includes: Producer, Programme Responsible Party, Trader & Broker and Retailer

Strategy

Eneco	Essent
- Sustainability for everyone (Leader in sustainability) - 100% Sustainable (partly trough efficiency), Roadmap: 2012 = 20%, 2020 = 70% - More Decentralized Generation (incl. stimulating prosumers) - Stimulating electric drive vehicles (EDV's) - Working closer together with citizens (e.g. Becoming shareholders of renewable energy sources), customers, shareholders and employees - Expanding through horizontal and vertical integration	- Focus on Affordability, Availability and Sustainability - Upscaling (primary horizontally) and therefore taking advantage of economies of scale - Developing towards a leading sustainable energy provider - Developing the energy of tomorrow - Taking shareholder towards a sustainable future

Business Model

Infrastructure management		*Product / Service*	*Custumer interface*	
Key Partnerships (KP)	**Key activities (KA)**	**Value Proposition (VP)**	**Customer relationship (CR)**	**Customer segments (CS)**
- Suppliers - RGO's - Large prosumers - TSO TenneT (because of RPR) - Technology providers - Knowledge providers TNO, ECN, KEMA, etc. - Universities	- Electricity trade - Electricity production - Program Reponsibility - Retail activities - Energy Services Advice (energy savings) Inspection Maintenance - R&D Improving efficiency DG for households Storage (e.g. CAES) **Key Resources (KR)** - People / tacit knowledge - Relation network - PRP qualified - Financial assets - Brand name - Production facilities and knowledge	- Electricity supply, 3 levels [1]: 1. Renewables (+++) 2. Sustainable (++) 3. Fossil (+) - Energy production 1. Renewable generation 2. Sustainable generation 3. Fossil generation - Energy services Free online advice Climate compensation Energy savings Climate footprint / CO_2 monitor - Maintenance Installation companies Energy metering Focus on: - Customization - Environment - Brand / Status - Cost efficiency	- Contracts (1, 3 or 5 years) - Self-service (online) - News letters (E-mail) - Relation magazines For the large customers - Personal assistance Call centers & information desk Dedicated assistance for large customers **Channels (CH)** - Sales force For large customers and business market - Web-sales (online) - Media (only advertisement) Television, Internet, Newspapers - Call centers - Information desks	- Large customers - Small customers - SME (Small & Medium Enterprises In Dutch: MKB Focus on: - Mass market - Expanding within Europe both focussing primary on N-W Europe

Financial aspects

Cost Structure (C$)	Revenue Streams (R$)
- People / man power - R&D (primary investments related to sustainable and renewable energy generation) - Purchases: Energy, Transport, Raw materials & Assets - Marketing & Sales - External costs: Temporary people, Material, Outsourcing, etc.	- Taking optimal advantage of differences in licences and susidies within different countries Possible through horizontal integration (international spread of interests) - Energy supply and transport (variable and constant prices) - Services and projects (for other companies) - Cost contribution for the projects of customers

Note: Information is gained from the annual reports of the companies
Assumption: Models are based on only their electricity part

[1] The plusses indicate the "green" factor. Therefore the more plusses the more renewable and sustainable generation. As a result providing better solutions to the needs of individual customers.

Figure 32: Strategies and the general business model of the Dutch electricity providers (Eneco, 2010; Essent, 2009)

The annual report of both selected companies clearly communicates the strategy of the company. While comparing the strategy of Eneco with the generic strategies of Porter (1985), it is clear that the focus is on creating a competitive position, by implementing a volume – differentiation strategy. In order to enhance the volume, horizontal and vertical integration is seen as the main driver for success. This volume strategy must lead to economies of scale, which is difficult to copy by competitors. Secondly, Eneco is differentiating itself from its competitors by offering products and services that supports the companies' vision, namely sustainability and an increasing customer engagement. As a result, different products and services are offered in order to fit better to individual customer needs, which will lead to economies of scope. When comparing the strategy of Essent with the strategy of Eneco and the generic strategies of Porter (1985), also for this company the main focus of creating a competitive position can be recognized. Although the strategy of Essent is in essence equal to that of Eneco, the main difference is the vision that both companies share about the future. Therefore, the products and services (differentiation) that are offered differ from each other. In the vision of Essent, customer engagement in term of generation is less important and sustainability must compete against affordability. Nevertheless, with this sample we cannot conclude that the volume – differentiation strategy is the dominant strategy among all electricity providers in the Netherlands. What we can conclude is that the different electricity providers in the Netherlands adapt to environmental forces.

Figure 32 provides the general business model that is used by the different electricity providers. This model is based on the annual report of only two companies, therefore the generalization of this model is only valid for electricity providers that use the same volume – differentiation strategy. However, this strategy is used by most companies in the Netherlands that includes all four actor groups into one single company, named electricity providers in this research. The main difference among the companies in carrying out this business model is the weight factor they give to each part of the different elements (nine building blocks).

The first element of the business model is the key partnerships. This element consists of seven different partnerships, which are needed to optimize the daily processes of the company and the electricity system as a whole. Next, this element also consists of partnerships that are needed to adapt to environmental forces, in the form of research and development partnerships.

The second element provides all the key activities that are needed to provide the desired value propositions. Next to the four standard activities that belongs to each actor, two different key activities can be recognized, namely energy services and R&D. The energy services enable electricity providers to offer a different value proposition to their customers, which is based on economies of scope. R&D is included in order to improve their assets (production facilities) and for developing new value propositions in order to distinguish themselves from the competition. Furthermore, the main advantage of having the four basic activities (vertical integration) into one company is that transaction costs can be reduced significantly.

The third element, key resources, provides the most important resources that enable the business model to work. Those resources consist of human, physical, financial and intangible assets. Since the unbundling law, the intangible assets (brand name and relation network) receives the most attention, as those assets mainly determine the position of the company in the market.

The forth element is the core of the business model, namely the value proposition, which consists of four different services. In order to provide those services to individual customer needs on a mass production scale, electricity providers have divided again the offered services into different sub-categories. As a result, the choice a customer has in selecting energy services is increasing, for which the different services are mainly related to the following three sub-categories:

- Fossil fuel generation;
- Sustainable generation;
- Renewable generation.

Nevertheless, the focus of providing the value proposition is on the following elements:

- Customization / newness / uniqueness
- Environment
- Brand / Status
- Cost & energy efficiency

The fifth element deals with the customer relationship. Depending on the customer segment (next element of the business model) different relationships are provided. For the small customers, contracts of 1, 3 or even 5 years, a website, newsletters, call centres and information desks are used. It is important to note that electricity providers try to bind customers for longer periods, for which the choice of duration differs per company. For the large customers all types of relationships noticed in Figure 32 are used, which can only differ in the duration of the contracts.

The sixth part of the business model provides the customer segments, which focuses on the mass-market within an expanding region. Since the unbundling law, both companies have expanded their customer area to N-W Europe, as a result of their horizontal integration strategy. Within this customer segment both companies recognize different types of customers. While Eneco recognizes only two customers, small and large customers, Essent recognizes also a third type of customer, namely SME's. The main difference between those different types of customers is that small and probably also SME's are active on the retail market, while large customers are active on the wholesale market, explained in Section 3.1.3.

In order to reach and communicate with the customers the seventh element provides the different channels that are used. For the small customers the following channels are used; web-sales, call centres, information desks and media. While for the large customers and SME's the communication channels sales force, web-sales, call centres and information desks are used.

The last two elements are concerning the financial aspects of the electricity providers. As both organisations selected for this analysis are using a volume – differentiation strategy, their focus is on creating a competitive position. Therefore, the cost structure is value driven and not cost driven. The main costs related to this business model are costs in order to carry out the daily activities and costs related to creating unique value to their customer segment. Nevertheless, as there is a focus on volume, cost efficiency results mainly from economies of scale. When we look at the revenue streams in Figure 32 we can recognize four different types of revenues. Although the last three revenue streams result directly from the products and services that are offered to the market, the first revenue stream is purely gained through the horizontal integration strategy.

6.2 New business models, integrating BSS

Based on the selected applications and actors concluded in the previous chapters and the data gathered with the interviews, three new business models are designed in this section. In this section the four general domains of a business model are taken into account (Osterwalder & Pigneur, 2010). Nevertheless, the financial domain is not backed with in-depth financial details, as different other studies, mentioned in this section, prove that more in-depth research is needed for this topic. The second reason is that the current system does not include storage purposes, which is the main focus of this research. The third reason is that the value of each element should be determined first, which is out of scope for this research. A clear direction or strategy will provide more input to the financial domain, which can be used as a solid foundation for calculating revenues and costs for further research. Furthermore, this section assumes that storage in the form of flexibility will become more worth in the future due to the environmental forces determined in the previous chapters, which will result in feasible business cases.

6.2.1 Business model 1: RGO model

The purpose of the first business model is supporting the copperplate thought, which is a well-known concept within the utility industry (Senternovem, 2009). This concept treats the transmission and the distribution grids as a large copperplate where everybody can plug-in his power source and load, without experiencing any restrictions. The copperplate thought is visualized in Figure 33. Unfortunately our electricity grid consists of power lines, which are limited in capacity. Therefore, the RGO model holds the grid operators, both on a national and regional level, responsible for realizing this model. As a result, other actors than grid operators may not experience any problems in consuming or producing electricity, which is not the case in today's environment. Consequently, the basic thought of this business model is that the grid operators are the responsible actor for executing the RGO model and therefore own (key resource) the BSS technology. The first business model is based on the business model of the RGO's.

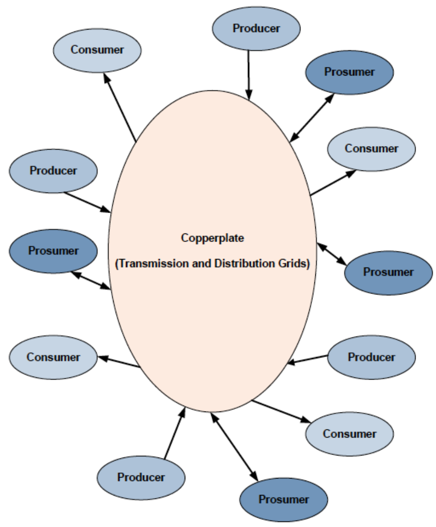

Figure 33: Copperplate thought

Business model concept, the value proposition

This model is based on upgrading the Dutch electricity grid, by implementing storage as a buffer in the distribution grids, in order to support the copperplate thought. The value proposition in this model is based on three applications resulted from the previous chapters. The first application is the congestion management application. As a result of connecting too much production capacity against too less transport capacity congestion occurs. By implementing smart storage in the distribution grids, the flexibility will be enhanced as comparable with other value chains, which can be used to reduce or even remove congestion. In the Netherlands congestion (collectively on a transmission and distribution level) costs around 100 million euro each year, which is charged through electricity prices to the consumer (Senternovem, 2009). Congestion is primary caused by the freedom electricity producers have in choosing a production location, which is again caused by the unbundling law. Nevertheless, in distribution grids households in the form of prosumers do not even have a choice, as they are restricted to their own space. Therefore the political question that arises is "who is responsible for this problem?". Is it the grid operator that has too less transport capacity or is it the electricity producer that provides too much electricity at a specific point? Since, this issue is high on the political agenda and therefore no judgement has been made, we can argue that it is the social responsibility of the grid operator to reduce those costs (at least in this model).

The second application is the distribution upgrade deferral application. Since, we are in the beginning of the energy transition, many structural changes will follow in the next decades. In order to adapt to those environmental changes, different studies are performed in order to predict and understand the future, as included in the previous chapters. Although we cannot predict the exact future, we know that efficiency, sustainability and flexibility will become increasingly important as a result of increasing fluctuations in supply and demand. As our current electricity grid is not designed for those types of changes, high investments are needed to support this transition. As a result of the interviews, it is clear that without implementing smart technologies the grid should be reinforced with a factor 5. As the current value of our electricity grid is around 20 billion euro's (Ongkiehong, 2006), enormous high investments are needed. Furthermore, investments in the electricity grid have a lifetime of around forty years, which means that not all parts are completely amortized. As a result, tremendous economic losses will be gained if we do not extend the lifetime of the equipment that has not exceeded its lifetime. At the same time this application also allows to extend the lifetime of other equipment, as levelling energy flows will increase the lifetime.

The third application is the balancing of forecast errors (renewable integration). In order to reduce the costs of forecasting errors caused by unpredictable sources flexibility in supply and demand is required. When implementing this flexibility in the distribution grids more sources can make use of the same equipment, which will decrease the costs and is therefore from a social responsibility perspective the responsibility of the Dutch grid operators (RGO is made responsible in this model).

We can conclude that only the applications are included that support the core business of the RGO's, in which commercial activities are excluded to a maximum extent. Therefore, the other two promising applications resulted from the previous chapters are excluded from this model. Different case studies provide that storage in low voltage grids can have a significant value in the future, e.g. by the recent study of Y. van Vlimmeren (Vlimmeren, 2010).

Infrastructure management and customer interface design

In this model the regional grid operators can be seen as the most important actor, which determines the success of this model. The BSS system (key resource) is owned by the regional grid operator, which he uses for providing the value proposition. Nevertheless, the overall problem owner is the Dutch Ministry of Economic Affairs, which has the end responsibility of the performance of the Dutch electricity system as a whole. All the key roles of this model are included below in Table 6.

Table 6: Roles of the RGO Model

Role	Actor
Problem Owner	Dutch Ministry of Economic Affairs
Responsible party	National and Regional grid operators
Administrator & Executive	Regional grid operators
Consulting	- Universities - (Energy) Consulting firms - Knowledge & research institutes - Technology providers
Controlling	Office of Energy Regulation

In order to give an overview about how this model works within the current multi-actor environment Figure 34 gives a schematic overview (market model). Within this figure the data, financial and energy (product) flows are included. The green colour indicates the parts that will be affected by this model. Furthermore, this model assumes that the BSS technology will be a key resource of the business model of the RGO's, who has or can easily gain all the required capabilities to operate and maintain this technology.

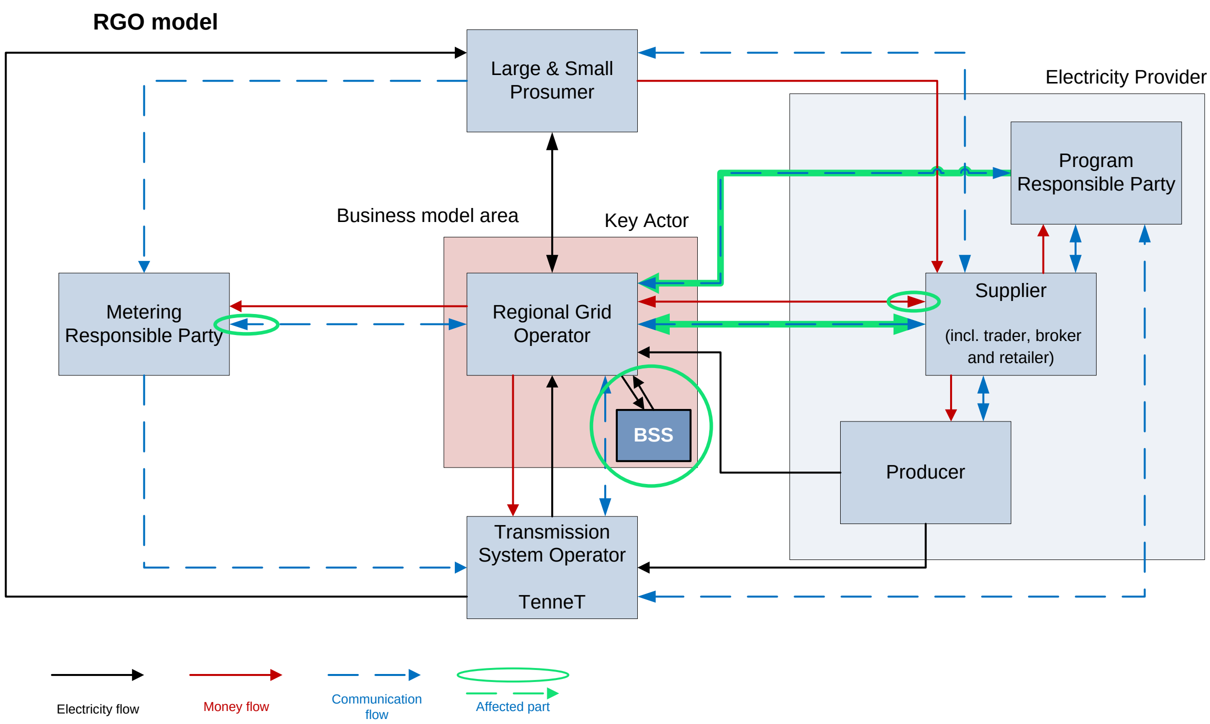

Figure 34: Actors in the RGO Model (market model)

At first, we can conclude that the interaction between the different actors in the physical value chain will not be affected, which is the purpose of the copperplate thought. This model focuses on an optimal market operation in which competition is not limited due to transportation restrictions. When we analyse the electricity flows, time shifting due to storage in the Dutch distribution grids is the only affected part, which is an internal operation of the RGO's. Secondly, the main communication effects that will occur are between the RGO's, metering responsible parties (MRP's) and electricity providers. The RGO's should record the electricity that they store in the grid, in order to communicate this to the MRP's. This data is needed for calculating the balance, as losses should be charged to the RGO's. The communication between the electricity providers will be affected as shifting the buying and selling process affects the e-programs for the programme responsible parties (PRP's). Nevertheless, losses should be purchased from suppliers and included in the e-programs. The losses can be added up to the usual grid loses that grid operators encounter.

Financial design

The last important part of the business model design process is the financial design, which determines the main costs and revenue streams of the business model. As this model is based on future expectations of BSS developments and is very case specific, financial benefits are hard to distinguish. In different discussions with different experts within the utility industry (Siemens, Delft University of Technology and experts interviewed during the validation phase) it became clear that a separated research based on individual cases should provide more clarity, for which the recent study of van Vlimmeren (2010) is a good example. Furthermore, this business model exceeds financial benefits, by including social benefits as implementing renewables and enabling further integration of the unbundling law, for which it is difficult to determine the "willingness to pay" factor. As a result, the main costs, revenues and risks are as follows (from a RGO's point of view):

Costs:

- High technology investments, future expectation capital cost around 250 €/kWh (based on Li-ion batt.) (Offer, et al., 2010);
- Maintenance costs;
- Operating costs, including trading for non-commercial purposes.

Revenues:

- Solving congestion problems, current market in the Netherlands around 100 million euro each year (Senternovem, 2009);
- Defer distribution grid upgrades;
- Integrating renewable (balancing services), payment done by owners of renewable sources;
- High quality factor (price-gap regulation, see section 3.1.6).

Risks:

- When solving congestion producers can be triggered to install more production facilities, which result in again in congestion and therefore does not solve the problem;
- Changing market models and economic structures can decrease the value of congestion management, e.g. provide grid operators with more power in providing connections to their grid;

- BSS is a High-Tech technology, which means: (1) Technological uncertainty, (2) Market uncertainty and (3) Competitive volatility (Mohr, et al., 2005);
- Research and Development is still needed, which can change future perspectives;
- Major trends in modern society can change.

Advantages and Disadvantages

As concluding remarks, the main advantages and disadvantages are included below in Table 7 and Table 8.

Table 7: Advantage of the RGO Model

Nr.	Advantages
1	High level up-front investments can be divided (recovery) over all members.
2	Long payback times are no issue for RGO's.
3	Uncertainty can easily be shared with all members.
4	Equipment can be shared with more renewable sources, economies of scope.
5	Perfect fit with the social responsibility of RGO's.
6	Supporting the energy transition.

Table 8: Disadvantage of the RGO Model

Nr.	Disadvantages
1	Limited financial incentives, except for distribution grid upgrade deferral, are available.
2	Congestion occurs due to current market structures, changing market structures can affect the value of the congestion management application. E.g. why should all citizens pay for those unnecessary congestion costs?
3	Currently RGO's are not responsible for solving congestion problems or stimulating renewables. Organizational issues exist.
4	Technology, financial and social benefits are still highly uncertain.
5	Current law and regulation does not allow RGO's to trade in energy. RGO's are limited to the physical part only. This means that Law and Regulation hampers the introduction of this model.

6.2.2 Business model 2: Private model

Within this model the consumer, producer or prosumer takes an active role in executing the energy transition. Therefore this model assumes that he or she is willing to implement a BSS at his or her side. This means for households and larger consumers, producers or prosumers connected to the distribution grids that the BSS is placed on their private space, which explains the name of the model. Furthermore, in this model consumer and producer are included in the prosumers, as consumers or producers will automatically become a prosumer by implementing a BSS. The second business model is a business model for the consumers (or prosumers), which can work in combination with an aggregator. In the case of an aggregator, the aggregator will operate the BSS technology on behalf of the consumer (or prosumer).

Business model concept, the value proposition

This model is based on upgrading the Dutch electricity grid, by implementing storage at the prosumers side. As this is seen as a commercial model for which prosumers are mostly attracted by financial incentives, maximizing financial benefits for prosumers is used as the primary objective. This model operates completely in the non-regulated part of the Dutch electricity system, which means that all five applications resulted from the previous chapters are applied in this model for the value proposition. The first application is the demand charge management application. This application focuses on purchasing inexpensive off-peak electricity in order to avoid expensive on-peak electricity and on lowering capacity tariffs by decreasing the maximum peak load. Lowering capacity tariffs is only valid for large prosumers, which basically means others than prosumers connected to the retail market. When taking the increasing energy price, the increasing energy use and the decreasing price of the BSS technology into account, BSS can already become feasible for only this application in the future (see financial design).

The second application is the balancing of forecast errors (renewable integration). This application focuses on creating flexibility in order to balance forecast errors caused by unpredictable sources owned by the prosumer, which are charged by TenneT. Nevertheless, this is not applicable for household in the Netherlands, as this customer segment has no program responsibility. The responsible actor for households is the electricity retailer, which can pay households (or give them discount) for balancing their unpredictable sources.

The third application is the electric energy time shift application. The purpose of this application in this context is supporting the integration of renewables that are placed somewhere else in the electricity grid. This means that the prosumer gives a certain control power of charging or discharging away to the electricity providers, for in case of over or undercapacity caused by renewables. In this case electricity providers can (partly) manage the imbalance their selves, which saves expensive imbalance costs charged by TenneT. Electricity providers should pay the prosumer for this service.

The forth and the fifth application, resulted from the previous chapter, can be combined into one service provided to the RGO's. Those two applications are congestion management and distribution upgrade deferral. With this service RGO's can buy flexibility from their customers, by controlling the battery to some extent, in order to prevent congestion or to defer upgrades by reducing peak loads.

We can conclude that this business model is based on a multi-sided platform, as described in Section appendix A, which brings more customers together in order to create the maximum possible value. Three customers of the prosumers can be recognized, which are summarized below in Table 9.

Table 9: Customer segment, Private Model

Nr.	Customer	Related value proposition
1	Consumer or prosumer	Reducing energy costs (internal customer)
2	Regional grid operators	Reducing congestion and high grid investments
3	Electricity providers	Reducing imbalance costs, due to renewables

Infrastructure management and customer interface design

The key actor of this model is the prosumer that determines the success. By implementing financial incentives, problems of other actors in the Dutch electricity system can be solved as well, which can make this model further attractive for the prosumer. This model assumes that the prosumer will be the owner of the BSS, directly or indirectly (e.g. lease contracts). Furthermore, the key roles of this model are included below in Table 10.

Table 10: Roles of the Private Model

Role	Actor
Problem Owner	- Consumer (or Prosumer) - Dutch Ministry of Economic Affairs
Responsible party	- Consumer (or Prosumer) - National and Regional grid operators
Administrator & Executive	Consumer (or Prosumer) or aggregator
Consulting	- Universities - (Energy) Consulting firms - Knowledge & research institutes - Technology providers
Controlling	Office of Energy Regulation

In order to give an overview about how this model works within the current multi-actor environment Figure 35 gives a schematic overview (market model). Within this figure the data, financial and energy (product) flows are included. The green colour indicates the parts that will be affected by this model. Furthermore, this model assumes that the BSS technology will be a key resource of the prosumer, who gains all the required capabilities to operate this technology.

The first two applications of the value proposition are used for own use only and will therefore not affect any electricity (product), financial or data flow. The third application will affect the data and money flow to and from the electricity provider. The electricity provider should send a signal to the BSS system in order to activate (charge or discharge) or deactivate it. Also price arrangements, responsibility issues and legal issues should be communicated, preferable by contracts. As a result for providing the service, electricity providers should pay prosumers, which changes the single direction of the money flow into a bi-directional money flow. The last two applications will have the most affect on the current multi-actor environment, as it will affect the flows from the RGO's to the prosumers and to the electricity providers. For those applications, the RGO's should, just like the previous application, make arrangements with the prosumer and send a data signal in order to activate or deactivate the system. As an addition to the current model, an extra money flow is added in order to pay the prosumer for the service. Furthermore, the RGO's should arrange the time shift with the electricity providers or they should pay for the imbalance costs, which affect the communication and money flows between the RGO's and the electricity providers. At last, the communication towards the metering responsible parties should be extend with information about the usage of the BSS by the other parties, in order to charge the right actors.

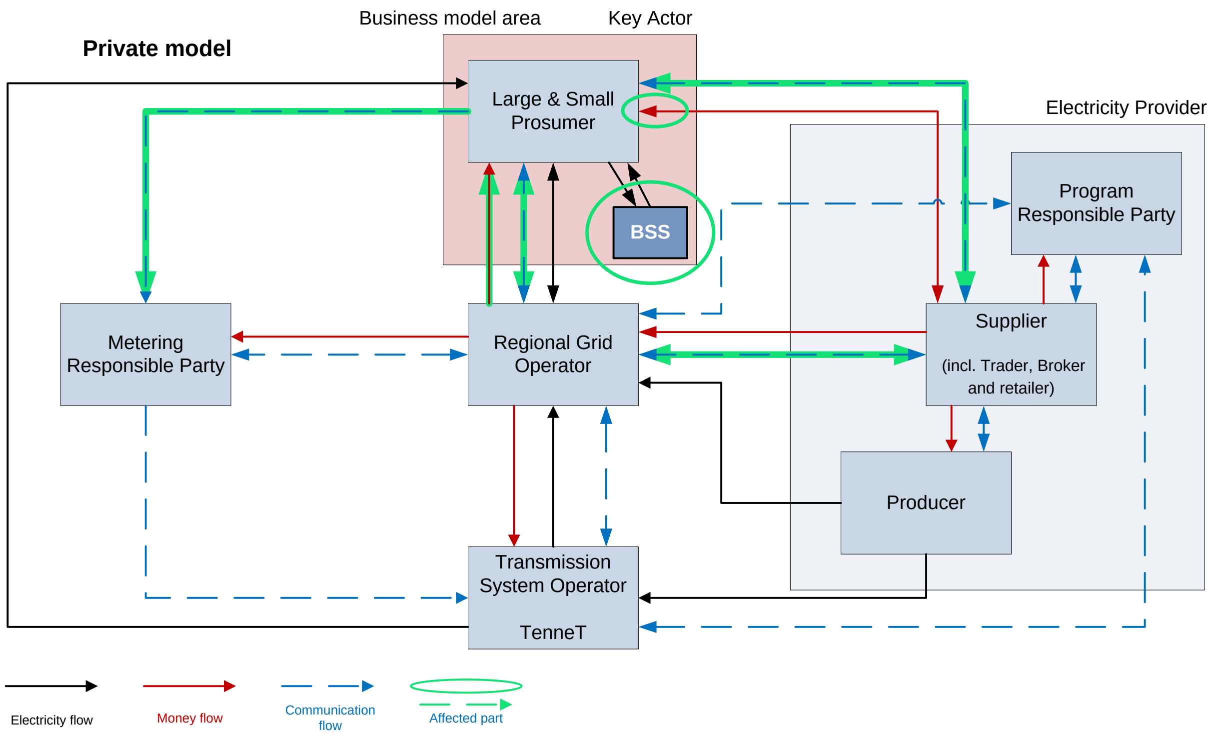

Figure 35: Actors in the Private Model (market model)

Financial design

The last important part of the business model design process is the financial design, which determines the main costs and revenue streams of the business model. Although an in-depth financial analysis is out of scope (see previous model), below two different examples are included to indicate the future attractiveness of the demand charge management application.

Example for large consumers	*Example households*
We assume for this example that the difference between the peak and off peak price on the APX is 70 €/MWh (Figure 44), that BSS has an efficiency of around 100% and the future CAPEX of BSS is 250 €/kWh (Offer, et al., 2010). This means that the payback time of the system is less than 10 years (no interest included) and is therefore feasible in the near future (life-time > 10 years). Nevertheless, in this example we did not take into account the increasing energy price and a further decreasing cost price of BSS, which can make this system even more attractive.	We assume for this example that the difference in day and night tariffs is around 0,04 €/kWh, the average consumption is 3500 kWh/year and that 2/3 of the energy is consumed during on-peak hours. This means that we have to install a 6,5 kWh BSS system to cover the whole on-peak period. In the near future this will costs €1625,-, while we can save around €90,- per year. For this group we have a payback time of around 18 years (no interest included), which is not attractive. Nevertheless, in combination with other applications, an increasing energy price, a further decreasing CAPEX of BSS and/or a higher value due to the energy transition, also this example can become attractive in the future.

The above examples gives a clear indication that in the near future only including the demand charge management application can become feasible, but is not quite attractive in the current circumstances. Therefore, the main value must come from combining the five applications, for which the value of the other applications is mainly determined by the development of the energy system. E.g. when renewable energy sources will have a significant share in distribution grids, the value of flexibility in the distribution grids will increase. Nevertheless, determining the financial value of those applications and in combination is out of scope for this research. As a result, the main cost, revenue and risks for this business model are as follows (from a prosumers point of view):

Costs:

- High technology investments, future expectation capital cost around 250 €/kWh (based on Li-ion batt.) (Offer, et al., 2010);
- Operating costs;
- Maintenance costs.

Revenues:

- Reducing energy prices;
- Solving congestion and upgrading problems for grid operators (providing flexibility);
- Providing flexibility for electricity providers, which they can use for integrating renewables (reducing risks).

Risks:

- Income from RGO's can be temporary, flexibility will not be needed anymore in the case of reinforcing the grid;
- Changing market models and economic structures can decrease the value of congestion management and upgrade deferrals, e.g. provide grid operators with more power in providing connections to their grid;
- Penetration rate of renewables influences the value of this model;
- BSS is a High-Tech technology, which means (Mohr, et al., 2005): (1) Technological uncertainty, (2) Market uncertainty and (3) Competitive volatility;
- Development of the Dutch electricity system determines the value of this model (Section 3.2), which is very uncertain.
- Do the benefits outweigh the risks for the prosumers? In today's environment grid operators and electricity providers are responsible.

Advantages and Disadvantages

As concluding remarks, the main advantages and disadvantages are included below in Table 11 and Table 12.

Table 11: Advantage of the Private Model

Nr.	Advantages
1	Involvement of the prosumer will directly lead to benefits for the end-user.
2	Maximally optimizing the electricity system for all related actors.
3	Limited resistance from law and regulation.
4	Supporting the energy transition.

Table 12: Disadvantage of the Private Model

Nr.	Disadvantages
1	High up-front investments and long payback times will hamper prosumers to install such a system.
2	Congestion management and distribution upgrade deferral is an uncertain income.
3	Currently RGO's or electricity providers are not responsible for solving congestion problems.
4	Technology, financial and social benefits are still highly uncertain.
5	Financial incentives are in the current market structure very limited available.
6	Financial arrangements should be made with different parties, which is very time consuming for prosumers (including transaction costs).

6.2.3 Business model 3: Provider model

This model takes the electricity provider as the key actor, which owns and operates the BSS system. Due to the current law and regulation RGO's are not allowed to create flexibility in the grids, by implementing storage facilities, as this intervenes the trading operations. Furthermore, many problems that occur due to the energy transition, e.g. fluctuations in supply due to renewables or congestion caused by too many producers active in one area, must not be a problem of the consumer or prosumer. As a matter of fact, electricity providers can be hold responsible for those problems. Therefore, the basic thought of this model is that electricity providers should be able to create flexibility in order to conquer the problems that occur, due to the energy transition, which explains the name of the model. The third business model is based on the business model of the electricity providers.

Business model concept, the value proposition

This model is based on upgrading the Dutch electricity grid, by implementing storage at the electricity providers' side. As this model is operating completely in the non-regulated part of the Dutch electricity system, four applications (determined in the previous chapters) are applied in this model for the value proposition.

The only application that is excluded from this model is the demand side management application, which is only valuable when storing electricity at the end-users side. The first application is the electric energy time shift application. The purpose of this application is to store inexpensive off-peak electricity in order to provide more capacity during expensive on-peak periods. A second purpose of this application is to spread the load, which means that production facilities can run more constantly. Running more constantly results in higher efficiency.

The second application is the integration of relatively unpredictable renewable energy sources. This application allows electricity providers to balance forecast errors, to store electricity in the case of overcapacity and to provide electricity in the case of undercapacity or during short interruptions. As a result, the value of renewable sources will increase, because renewables become a true replacement for our current depleting resources.

The third application is the congestion management application. In this model electricity providers are hold responsible for congestion, as they are locating close to each other that causes congestion. This application enables electricity providers to conquer the congestion problems, by shifting the transportation of energy over time.

The last application is the upgrade deferral application that is offered to the RGO's. With this service RGO's can buy flexibility from electricity providers in order to shift peak loads over time. As a result, the grid operators can balance their grids better and capacity problems can be deferred, which also means that investments for grid purposes can be deferred.

Infrastructure management and customer interface design

This model belongs to the electricity providers, who determines primary the success of this model. Consequently, the BSS system is owned by this actor and is treated as a key resource. Nevertheless, the overall problem owner is the Dutch Ministry of Economic Affairs, which has the end responsibility of the performance of the Dutch electricity system as a whole. The key roles of this model are included below in Table 13.

Table 13: Roles of the Provider Model

Role	Actor
Problem Owner	Dutch Ministry of Economic Affairs
Responsible party	Electricity providers
Administrator & Executive	Electricity providers
Consulting	- Universities - (Energy) Consulting firms - Knowledge & research institutes - Technology providers
Controlling	Office of Energy Regulation

In order to give an overview about how this model works within the current multi-actor environment Figure 36 gives a schematic overview. Within this figure the data, financial and energy (product) flows are included. The green colour indicates the parts that will be affected by this model. Furthermore, this model assumes that the electricity provider has all the required capabilities to operate and maintain this technology.

The first three applications are for own use and therefore limit the affect on the current multi-actor environment. Those three applications will only affect the internal operations (communications) between the supplier, PRP and producer. The affected communication is primary based on or about the charge and discharge strategies for BSS. The last application is a service that is offered to the RGO's. This application requires a communication flow in which the RGO's communicates their charge and discharge preferences. The electricity providers will use this information as an input for their charge and discharge strategies.

Physically the BSS will be installed at a separate connection or added to an already existing connection owned by the electricity provider, e.g. added to a production facility. Therefore, the BSS is included in Figure 36 as a separated unit that must be metered as well.

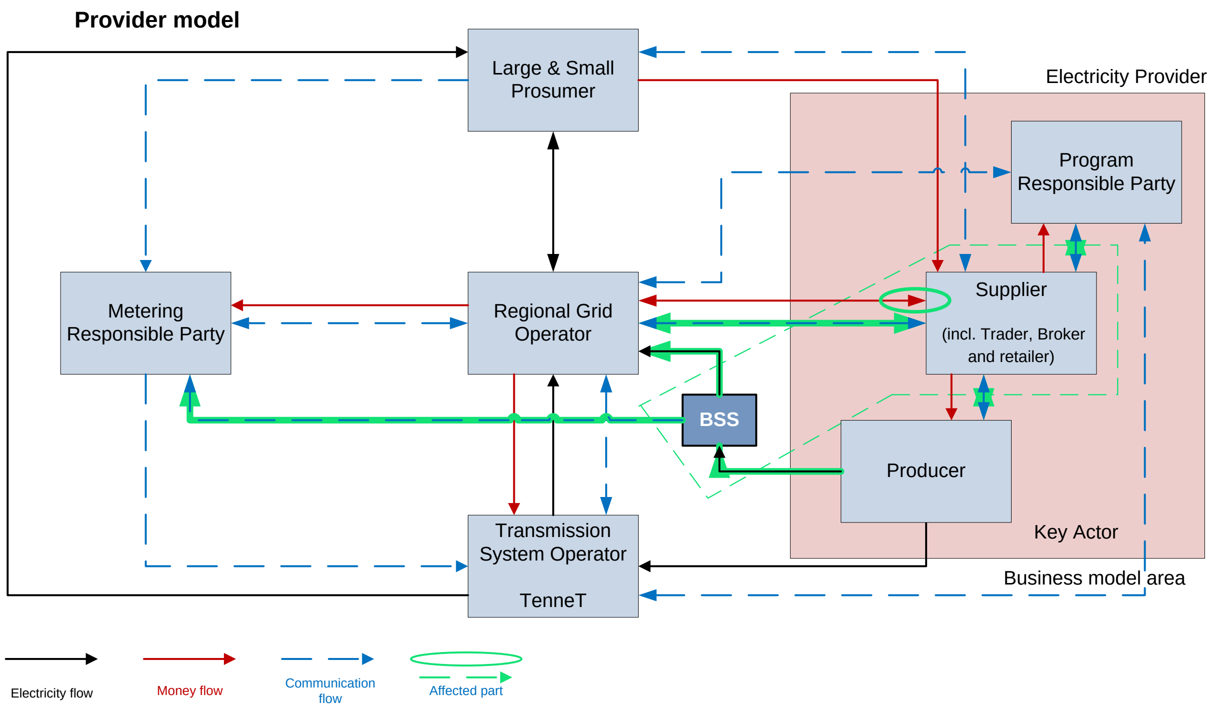

Figure 36: Actors in the Provider Model (market model)

Financial design

The third and last important part of the business model design process is the financial design, which includes the main costs and revenue streams of the business model. As this model is based on future expectations of BSS developments and the energy transition, financial benefits are hard to distinguish, as explained in the first business model. Furthermore, this model obligates the electricity providers to solve the problem of integrating renewables on a large scale and to solve the problem of congestion. Therefore, the value of flexibility will increase, which enhances the success of the business case. As a result, the main cost, revenue and risks for this business model are as follows (from an electricity providers point of view):

Costs:

- High technology investments, future expectation capital cost around 250 €/kWh (based on Li-ion batt.) (Offer, et al., 2010);
- Operating costs;
- Maintenance costs.

Revenues:

- Reducing energy costs;
- Solving problems related to congestion and large scale integration of renewables;
- Solving upgrading problems for grid operators (providing flexibility);

Risks:

- Changing market models and economic structures can decrease the value of congestion management for electricity providers, e.g. congestion is the responsibility of the grid operators.
- BSS is a High-Tech technology, which means (Mohr, et al., 2005): (1) Technological uncertainty, (2) Market uncertainty and (3) Competitive volatility;
- Development of the Dutch electricity system determines the value of this model (Section 3.2), which is very uncertain (e.g. highly dependent on energy strategies of the government).

Advantages and Disadvantages

As concluding remarks, the main advantages and disadvantages are included below in Table 14 and Table 15.

Table 14: Advantage of the Provider Model

Nr.	Advantages
1	High level up-front investments can be divided (recovery) over all members.
2	Limited resistance from law and regulation.
3	Uncertainty can be shared with all members.
4	Supporting the energy transition.
5	Equipment can be shared (within one organization) with more renewable sources, economies of scope.

Table 15: Disadvantage of the Provider Model

Nr.	Disadvantages
1	Financial incentives are in the current market structure very limited available.
2	Lack of responsibility for congestion and integrating renewables.
3	Technology, financial and social benefits are still highly uncertain.

6.3 Value assessment

The value of the three business models is evaluated in this section on a feasibility level, which is achieved in two steps. The first step is the understanding of how those new business models will change the current business models of the most important actors in the Dutch electricity system. The new business models should support the strategy and fit to the current business models in order to become a success. Therefore, this fit determines for a large part the acceptability of the new business models by the actors involved. Consequently, the first step compares section 6.1 with 6.2 and determines the strategic fit between the current and new (or additional) business models. The second step is a feasibility assessment that determines the value of the three new business models in practice. In this step the knowledge gained from the previous chapters is evaluated in relation to the three new business models on five criteria, namely consumer/end-user engagement, technology & system feasibility, market facilitation feasibility, law & regulation feasibility and economic feasibility. Both steps are carried out by the researcher on the knowledge gained from this research project.

6.3.1 Step 1: Effects on the business models of the most important actors

At first the three new business models, Section 6.2, are compared with the current business model and strategy of the RGO's, Section 6.1. The result of this comparison can be enumerated as follows:

Key partnerships (KP): The *RGO model* requires more extensive communication with the suppliers, as the grid operators will change the e-programs to some extent (incl. buying in losses). Next, the metering responsible party can become a key partner, because collaboration is required more often. The *private model* will result in a key partnership with the prosumer, as the RGO's want to make use of the resources of the prosumer. At last, the *provider model* requires a more extensive partnership with the suppliers, because RGO's will become more dependent on them.

Key activities (KA): The *RGO model* requires key activities in order to operate and maintain the BSS system, which includes the strategic planning of this resource. In the *private model* the BSS system should also be strategically managed, but this activity is limited to sending controlling signals to the prosumer. In the *provider model* strategic transportation schemes should be provided to the electricity providers. All activities related to BSS are new activities, but differ in their level of importance.

Key Resource (KR): Only in the *RGO model* changes will occur, namely owning the BSS system itself.

Value Proposition (VP): The value proposition, providing the different applications, can best be applied in the *RGO model*. In the other models the value of the applications are limited, as the most important applications for this actor are treated as less important. Nevertheless, in all three models the objective is to increase the efficiency of managing the assets.

Customer relationship (CR): The *RGO* and the *provider model* require a relationship with the electricity provider, in order to communicate together on a regular basis. This is needed to adapt both preferences in one strategic charge and discharge scheme. In the *private model* the relationship with the prosumer and RGO will become increasingly important, which requires customer contacts more often.

Channels (CH): For all three models communication will become increasingly important. Therefore, the channels will be used more often and it must become easier to contact the right person.

Customer segment (CS): Only in the *RGO model* this part will be affected, as a new customer will be added (suppliers of renewables). In the other two models, the RGO will become a customer and/or key partner of other actors.

Cost structure (C$): In the *RGO model* costs are caused by owning the system. While in the other two models costs are caused by buying flexibility services from prosumers or electricity providers.

Revenue streams (R$): In all three models revenues comes from reducing congestion and defer distribution grid upgrades. Nevertheless, in the first model, *RGO model*, those revenues will have the largest magnitude. In the *RGO model* revenues can be extended by providing a renewable integration (balancing) service to the electricity providers.

The results of this analysis are summarized below in Table 16, in order to provide a quick and clear overview.

Table 16: Qualitative evaluation of the RGO's business model, a summary

		Business Models		
		RGO	Private	Provider
The 9 building blocks of a business model	KP	- Suppliers (more extensive) - Metering Responsible Party	- Prosumer	- Suppliers (more extensive)
	KA	- Planning distribution - Operate + maintenance	- Controlling BSS at the customers side (strategically)	- Provide strategic transportation scheme's
	KR	- BSS		
	VP	- Transport electricity in the most efficient way	- Efficient asset management, result in "cheaper" transport fees	- Efficient asset management, result in "cheaper" transport fees
	CR	- Connection between controlling departments (electric provider)	- Prosumer (more extensive) - Electricity provider (more extensive)	- Connection between controlling departments (electric provider)
	CH	- Direct connection, preferable through an Internet connection	- More communication required	- Direct connection, preferable through an Internet connection
	CS	- Suppliers of renewables		
	C$	- Operation and maintenance - High upfront investments	- Flexibility services provided by the customer	- Flexibility services provided by the electricity providers
	R$	- Upgrade deferral - Reducing Congestion - Balancing (renewable) services	- Upgrade deferral - Reducing congestion	- Upgrade deferral - Reducing congestion

While comparing the current strategies of the RGO's with Table 16, it is clear that the RGO model has the best fit, because reliability, costs, quality, enabling renewables, etc. can from a RGO's point of view best be performed and secured with the first model.

Secondly, the three new business models, Section 6.2, are compared with the current business model and strategy of the electricity providers, Section 6.1. The result of this comparison can be enumerated as follows:

Key partnerships (KP): All three business models will not add any actor to the key partnership list for electricity providers. Nevertheless, the *RGO model* will result in a more extensive partnership with the RGO's and the *private model* with RGO's and prosumers. The increasingly importance of partnerships is a result of sharing benefits by optimizing the usage of assets.

Key activities (KA): The *RGO model* requires the activity of providing strategically interesting transportation schemes to the RGO's, in order to reserve battery capacity. The *private model* is limited by sending controlling signals to the prosumer, which has basically the same purpose of the transportation schemes. The third model, *provider model*, requires key activities in order to operate and maintain the BSS system, which includes the strategic planning of this resource.

Key Resource (KR): Only the *provider model* will be affected, as the electricity provider owns the BSS system in this model.

Value Proposition (VP): All three business models enable the integration of renewables and the reduction of congestion services. Nevertheless, the *provider model* also enables the electricity providers to provide flexibility services to the RGO's.

Customer relationship (CR): The *RGO* and the *provider model* require a relationship with the RGO's in order to communicate together on a regular basis. This is needed to adapt both preferences in one strategic charge and discharge scheme. In the *private model* the relationship with the prosumer and RGO will become increasingly important, which requires customer contacts more often.

Channels (CH): For all three models communication will become increasingly important. Therefore, the channels will be used more often and it must become easier to contact the right person.

Customer segment (CS): Only in the *provider model* a customer relationship exist, with the RGO's. In the other two models the electricity provider will become a customer and/or key partner of other actors.

Cost structure (C$): In the *provider model* costs are related to operating and maintaining the BSS technology and to the high-upfront investments. While in the other two models costs are caused by buying flexibility services from RGO's or prosumers.

Revenue streams (R$): In all three models revenues are directly related to the value proposition. Therefore, in all three models revenues comes from enabling more renewables and reducing congestion costs. Nevertheless, in the *provider model* also revenues can be gained from the flexibility service provided to RGO's.

The results of this analysis are summarized below in Table 17, in order to provide a quick and clear overview.

Table 17: Qualitative evaluation of the electricity providers' business model, a summary

		Business Models		
		RGO	Private	Provider
The 9 building blocks of a business model	KP	- RGO's (more extensive)	- Prosumers (more extensive) - RGO's (more extensive)	
	KA	- Provide strategic transportation scheme's	- Controlling BSS at the customers side (strategically)	- Strategic planning storage - Operate + maintenance
	KR			- BSS
	VP	- Integrating renewables - Reducing congestion	- Integrating renewables - Reducing congestion	- Integrating renewables - Reducing congestion - Providing flexible transport
	CR	- Connection between controlling departments (RGO's)	- Prosumer (more extensive) - RGO (more extensive)	- Connection between controlling departments (RGO's)
	CH	- Direct connection, preferable through an Internet connection	- More communication required	- Direct connection, preferable through an Internet connection
	CS			- RGO's
	C$	- Flexibility service RGO's	- Flexibility services provided by the customer	- Operation and maintenance - High upfront investments
	R$	- More renewables - Reducing congestion	- More renewables - Reducing congestion	- More renewables - Reducing congestion - Providing flexibility to RGO's

While comparing the current strategies of the electricity providers with Table 17, not one model has a clear preference. The first (RGO) model can be attractive, as electricity providers are not focussing on assets other than generation assets. The second (private) model can be attractive as electricity providers have the objective to work more closely with consumers and/or prosumer in order to satisfy individual needs. The last (provider) model can be attractive because of the push to implement more renewable sources into the electricity grid and provide the BSS technology. In this model the electricity providers have the full power to integrate renewable sources faster, assuming that they are competitive to other sources. The competitiveness in this case is dependent on future government decisions related to renewable energy sources.

6.3.2 Step 2: Feasibility assessment

The final step in the design process is determining the feasibility of the three business and therefore also market models (Figure 34, Figure 35 and Figure 36), by carrying out a feasibility assessment. This assessment is based on the knowledge gained from the previous sections and chapters. In scientific literature different definitions can be found for the term feasibility assessment or feasibility study, but they all have the same purpose (Mzallassi, 2005). The purpose of a feasibility assessment is assessing both the possible and practical aspects of a project, process, etc. by performing different analyses in order to determine whether the project, process, etc. is capable of being accomplished (The American Heritage Dictionaries, 2000). As a result, in this section the business models are assessed by the researcher on the following five criteria:

- Consumer / end-user engagement feasibility;
- Technology & System feasibility;
- Market facilitation feasibility;
- Law & Regulation feasibility;
- Economic feasibility.

A summary of the feasibility assessment is included in Table 18 on page 91.

Consumer / end-user engagement feasibility

The end-user is the main actor who determines the success of a new or additional business model (Balsters, 2008). Therefore, the first feasibility assessment is based on satisfying the end-user, for which the level of participation, privacy, and accessibility is the main focus.

All three models have in common that they add benefits to the end-user (directly or indirectly), but the main difference between those models is the level of customer engagement that is required. In the *RGO model* the main focus is that the end-user should not experience any consequences of the energy transition. Therefore, the complete responsibility is for the RGO's, who has probably the best insights in the flexibility needed in the distribution grids. Although the end-user will gain indirectly the advantages of this, he cannot fulfil his individual energy needs. Also privacy issues are limited to the maximum extent in this model, because the flexibility will not be determined on individual energy profiles.

The *private model* on the other hand requires an extensive participation of the end-user. This participation is needed on a financial (high upfront investments), technology (BSS owner) and organizational basis (contracts with RGO's and electricity providers). Although this model results in an optimal fulfilment of individual energy needs, most customers will probably not accept this model directly. As a result and during the possible implementation phase, customer participation should be limited to the maximum extent, e.g. reducing financial investments by lease contracts. Next, the privacy of the end-users is a main issue in this model, as detailed data needs to be exchanged with RGO's and electricity providers. Although privacy issues can be taken maximally into account, this problem cannot be taken away completely. The third point of criticism is the lock-in affect that may occur due to this model. End-users become more dependent on their energy provider, which disturbs the market operation. As a result, this model will be valued completely different among end-users and their needs to control the energy supply and demand.

The *provider model* can be assessed equally as the RGO model, as the end-user will benefit indirectly from the advantages, carried out by the electricity providers. The main difference compared to the RGO model is that this model will focus more on integrating renewables owned by the electricity provider and less on optimizing transportation efficiency. Nevertheless, the end-user will notice only the difference if one of the two models (RGO or provider) will result in a significant difference in total energy costs.

We can conclude that the RGO and the provider model will be assessed positively. Nevertheless, an optimal result cannot be obtained, as individual customer needs cannot be fulfilled. The private model will be assessed negatively as too much end-user engagement is required.

Technology and System feasibility

The second feasibility domain is related to the technology and system design. During this assessment the focus will be on the level of technological complexity and the level of contribution towards the Dutch electricity system requirements. The technological complexity determines the capabilities the involved actor should gain, in order to operate and maintain the system. The system requirements will follow directly from the available applications per model.

The first (*RGO*) model is from a technological point of view the preferred model, as the RGO's have all the capabilities in house to operate and maintain this technology. As the RGO's have the full responsibility in this model and services offered to other actors are limited, the complexity is reduced to a minimum. Furthermore, the applications offered with this model are reduced to only three, but those three can optimally be used. As a result, this model offers a great support to the system requirements. The main reason for this high support level is that the benefits of the assets are not limited to a company, but can be shared among all actors involved.

The *private model* is from a technological point of view a very complex model, as many actors are involved. In order to let the BSS technology work as intended, a complex communication (IT) structure is required. Therefore, the control and power conditioning system (C-PCS) will become increasingly important and complex. As the BSS system is installed at the prosumers side, they must have or gain the capabilities to operate and maintain the system, which is not naturally the case. As a result, this model will have a negative effect on the reliability, safety and affordability requirements of the system, which can be reduced somewhat by introducing an aggregator. Nevertheless, if we assume that the complex technology works as intended the "new" system requirements can be supported to the maximum extent.

The third, *provider*, model is just like the RGO model primary used to support the in-house processes. Therefore the actors involved are reduced to a minimum, which results in a limited technological complexity level as well. However, this model fits into the non-regulated part of the Dutch electricity system, which means that it will be used for competitive purposes. Therefore, the technology will not be shared with competitors, which can result in inefficient solutions. Also the level of services provided to the RGO's will be limited, as this service will have to lowest priority. As a result, the system requirements will be supported to a limited extend, with the provider model.

We can conclude that the RGO model will provide the highest score for this assessment. Secondly the provider model, as the system requirements are less satisfied. At last the private model, as complexity will increase enormously and providing all applications will be very difficult.

Market facilitation feasibility

The third feasibility domain focuses on the feasibility of the market facilitation that is required. This means that the required organization, infrastructure, customer interface and relations between actors will be the main part of this assessment.

The *RGO* and the *provider model* are relatively easy organized, as the models are primary focussing on internal processes, which requires a relatively easy infrastructure management. Since the primary focus is on internal processes, the customer interface and the relation with other actors are also limited affected. The *private model* on the other hand requires a quite extensive infrastructure management, as important services are provided to different actors. Those actors become increasingly dependent on each other, for which the prosumer has the most important role. The prosumer will become increasingly important, as he owns the technology that will be used by other actors.

We can conclude that from a market facilitation point of view the RGO and provider model can easily be implemented. However, the private model will become very complex if we keep focussing on satisfying all five applications (as we have decided in this thesis).

Law & Regulation feasibility

The forth element of this feasibility assessment is regarding the current law and regulation. Since, storage is not included in the current law and regulation actors who operates in the regulated part of the Dutch electricity market can encounter problems with implementing this system. Therefore, this part of the feasibility assessment focuses primary on the restrictions, possibilities and the stimulation of storage following from the current law and regulation.

At first, the current Dutch electricity law and European regulation seems not to rule out local system services regarding storage. However, the refinement of the Dutch electricity regulation (system codes), the directives from TSO TenneT and the unbundling law do rule out local system services, which is mainly caused by the requirements on the availability and size of the suppliers and the market structure. Since, RGO's are free to charge the tariff system (included in the tariff codes), local system services can be provided by third parties through price incentives. Nevertheless, the Dutch electricity regulation requires that RGO's should not discriminate between connections and that implementing a BSS system must be approved first by all network operators. Secondly, storage can be seen as intervening the trading market, which is not allowed within the regulated part of the Dutch electricity market. This means that actors operating within the regulated part of the Dutch electricity system are not allowed to install electricity storage systems for commercial purposes. As a result, the current market structure does not allow any storage facilities installed in the distribution grids or allows local system services, which affects all three models negatively. However, the RGO model is from this point of view completely disallowed while the private and provider models are allowed without the services provided to the RGO's. Furthermore, the current regulation (tariff codes) does not stimulate (large and small) consumers, prosumers or producers to implement any storage facilities, due to the current pricing mechanisms used, which is further discouraged by the low energy prices.

Economic feasibility

The last part of the feasibility assessment is the economic feasibility. Within this part the investments, (operational) costs streams, benefits and societal interests are taken into account.

BSS needs a high upfront investment that can still only be recovered by amortization over long periods, which is only possible in combination with long lifetimes. The lifetime of a battery storage system is mainly dependent on the type of battery used, described in Chapter 4. Nevertheless, in this thesis we assume that different environmental forces will increase the value of storage and therefore business cases related to BSS will become feasible in the near future for power applications. As three of the five applications are mainly providing benefits for the whole society, it would be logical to divide the costs related to them as well. If we take the long lifetime, high level of technological uncertainty, market development uncertainty and societal interest into account, RGO's would be the logical responsible actor. By providing RGO's with the responsibility to implement storage in the distribution grids, all actors can gain the same benefits and the accessibility will be guaranteed. This enhances the market operation, as relatively small electricity providers are not faced with high extra upfront investments, and provides the maximum hardware efficiency, as the usage can be shared among all parties.

The operational aspects related to BSS have the best fit with the daily operations of the RGO's and secondly with the (large and small) producers. Both actors should have the (technical) knowledge in-house in order to safely operate and maintain the system. Therefore, this technology will become an additional asset to their already existing assets, which results in the lowest operational costs.

We can conclude that from an economic feasibility point of view the RGO model has the preference, followed by the provider model. In the RGO model investments and benefits are shared among all members and operational costs are limited to the maximum extent. This model provides also the lowest transaction costs, as the most important applications are for internal usage only. The provider model has the disadvantage of not sharing the assets, which can result in inefficient usage of the storage capacity. The last, private, model has the disadvantage that the knowledge to operate and maintain the technology is not naturally in-house, which is costly and can be dangerous as well.

The results of the complete feasibility analysis are included below in Table 18. The double plusses indicate the most positive outcome and counts for 10 points, followed by the single plus that counts for 5 points. Zero points indicates that there is no significant influence on the success of the model. The double minuses indicates the most negative outcome and counts for -10 point and the single minus for -5. In this table all five assessments have the same weight factor.

Table 18: Feasibility assessment, a summary

Criteria	Business Models		
	RGO	Private	Provider
Consumer / End-user engagement feasibility	+	-	+
Technology & System feasibility	++	-	+
Market facilitation feasibility	++	--	++
Law & Regulation feasibility	-	+	+
Economic feasibility	++	-	0
TOTAL	**30**	**-20**	**25**

From the table we can conclude that the RGO model will have the highest potency in the market, although the law and regulation should adapt storage first in order to make this model possible. The provider model will be the easiest model to implement, but gains from an economic point of view no incentives. The private model has the worst outcome if we take all five applications into account. If we would implement this model for only own usage this model can become feasible as well, especially in relation with own generation and changing tariff structures (as in different foreign countries like Germany).

The outcome of the feasibility assessment is in line with the expectations of the interviewees, described in Chapter 5, in which they indicate their main concern about the current law and regulation. According the interviewees the current law and regulation will hamper or block the introduction of BSS in practice. This section provides an extensive understanding and confirmation about their concern.

6.4 Conclusion

In the Netherlands the RGO's consist of a natural monopoly position, because of the physical limitations of their assets. Therefore, the Dutch Ministry of Economic Affairs has decided to regulate this part of the system. As a result, the RGO's have no competition, but are challenged by the Office of Energy Regulation to perform better than their colleagues in the same market. Within the Netherlands we have eight RGO's, of which three of them determine around 90% of the market. Based on those three RGO's (Stedin, Alliander and Enexis) a strategy and business model analysis is carried out in this chapter. The current strategy of RGO's is based on quality in the form of differentiation, in which satisfying changing market conditions is the primary focus. Between RGO's the only difference that exist is their believes about how the future electricity system will develop. On a business model level the value proposition consist of providing connections to their distribution grids and transporting energy over their distribution grids.

Since the unbundling law, the amount of electricity providers (includes producer, PRP, retailer, trader and broker) are increasing in the Netherlands. Although different strategies are used within this actor group, the sample companies carry out the same strategy. This strategy is based on the generic volume – differentiation strategy provided by porter (1985). The volume strategy focuses primary on horizontal and vertical integration. Meanwhile the differentiation part is based on different visions, which basically explains the different services provided within the value proposition of the business model. The value proposition of the electricity providers is based on satisfying individual customer needs on a mass production scale. Therefore, an increasing amount of different products and service combinations are evolving within this market. The offered products can basically be categorized by fossil, sustainable or renewable electricity generation.

Based upon the previous chapters, three business models are developed. The first model is the RGO model, which treats the RGO's as the main responsible actor for enabling the energy transition. The second model is the private model, which puts the responsibility at the prosumer. The last model is the provider model, which is based on the electricity provider. Within the three models an increasing cooperation with other actors is required, in order to provide the applications resulted from the previous chapters. As a result, the actors will become more dependent on each other.

Thereafter, the three "new" business models are assessed on the fit they have with the current business models and strategies of the existing actors. Based on this assessment we can conclude that the RGO model is the preferred model from a RGO point of view, as this model fits good to its current business activities and resources. This model will also reduce the dependency of this actor on other actors, which guarantees the reliability of the distribution grids. While assessing the three models from an electricity provider point of view, not one single model has the highest preference. All three models have their own advantages and disadvantage, which have more or less an equal value.

At last, a feasibility assessment is carried out in order to determine the potency of those models in practice. From this feasibility assessment we can conclude that the RGO model has the highest value in practice, although the law and regulation should adopt storage possibilities first. The current law and regulation does not allow RGO's to operate any storage facilities, which is mainly caused by the current system codes, directives from TSO TenneT (availability and size of the suppliers) and unbundling law. The provider model will follow on the second place, which gains from an economic point of view no incentives. The Private model has the worst value, which is caused by the mismatch of the five applications. The expectation is that the value of this model can be increased when focussing on only the applications for own usage (and optimally levering the demanded environment). Nevertheless, this structure will not be very beneficial for the system as a whole, which is an objective for this research (satisfying the system requirements).

The final conclusion of this chapter is that BSS can best be owned, operated and maintained by RGO's. This will result in the highest value for the Dutch electricity system as a whole.

7 Conclusion and recommendations

This chapter provides the final conclusions and recommendations of the research undertaken and therefore shutdown the research project. The first section includes the conclusions in which the main focus is on answering the main research question. Secondly, this section provides the main findings of this research, which are relevant for the scientific community and organizations active in the electricity industry. The second and last section of this chapter provides the recommendations, which includes the recommendations for further research.

7.1 Conclusion

During recent years, different environmental forces have significantly changed the Dutch electricity system, which characterizes this system as dynamic, uncertain and complex. As this system is still evolving, creating and capturing sustainable competitive advantages becomes increasingly important and difficult to manage. Therefore, scientific research is highly recommended and demanded when implementing new technologies in this system, which will affect the technical, institutional and economic structure of the system. This research project is one those examples, adduced by Siemens Netherlands and the Delft University of Technology. This research project focuses on implementing a new technology, Battery Storage Systems (BSS), in the Dutch electricity system, by emphasizing the related business models and implementation barriers. As a result, the posed research question for this research undertaken is as follows:

"What is the most promising future business model for Battery Storage Systems in the Dutch electricity system?"

In order to answer this research question, this research project consist of three core phases. The first core phase is an extensive literature study in which the scientific strategic management literature is analyzed in-depth, in order to understand the design issues of a business model. As different theories about business model designs exist, a choice has been made for a theory that has a good fit with this research project. The solid scientific business model theory of Osterwalder (2010) is chosen for this research project. Based on the framework provided by Osterwalder (2010) and the research provided by Zegveld (2006) two different analyses are carried out, namely:

- **Outside-in:** From an outside-in perspective, it is important to understand the system in which the technology will be introduced and the forces that will reshape this system. As a result, the (future) Dutch electricity system requirements are determined, which should be supported by the introduced technology to become a success. Furthermore, this analysis provides an overview of the actors involved and their roles in the system, as we are dealing with a multi-actor environment.
- **Inside-out:** From an inside-out perspective, the capabilities and resources that provide an outstanding performance should be analyzed and adapted to the Dutch electricity system requirements. Therefore, the unique technological characteristics and limitations of the BSS are determined first. Thereafter, the related applications and the alternative technologies are determined, in order to determine the uniqueness of BSS in the Dutch electricity system.

As most scientific literature available for this research phase is based on case studies carried out in Denmark and the United States of America, a second research (core) phase is needed to validate the collected data for the specific case in the Netherlands. Furthermore, this phase is needed to collect the additional data required for designing the solid and robust business models, related to BSS. Therefore, the second research phase consisted of an extensive field study, which is based on expert interviews. The experts chosen for this research is based on a semi-structured selection procedure. The main results of the interviews (supplemented by the literature phase) can be enumerated as follows:

- All interviewees expect that BSS will have an important role in the future electricity system. Nevertheless, the level of significance will be determined by the penetration level of decentralized (renewable) energy sources and the magnitude of demand side management. Furthermore, the expectation is that this technology will be relevant within 5 – 15 years.
- The transition towards a more sustainable electricity system is seen as the main driver behind the development of BSS, which includes the following (mega) trends: climate change, smart grids, smart homes, mass-individualization and EDV's. Next, storage on each transportation level in the physical part of the Dutch electricity system will become increasingly important. Nevertheless, the technology itself must be improved first before feasible business cases can be realized, which is expected in the (near) future.
- The focus of BSS should be on supporting the following (future) system requirements: reliability & accessibility, quality, security of supply, sustainability and flexibility. The requirements that are still uncertain are: affordability, economically, efficiency and transparency, which are highly dependent on the energy transition and technological developments.
- The most promising applications for BSS in the Dutch electricity system are: (1) electric energy time shift, (2) congestion management on distribution level, (3) distribution upgrade deferral, (4) demand charge management and (5) balancing forecast errors. Furthermore, three applications are recognized for further research (out of scope): V2G & G2V, innovative retail applications and smart home applications.
- Three main actors are recognized in the Dutch electricity system who can gain the most benefits with this technology, namely: (1) regional grid operators, (2) consumer (or prosumer) and (3) electricity provider (includes producer, programme responsible party, trader & broker and retailer).
- From a strategic point of view, the main focus for BSS should be on actors and organizations that use a differentiation strategy and on gaining first movers advantages. Although RGO's do not have any competition, BSS allows them to operate more efficient than their colleagues in the same market, which is highly demanded caused by the price-gap regulation. Furthermore, BSS seems to have a good strategic fit with the RGO's.
- All interviewees believe that this technology will reshape the current business models of the RGO's and electricity providers. Following the framework of Osterwalder (2010), a significant share of the interviewees believe that: (1) BSS will become a key resource of the RGO's. (2) adds new key activities to the activities of the RGO's, (3) for both actors the key partnerships will be affected, (4) the consumer interface will develop to more extensive relationships with the

customers (for both actors), (5) financial aspects are highly uncertain, but the expectation is that this technology will result in less sharp increasing costs. Furthermore, this technology will be used to differentiate from the competitors, which results not necessarily in cost reductions. Finally, the speed of introduction will follow automatically from the energy transition.
- All interviewees do not expect any resistance against this technology development, only that some actors will experience this development as unpleasant and are therefore not willing to contribute to this development. Furthermore, resistance can arise on the recommended market / business model.
- All interviewees recognize problems in the current law and regulation, as storage is completely unknown. A significant share of the interviewees expect that therefore the law and regulation will be the main implementation barrier for this technology.

The information gathered in the first two core phases is used as an input for the last core (design) phase, which consist of three extensive business model designs. Next, this phase includes a business model analysis of the current business models of the RGO's and electricity providers, in order to determine the strategic fit of the designed business models. Furthermore, an extensive feasibility study is carried out, which is together with the comparison of the business models, part of the value assessment. The value assessment evaluates the three business models and determines the preferred business model design. As a result, the most promising business model design is the RGO model. The RGO model can be summarized as follows, by taking the four business model domains of Osterwalder (2010) into account:

- **Product / Service (Value proposition):** The service that is offered with this model is storage (buffer / flexibility) in the distribution grids, for which the costs and benefits can be shared among all members. Furthermore, the emphasize of this model is on three applications, namely: (1) congestion management, (2) distribution upgrade deferral and (3) balancing of forecast errors.
- **Infrastructure management:** The BSS technology will become a key resource of the RGO. This includes all the operational and management activities related to it, which have almost a perfect fit with their core business (asset management). In this configuration the market operation will not be disturbed and therefore the integration of distributed (renewable) energy sources can be stimulated optimally. Nevertheless, partnerships between the RGO's and the electricity providers will become increasingly important, in order to gain the maximum benefits.
- **Customer interface:** This part of the business model will be limited affected. The main difference is that the customer profile will change in which distributed (renewable) energy sources will become increasingly important. Furthermore, the electricity suppliers can be recognized as an new customer for the RGO's.
- **Financial aspects:** The future value of the benefits is difficult to distinguish, as this is dependent on the development of the energy transition. The main determinant in this transition is the magnitude of decentralized generation, which is case specific. Next, the development of BSS is of interest, as price and performance are still far from feasible. Furthermore, the feasibility is dependent on the increasing price for energy, increasing costs for fossil fuels, increasing unpredictable energy sources, political choices and future market structures.

Determining the value of those variables is out of scope for this research, but highly recommended for further research.

In order to provide information about the feasibility of the RGO model, the value assessment included in Chapter 6 provides the main insights. This assessment showed that the physical layer of the Dutch electricity system will not encounter any major implementation barriers, but that the main barriers occur in the economic and institutional layer, as expected by the interviewees. Those main barriers lie in the detailed rules and guidelines regarding the Dutch electricity law and regulation, including the system roles of different actors.

The unbundling law, system codes and directives of TSO TenneT rule out the usage of BSS in the Dutch distribution grids, which is mainly caused by the availability & size of the storage capacity and market structure. First, storage in the distribution grids can be seen as intervening the trading market and therefore disturbing the market operation. Secondly, the current tariff structures do not stimulate (financial incentives) any storage facilities or services. At last, the guidelines of TSO TenneT does not accept the uncertain availability (time of response and minimal duration) and small size of BSS on the balancing market. Furthermore, TenneT has the only system operator role, who has a higher preference for interconnections (can result in lock-in effects). Therefore, the RGO is according the current Dutch law and regulation not allowed to carry out any system operation activities, which includes storage. As a result, major barriers needs to be removed in order to include storage in the Dutch distribution grids (regulated part of the electricity system), which can be a long and intensive process.

7.2 Recommendations

Throughout the research undertaken, different recommendations have been identified. First, the general recommendations regarding the implementation of BSS in the Dutch electricity system are included in this section. Secondly, the recommendations for further research are included, which could not be included into the scope of this research project due to their complexity and magnitude.

General recommendations

At first, the expectation is that not one of the business models designed in Chapter 6 will become the only model in practice, although the RGO model has the highest potential and value for the Dutch electricity system as a whole. Depending on the energy transition and political decisions in the future (e.g. making parties responsible for solving imbalance regarding renewables), other models can become more valuable. Therefore, the first recommendation for technology and knowledge providers, including Universities, is to keep the other models in mind when developing the BSS technology.

Secondly, electricity storage should be included in the Dutch electricity law and regulation, especially if we would like to implement a significant share of unpredictable (renewable) energy sources in the most efficient manner. This includes the rules and guidelines needed in order to use the storage capacity as intended, e.g. how to store only renewable energy and not energy generated from fossil fuels. This also includes permitting limited storage services for RGO's, which includes the permission for the required energy trading. Furthermore, financial incentives for storage are recommended to enhance the investment climate, e.g. financial incentives for prosumers to store their generated energy for own use, which reduces the required investments in the distribution grids and keeps the distribution grids better manageable. Nevertheless, a clear decision by the Ministry of Economic Affairs on the future market model is preferable. Technology and knowledge providers can start the discussion with all actors involved, which stimulates win-win situations for all actors.

Thirdly, RGO's should get a limited system operation responsibility for managing and balancing the distribution grids, especially when distributed generation becomes increasingly important. BSS can be seen as an important managing technology for RGO's. Furthermore, it is important to involve TenneT in this discussion, as TenneT has currently the only system operation responsibility. This means that TenneT should give a part of their responsibilities (power) to the RGO's, which they probably not prefer and therefore enhances their advise for interconnections to the Ministry of Economic Affairs. As win-win situations are highly preferable in such conflicts, the system operation responsibility for RGO's should be limited to managing their own distribution grids. As a result, RGO's can function as an intermediary in order to execute (balance) a part of the e-programs, regarding their own distribution grids, which has a positive effect on the system operation responsibility of TenneT (assuming a significant share of distributed generation in the future distribution grids).

Fourthly, the BSS technology is currently in the research and development phase and is therefore not yet feasible for the mass-market, as explained in this thesis. Nevertheless, it is highly recommended for technology providers to get involved in the pilot projects with future customers and other niche markets, in order to build trust and show the potential of the BSS technology in practice. As a result, technology providers will create a brand name for this technology in a potential future business market and gather information about user experiences. Furthermore, those pilot projects can be used to validate the provided business models and fine-tune were needed.

Fifthly, a technology provider should not only focus on BSS, but also on demand side management and other local storage technologies (e.g. fuel cell), as all interviewees expect a combination of demand side management and local storage technologies in order to meet the future system requirements. By investing in different technologies the investments risks can be reduced and spread over the different technologies.

At last, according Osterwalder (2010) the next step in the design process should be writing a business plan, which is company specific and therefore not included in this research. Nevertheless, it is highly recommended to write this plan before investing in the BSS technology.

Recommendations for further research

At first, this research provides a clear framework for further research in order to investigate the financial aspects into more depth, including quantifying the non-financial benefits. An important element in this financial research should be determining the financial value of the future requirements, when taking the three energy transition scenario's into account. Furthermore, this financial research should include investigating the different costs structures, revenue structures, suitable contracts (e.g. lease contracts) and priorities (e.g. when choosing for which technology). As a result, this research should preferably be carried out in collaboration with a Dutch RGO.

Secondly, the end-consumer (or customer) should be included more extensively in this research, as this actor will determine the main success of this technology (Balsters, 2008). Therefore, it is highly recommended to carry out a research among this actor group, in order to gain knowledge about their requirements and preferences. The five main questions that should be investigated are:

- What is the maximum acceptable payback time for BSS, before they accept and buy this technology?
- What should be the maximum acceptable price for BSS (willingness to pay factor)?
- Do they prefer to be self-supporting, instead of being dependent on grid operators and electricity providers?
- Which incentives will stimulate them to invest in renewable sources and storing energy?
- How important are renewable energy sources to them?

The answers on those questions will provide more information about the acceptability and potency of the private model and the RGO model in practice.

At last, three important BSS applications are recognized by the interviewees, which are not investigated in this research (out of scope). The three applications are: V2G & G2V, innovative retail applications and smart home applications. Those three applications can have a significant value in practice and are therefore recommended to include in further research.

8 Reflection

Two years ago I stopped working as an part-time employee for a Dutch electricity provider and decided to start my Masters at the Delft University of Technology. Since I had work experience for more than two years in that company, I thought that I understood the Dutch electricity system completely. Thanks to this research project I can now conclude that I was completely wrong. The Dutch electricity system is more complex than might thought before and due to the different environmental forces, explained in Chapter 3, characterized as increasingly dynamic, complex and uncertain. The research done in this thesis provides a clear overview about the complete system, which is recommended to understand for each individual active in the Dutch electricity sector, in order to understand the size and complexity of the system in which they are working. Nevertheless, the overall purpose of this chapter is to take a step backwards and look over and beyond the research undertaken, in order to reflect the methodology, determine the research contribution and stressing the limitations of this research.

This research project is divided into five phases of which the first and last phase should be a standard in each research project, namely defining and closing the project. In the first (define) phase, the complete project is determined in which the main purpose should be defining the following issues:

- Research problem and goal;
- Research questions;
- Research method;
- Research relevance.

This phase is the foundation of the research project and should therefore not be neglected. From my own experience I can say that this phase is one of the most important phases, which determines the scope of the project and is used as a communication tool among all parties involved. When the communication is not clear to all parties involved, different parties will expect different outcomes at the end of the research project. Different expectations will result in conflicts during the execution of the research, which can have negative effects (e.g. delay). Therefore, investing in this phase will smoothen up the research process and saves time at the end of the project.

The second phase of this research consisted of a literature / desk research, in which the research framework is determined and the relevant data provided in literature collected. This phase gives a clear overview about what is already known and what should be investigated. The business model framework of Osterwalder (2010) provides a solid and scientifically proven method to collect the required and relevant data. An important issue here is scanning the environment (outside-in approach) and the key elements of a business (inside-out approach), which can be done through a literature / desk research (as done in this thesis). Based on the research the design requirements should be determined. In this research a choice has been made to design business models that satisfy the total system requirements and therefore create value for all actors involved. Furthermore, the second purpose of this phase is to understand the complete context of the research undertaken.

The third phase consisted of a field research in which the collected data of the previous phase is validated and the additional required data is collected. Validating the collected data of the literature research improves the validity and reliability of the research undertaken. This is especially recommended when using (many) literature based on case studies that are carried out in different surroundings. In this phase, it is important that all the required data is made very clear, because a field study can be carried out only once. A clear framework, as the framework of Osterwalder (2010), provides a good checklist as all elements should be covered after the data collection analysis. Furthermore, an extensive data collection plan is required in order to collect valid and reliable data. While reflecting the data collection plan, protocol and collected data of this thesis, a valid and solid research has been carried out. The sample determined in the data collection plan, has resulted in a sample of very knowledgeable interviewees, which had a good view on the BSS technology, the Dutch electricity system and the results of a combination of both. An important contribution to the scientific community, resulted from this phase, is how experts (and actors) evaluate and value local storage in the Dutch electricity grids, which is lacking in current scientific literature.

The fourth (design) phase, is focused on combining the collected data in the framework of Osterwalder (2010), which results in the new business models. In particular for the research undertaken, the financial domain of the business model is limited to general financial insights and therefore deals with different shortcomings. During the research process, it became clear that financial details are hard to get and limited included in scientific literature. Furthermore, organizations are not willing to share detailed information related to this topic, which makes it a research topic on its own. Therefore, this limitation is included in the previous chapter as a recommendation for further research. Nevertheless, the applications used in this chapter are already financially feasibly in other countries and are expected to become feasible in the future Dutch electricity system as well. The main research contribution of this phase is providing insights in the most promising storage applications and their related business and market models in the Dutch electricity system, by taking a multi-actor point of view into account.

The last phase deals with closing the project and should, as already told before, be a standard phase of each research project. This phase is primary dealing with conclusions, recommendations, reflections and handing over the project results. Nevertheless, an overall validation or robustness check, during this phase, should have increased the validity and reliability of this research project even more. As customer experiences and discussions are recommended for this overall validation check, this check is included in the recommendations of the previous chapter.

At last, some overall reflections can be shared with peers. When a scientific research is carried out in an organization outside the University, the first phase becomes increasingly important. It is important to include what will be delivered to each party (organization and University), which they both should agree on. This is one of the primary mistakes that I have made during this research project and therefore I hope that others can learn from that. Next, repeatability should be taken into account during each research phase, which has been done in this research to the maximum extent. Thereafter, longitudinal research can increase the validity, reliability and sustainability of this research, as the Dutch electricity system is characterized as a very dynamic system. Furthermore, a case study research is a very dynamic process, which requires many feedback loops. Finally, I can conclude that the main research question is successfully and scientifically answered, for which the research results and the research process will both contribute to the scientific and professional community.

References

Alliander. (2010). *Annual report 2009.* Arnhem: Alliander.

Anderson, C. (2006). In *The Long Tail: Why the Future of Business is Selling Less of More.* New York.

Anderson, C. (2008). *Free! Why $0.00 Is the Future of Business.* Wired Magazine.

Anderson, C. (2009, 01 31). *The Economics of Giving It Away*. Retrieved 05 06, 2010, from The Wall Street Journal | Economy: http://online.wsj.com/article/SB123335678420235003.html

Andriessen, E. (2009). *MOT 2310, Research Methods 4: Data collection methods.* Delft: Delft University of Technology.

Applegate, L. (2001). E-business Models: Making sense of the Internet business landscape. In G. Dickson, & W. Gary, *Information Technology and the Future Enterprise: New Models for Managers.* Upper Saddle River: Prentice hall.

APX Group. (2010). *APX Power NL*. Retrieved 04 13, 2010, from APX Group: http://www.apxgroup.com/index.php?id=10

APX-ENDEX. (2010). *Integration of APX and Endex gives us a larger mirror on the market*. Retrieved 04 13, 2010, from APX Endex: http://www.apxendex.com/

Asseldonk, A. van (1998). Financial value creation. In *Mass-individualisation.*

Balsters, M. (2008). *Lean Six Sigma DMADV.* Rotterdam: Eneco Energie.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management , 17* (1), 99 - 120.

Bentley, R., Madsen, M., & Ormerod, P. (2009). Physical space and long-tail markets. *Physica A* , 691 - 696.

Brandenburger, A., & Nalebuff, B. (1995). The right game: Use game theory to shape strategy. *Harvard Business Review* , 57 - 71.

BridNed. (2010). *BridNed*. Retrieved 04 16, 2010, from www.bridned.com

Bruijn, H. de, & Heuvelhof, E. ten (2008). In *Management in Networks, On multi-actor decision making.* New York: Routledge.

Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & Leadership* , 12 - 17.

Chesbrough, H. (2009). Business Model Innovation: Opportunities and Barriers. *Elsevier, Long Range Planning* .

Chesbrough, H. (2006). Open Business Models: How to thrive in the new innovation landscape. Boston: Harvard Business School Pres.

Collis, D., & Montgomery, C. (1995). Competing on resource strategy in the 1990s. *Harvard Business Review* , 118 - 128.

Courtney, H., Kirkland, J., & Viguerie, S. (1997). Strategy and Uncertainty. *Harvard business Review* .

Cummings, S. (1993). The First Strateists. *Strategy* , 25-28.

de Vries, J., Correlje, F., & Knops, P. (2009). *Electricity & Gas, Market design and policy choices.* Delft: Delft University of Technology.

Deconinck, G. (2010, 03 25). Workshop on Intelligent Infrastructures. *Electricity Infra* . Delft, the Netherlands: Delft University of Technology.

Dehen, W. (2009). *Pictures of the Future: The new Age of Electricity.* Munich: Siemens AG.

Divya, K., & Ostergaard, J. (2009). Battery energy storage technology for power systems - An overview. *Electric Power Systems Research* , 511 - 520.

Eisenhardt, K., & Martin, J. (2000). Dynamic capabilities: what are they? *Strategic Management Journal , 21*, 1105 - 1121.

Eisenmann, T., Parker, G., & Van Alstyne, M. (2006). Strategies for Two-Sided Markets. *Harvard Business Review* , 1 - 12.

Elberse, A. (2008). Should You Invest in the Long Tail? *Harvard Business Review* (July - August), 1 - 11.

Endex. (2010). *Power Trading*. Retrieved 04 13, 2010, from Endex: http://www.endex.nl

Eneco. (2010). *Annual report 2009.* Rotterdam: Eneco Holding N.V.

EnergieNed. (2009a). *Energy in the Netherlands 2009.* Arnhem: EnergyNed.

EnergieNed. (2009b). Wegwijzer van de Energievoorziening 2009-2. EnergieNed.

Energy Intelligent Europe. (2010). *IMPROGRES: Regulatory strategies for selected Member States (Denmark, Germany, Netherlands, Spain, the UK).* Petten: Energy Intelligent Europe.

Enexis. (2010). *Annual report 2009.* Rosmalen: Enexis.

ESA. (2009a). *Electricity Storage Association*. Retrieved 05 28, 2010, from Electricity Storage Association: www.electricitystorage.org

ESA. (2009b, 04). *Technologies*. Retrieved 05 25, 2010, from Electricity Storage Association: www.electricitystorage.org

Essent. (2009). *Anual report 2008.* Arnhem: Essent.

European Network of Transmission System Operations for Electricity. (2009). *Statistical Yearbook 2008.* ENTSO-E.

Evans, D., Hagiu, A., & Schmalensee, R. (2006). Invisible Engines: How Software Platforms Drive Innovation and Transform Industries. Cambridge: The MIT Press.

Eyer, J., & Corey, G. (2010). *Energy Storage for the Electricity Grid.* New Mexico: Sandia National Laboratories.

Financieel Dagblad. (2010, 03 27). *het financiele dagblad*. Retrieved 03 27, 2010, from "CO2-uitstoot in 2020 geen goede maatstaf": http://www.fd.nl/artikel/8179572/co2-uitstoot-2020-geen-goede-maatstaf

Foreest, F. van (2008). *The multidimensional energy value chain.*

Gilmore, E., Apt, J., Walawalkar, R., Adams, P., & Lave, L. (2010). The air quality and human health effects of integrating utility-scale batteries into the New York State electricity grid. *Journal of Power Sources* , 2405–2413.

Ginjaar, L. (2010, 04 20). *Wet- en Regelgeving, Wet milieubeheer, Chapter 16 Handel in emissierechten*. Retrieved 04 20, 2010, from Overheid.nl: http://wetten.overheid.nl/BWBR0003245/Hoofdstuk16/Titel162/Afdeling1621/Paragraaf16212/Artikel168/geldigheidsdatum_20-04-2010

Global Energy Network Institute. (2010, 03 03). Retrieved 07 08, 2010, from Utility energy storage no longer just giant batteries: http://www.geni.org/globalenergy/library/technical-articles/generation/batteries-storage/clean-edge-news/utility-energy-storage-no-longer-just-giant-batteries/index.shtml

Gordijn, J., & Akkermans, H. (2007). Business models for distributed generation in a liberalized market environment. *Elsevier, Electric Power Systems Research 77* , 1178 - 1188.

Haaker, T., Bouwman, H., & Faber, E. (2008). Chapter 2 Conceptualizing the STOF Model. In *Mobile Service Innovation and Business Models* (pp. 32 - 70). Berlin: Springer.

Hagel, J., & Singer, M. (1999, March - April). Unbundling the Corporation. *Harvard Business Review* , 1 - 8.

Hamel, G., & Prahalad, C. (1993). Strategy as stretch and leverage. *Harvard Business Review* (March-April), 75 - 86.

Hammons, T. (2005, 08). Integrating renewable energy sources into european grids. *International Journal of Electrical Power & Energy Systems* , pp. 462-475.

Hargreaves, S. (2009, 01 08). *CNN News.* Retrieved 01 05, 2010, from A $2 trillion bet on powering America.: http://money.cnn.com/2009/01/06/news/economy/smart_grid/index.htm?postversion=2009010818

Harrison, J. (1999). Micro CHP implications for Energy Companies. *Sigma Elektroteknisk AS* .

Hartigh, E. den (2009). *Technology and Strategy: Company business model evolution.* Delft: Delft University of Technology.

Hawkins, R. (2001). The "Business Model" as a Research Problem in Electronics.

Hodgson, G. (2003). Capitalism, Complexity, and Inequality. *JOURNAL OF ECONOMIC ISSUES , XXXVII* (2), 471 - 478.

Hrebiniak, G., & Joyce, W. (1985). Organizational adaption: Strategic Choice and Environmental Determinism. *Administrative Science Quarterly , 30* (3), 336 - 349.

Ibrahim, H., Ilinca, A., & Perron, J. (2008). Energy storage systems—Characteristics and comparisons. *Renewable and Sustainable Energy Reviews , 12*, 1221–1250.

IEA. (2010). *World Energy Outlook.* Retrieved 03 24, 2010, from http://www.worldenergyoutlook.org

International Energy Agency. (2010). *International Energy Agency*. Retrieved 04 21, 2010, from International Energy Agency: www.iea.org

Investopedia. (2010). *Dictionary*. Retrieved 04 27, 2010, from Investopedia: http://www.investopedia.com/terms/c/competitive_advantage.asp

Kester, J. (2004, 06). Domotica onmisbaar voor huisvesting ouderen. *Milieutijdschrift ArenA* , pp. 18 - 19.

Kester, J., & Zondag, H. (2006). *Demand Side Management achter de meter.* ECN. Petten: ECN.

Kirschen, D., & Strbac, G. (2004). *Fundamentals of Power System Economics.* University of Manchester Institute of Science & Technology (UMIST). West Sussex: John Wiley & Sons, Ltd.

Knowledge@Wharton. (2009, 03 25). *How About Free? The Price Point That Is Turning Industries on Their Heads*. Retrieved 05 06, 2010, from Knowledge@Wharton: http://www.wharton.universia.net/index.cfm?fa=viewArticle&id=1680&language=engli

Lewis, G., & Seddon, P. (2003). 7th Pasific Asia Conference on Information Systems. *Strategy and Business Models: What's the Difference?*, (pp. 236-248). Adelaide.

Lindley, D. (2010, 01 07). The energy storage problem. *Nature* .

Magretta, J. (2002). Why Business Models Matter. *Harvard Business Review* .

Massachusetts Institute of Technology. (2010). *Growing Up: Moving from Technology-Centered to Human-Centered Products*. Retrieved 03 28, 2010, from http://mitpress.mit.edu/books/NORVH/chapter2.html

Meijer, J. (2009). *Regulating Future Distributed Generation: Distributed Generation Challenges for the Dutch Distribution Network; an Exploratory Research for the Regulatory Framework.* Eindhoven University of Technology, Innovation Management. Eindhoven: Eindhoven University of Technology.

Ministry of Economic Affairs. (2010). *Ministerie van economische zaken.* Retrieved 03 24, 2010, from Werking Kleinverbruikersmarkt: Historie: http://www.ez.nl/Onderwerpen/Voldoende_energie/Werking_Kleinverbruikersmarkt/Historie

Ministry of General Affairs. (2010). Retrieved 05 26, 2010, from Congestiemanagement: http://www.rijksoverheid.nl/onderwerpen/elektriciteit/transporteren-elektriciteit/elektriciteitsnet-nederland/congestiemanagement

Ministry of Housing, S. P. (2010). *Ministry of Housing, Spartial Planning and the Environment*. Retrieved 03 27, 2010, from Schoon en zuinig: Nieuwe energie voor het klimaat: http://www.vrom.nl/pagina.html?id=32950

Mohr, J., Sengupta, S., & Slater, S. (2005). Marketing of High-Technology Products and Innovations. Nwe Jersey: Pearson Prentice hall.

Mzallassi, F. (2005). *Project feasibility assessment in Sustainable Urban Renewal.* Delft: Delft University of Technology.

Nederlands Elektrotechnisch Comité (NEC). (2007). *Nederlandse Technische Afspraak NTA 8130: Minimum set of functions for metering of electricity, gas and thermal energy for domestic customers.* Delft: Nederlands Normalisatie-instituut (NEN).

Netbeheer Nederland. (2009). *Smart Grids.* Arnhem: Netbeheer Nederland.

Netbeheer Nederland. (2010). Toekomst visie smart grids 2025. Arnhem, the Netherlands. Retrieved 2010, from http://www2.eurelectric.org/Content/Default.asp

NMa Energiekamer. (2010). *Energiekamer*. Retrieved 04 13, 2010, from NMa Energiekamer: http://www.energiekamer.nl/engels/about_ek/index.asp

NMa Energiekamer. (2009, 02 27). Systeemcode Elektriciteit. NMa Energiekamer.

NOS. (2010, 06 22). *Hof zet streep door splitsingswet*. Retrieved 06 22, 2010, from NOS: http://nos.nl/artikel/166502-hof-zet-streep-door-splitsingswet.html

Offer, G., Howey, M., Contestabile, M., Clague, R., & Brandon, N. (2010). Comparative analysis of battery electric, hydrogen fuel cell and hybrid vehicles in a future sustainable road transport system. *Energy Policy , 38* (1), 24 - 29.

Ongkiehong, O. (2006). *Electricity grids: Description of the state under the Dutch energy research program EOS (Energie Onderzoek Strategie).* SenterNovem.

Osterwalder, A. (2004). *The Business Model Ontology, a proposition in a design science approach.* Lausanne: Universite De Lausanne Ecole Des Hautes Etudes Commerciales.

Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation. Toronto, Canada: Self Published.

Pine II, J. (2010). *Mass customisation*. Retrieved 04 28, 2010, from Provenmodels: http://www.provenmodels.com/596/mass-customisation/b.-joseph-pine-ii

Porter, M. (1985). Competitive Strategy. In M. Porter, *Competitive Advantage: Creating and sustaining suprior performance* (pp. 1 - 59). New York: The Free Press.

Porter, M. (1981). The contribution of industrial organization to strategic management. *The Academy of Management Review , 6* (4), 609 - 620.

Porter, M. (1996). What is Strategy? *HBR November-December 1996* , 61 - 78.

Pottering, H., & Erlandsson, E. (2009). *REGULATION (EC) No 713/2009 OF THE EUROEPEAN PARLIAMENT AND OF THE COUNSIL: establishing an Agency for the Cooperation of Energy Regulators.* Brussels: Official Journal of the European Union.

Prahalad, C. (1995). New view of strategy: An interview with C.K. Prahalad. *European Management Journal , 13* (2), 131-138.

provenmodels.com. (2010). *Provenmodels.com*. Retrieved 04 28, 2010, from pest analysis: www.provenmodels.com

Rijk, M. de (2009). *Wetsvoorstel "Voorrang voor duurzaam" (31904).* Den Hague: Stichting Natuur en Milieu.

Rodel, J. (2008). *Ecology, Economy and Security of Supply of the Dutch Electricity Supply System.* Delft: Delft University of Technology.

Romme, A. (1992). *A self-organization perspective on strategy formation.* Faculty of Economics and Business, Administration. Limburg: University of Limburg.

Rosenbloom, R., & Chesbrough, H. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Cange* , 1 - 26.

Ross, D. (2006). *Game Theory*. Retrieved 04 30, 2010, from Stanford Encyclopedia of Philosophy: http://plato.stanford.edu/entries/game-theory/

Scheepers, M., & Wals, A. (2007). *New approach in electricity network regulation; an issue on Effective Integration of Distributed Generation in Electricity Supply Systems.* Petten: ECN.

Scholten, V. (2009). Technology and Strategy. *Introduction* . Delft: Delft University of Technology.

Senternovem. (2009, 08 17). *EnergieTransitie Duurzame Elektriciteitsvoorziening*. Retrieved 07 16, 2010, from Stroomgebruiker betaalt voor file op net: http://www.senternovem.nl/energietransitiedev/nieuws/stroomgebruiker_betaalt_voor_file_op_net.asp

Shafer, S., Smith, H., & et al. (2005). The power of business models. *Elsevier, Business Horizons 48* .

Siemens AG. (2009). *Energy Message Book.* Erlangen: Siemens AG.

Stedin. (2009). *Annual report 2008.* Rotterdam: Stedin.

Taylor, J., & van Doren, P. (2002, 01 10). Evaluating the case for renewable energy, Is government support warranted? *Policy Analysis* , 1 - 16.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal , 18* (7), 509 - 533.

TenneT. (2010a). *Congestion Management*. Retrieved 04 20, 2010, from http://www.tennet.org/english/transmission_system_services/Congestiemanagment/20howdoesitwork.aspx

TenneT. (2010b). *Infrastructure*. Retrieved 04 13, 2010, from TenneT: http://www.tennet.org/english/transmission_system_services/transmission_services/infrastructure/index.aspx

TenneT. (2010c). *PR register*. Retrieved 04 13, 2010, from TenneT: http://www.tennet.org/english/transmission_system_services/system_services/programme_responsibility/pr_register.aspx

TenneT. (2010d). *Transmission Services*. Retrieved 04 13, 2010, from TenneT: http://www.tennet.org/english/tennet/organisation/services/transmission_services.aspx

TenneT. (2010e). *Wetvoorstel voorrang voor duurzaam*. Retrieved 04 20, 2010, from http://www.tennet.org/klanten/nieuws/wetsvoorstelvoorrangvoorduurzaam.aspx

The American Heritage Dictionaries. (2000). The American Heritage Dictionary of the English Language, 4th Edition. Houghton Mifflin Harcourt.

The Ohio State University. (2007, 10 11). *Energy: Storage & Alternatives*. Retrieved 07 08, 2010, from http://www.physics.ohio-state.edu/~wilkins/energy/Resources/Lectures/storage-alts.html

Timmers, P. (1998). Business Models for Electronic Markets. *Journal on Electronic Markets , 8* (2), 3 - 8.

Treacy, M., & Wiersema, F. (1995). The Discipline of Market Leaders: Choose Your Customer, Narrow Your Focus, Dominate Your Market. New York: Perseus Books Group.

Ummels, B. (2009). *power System operation with Large-Scale Wind Power in Liberalised Environments.* Delft University of Technology. Delft: Delft University of Technology.

UNFCCC. (1997). *Kyoto Protocol.* Retrieved 01 05, 2010, from Kyoto Protocol: http://unfccc.int/kyoto_protocol/items/2830.php

United Nations. (2010). Retrieved 04 25, 2010, from United Nations: http://www.un.org/en/

Van der Hoeven, M. (2010, 02 09). *Instellingsbesluit Taskforce Intelligente Netten*. Retrieved 07 08, 2010, from Wet- en regelgeving: http://wetten.overheid.nl/BWBR0026549/geldigheidsdatum_09-02-2010

van Eck, T. (2007). A New Balance for the Energy Sector: no longer a puppet in the hands of technology, public interests and markets. Industrielinqs pers en platform.

Veen, R. van (2007). *Balancing market performance in a decentralized electricity sytem in the Netherlands.* Delft: Delft University of Technology.

Velde, M., Jansen, P., & Anderson, N. (2004). Guide to management research methods. Oxford: Blackwell Publishing.

Veldhoven, P. (2007). *Smart Metering: An analysis of the requirements and bottlenecks of meter-data service delivery.* Delft University of Technology, Technology, Policy and Management. Delft: Delft University of Technology.

Vlimmeren, Y. van (2010). *The introduction of local system services: The case of storage in the low voltage network.* Eindhoven University of Technolgy. Eindhoven: Eindhoven University of Technolgy.

Walawalkar, R. (2008). *Economics of Emerging Electric Energy Storage Technologies and Demand Response in Deregulated Electricity Markets.* Pittsburgh: Carnegie Mellon University.

Walawalkar, R., & Dann, C. (2009, 12 16). *Game-Changing Energy Storage: What Utilities Should Consider Today*. Retrieved 03 28, 2010, from http://www.ces-ltd.com/webinar.html

Wals, A. (2001). *Prijsvorming en marktgedrag op de elektriciteitsmarkt.* Energy research Centre of the Netherlands (ECN). ECN Beleidsstudies.

Weterings, R. (2008a). *Procesontwerp Alternatief ToonFrequent.* Electrical Engineering. Rotterdam: Rotterdam University, School of Applied Science.

Wijers, G. (1998). *Electriciteitswet 1998*. Retrieved 04 13, 2010, from Wet- en Regelgeving: http://wetten.overheid.nl/BWBR0009755/geldigheidsdatum_13-04-2010#Hoofdstuk1

Xueqing, Z. (2009). Improving the power quality and power reliability by energy storage technology - The practice of SMEPC. *20th International Conference on Electricity Distribution* (pp. 1-4). Prague: Shanghai Electric Power Design Institute Co..Ltd. China.

Yin, R. (2009). *Case study research: Design and Methods .* California: SAGE Publications.

Zegveld, M. (2006). Corporate strategy and technology. In J. O. R.M. Verburg, *Managing Technology and Innovation; an introduction* (pp. 209 - 226). Delft, the Netherlands: Routledge.

Appendices

Appendix A: Strategy & Business Models, a detailed inside

Strategy and the four generic models of strategic management

Perspective 1: Industry-based strategic management

Industrial organization theories approach strategy from the outside-in and therefore focus on the market structures in which the organization has to compete. Although competition among firms is one of the key drivers of those theories, monopoly and oligopoly market structures are also included. Industry-based theories are directly related to the industrial organization theory of the Harvard business school. In 1968 the Bain/Mason paradigm of industrial organization was developed at the Harvard Business School, which resulted during the 1970s in a solid systematic model for assessing competition within industries. As a result this model became a central issue in policy scholars (Porter, 1981). Later on, at the end of the 1970s Porter imported the model into the SWOT (Strength, Weaknesses, Opportunities and Threats) framework of strategic management. As a result Porter developed a new model, the five forces model, which is until today the primary used model in industry-based strategic management theories (Porter, 1985). The five forces model is given in Figure 37.

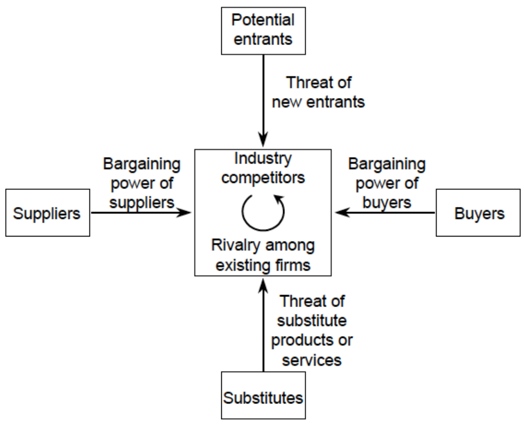

Figure 37: Five Forces Model (Porter, 1985)

The core of the five forces model is to distinguish two key issues, namely the attractiveness of the industry for long-term profitability and the relative competitive position of the firm within that industry. As a result the aim of the model is to establish a profitable position against the forces that determine the industry competition. In this model the profitable position is not a function of the organizations output (e.g. product, service, etc), but of the structure of the industry. Nevertheless, organizations can also influence the five forces with their own strategic position. According Porter three generic competitive strategies are available in order to create a competitive position, which is illustrated in Figure 2. The three strategies are respectively: (1) cost leadership, (2) differentiation and (3) focussing. When a firm set itself as a cost leader, it prefers to gain advantages of economies of scale and other absolute cost advantages gained from other sources. By focussing on differentiation a firm seeks to uniqueness in the industry, which is higher valued by customers. The last position a firm can achieve is by focussing on certain segments (customer groups), which they can serve with tailored products. By focussing on one segment the aim is to serve all the wishes and needs of that specific customer segment and therefore adds extra value. However, having only one strategy can be insufficient, as sometimes combinations of those value drivers fit better to customer wishes (e.g. good quality for a low price). In this situation a firm most seek for the optimal balance between the two value drivers, which emphasise the importance of customer satisfaction. Nevertheless, firms must be aware that trade-offs has to be made between the value drivers in order to not get stuck into the middle. Getting stuck in the middle means that a firm cannot choose its preferred value driver and is therefore not achieving advantages of any value driver (Porter, 1985; Porter, 1996).

Within the industry-based strategic management theory technology itself is treat as an unnecessary factor for successful strategy. In this view technology development is always a consequence of business development and opportunities, which are driven by the industry forces. Nevertheless, technology development is seen as a supporting factor that improves the competitiveness of the organization and is therefore indirectly important (Zegveld, 2006).

As a conclusion the characteristics of the industry-based strategic management perspectives are included in Table 19.

Table 19: Characteristics of the Industry-based strategic management perspective (adapted from Zegveld, 2004)

Assumption	Goals	Performance drivers	Strategy process	Fundamental units of analysis	Impact on strategy process	Success
Stable industry structure	Defensible position	Industry structure	Pick an industry, pick a strategic position, fit the organisation	- Industries - Firms - Products	Strategy from the outside-in	Profits

Perspective 2: Game theory

Game theory was invented in 1944 by Neumann and Morgenstern, but translated into business strategy theory in 1995 by Brandenburger and Nalebuff. The main input for the theory of Brandenburger and Nalebuff was the analysis on the theory of non-cooperative games by Harsanyi, Nash and Selten, who received the Economic Nobel Price for their work (Ross, 2006; Zegveld, 2006). Game theory can best be explained by the study of how and in what way strategic interactions among rational players will result in different outcomes, taking the preferences of the different players into account. This theory approaches business strategy from an outside-in approach as the environment is the main determinant. As this theory takes also actions and reactions of all players into account this theory approaches strategy from a dynamic point of view (also called interaction strategy). The rule of the game is that every action has its own reaction. Although there is a difference between long-term and short-term relations, according to Brandenburger and Nalebuff organizations must generally search for win-win strategies (Brandenburger & Nalebuff, 1995).

According Brandenburger and Nalebuff organizations should analyze the impact of cooperative strategies on the outcome of their own organization and on that of others in their value net. This means that organizations should think about how others will react and what value they will eventually bring into the game. The value of each player in the game can be determined by excluding one player in the calculations and determine the difference in value creation. The game that is played by organizations in the value net is all about creating and capturing value. Players that are defined in the value net are: customers, suppliers, substitutes and complementors (Brandenburger & Nalebuff, 1995). Nevertheless, it is not always the case that a win-win situation or the best outcome is pursued, due to lack of trust, information, etc. (e.g. in the well known case of the prisoner's dilemma).

Within game theory the role of technology development is mostly defined as an incremental factor for developing competitive strategies. Game theory treats technology development only as a completion role for executing strategies and is therefore irrelevant on a strategic level (Zegveld, 2006).

As a conclusion the characteristics of the game theory perspectives are included in Table 20.

Table 20: Characteristics of the game theory perspective (adapted from Zegveld, 2004)

Assumption	Goals	Performance drivers	Strategy process	Fundamental units of analysis	Impact on strategy process	Success
Industry viewed as a dynamic oligopoly	Temporary advantage	Right moves	Make the "right" competitive and collaborative moves	- Firm - Products	Instantaneous	Short-term gain

Perspective 3: Resource-based strategic management

Resource-based thinking started with Marshall by using only three resources (capital, land and labour). Later in the 1950s Selnick developed the first resource-based view, by stressing the firms resources as their key source for gaining competitive advantages (Collis & Montgomery, 1995). Unlike the first two perspectives, resource-based strategic management approaches strategy from the inside-out. This perspective treats the firms-specific factors as major determinants for outstanding performance and performance differences between firms in the same industry. Therefore in resource-based strategic management studies the firm itself is the primary domain of study. From an industry-based perspective resources include all sources that are controlled by the firm, which enables the firm to create, develop and implement strategies. This includes all assets, organizational processes, information, capabilities, knowledge, etc. in order to gain a sustainable competitive advantage. This also means that not all resources are automatically strategically relevant. Barney (1991) classified resources into three categories, for which he made a distinction between tangible, intangible, human and physical resources. The first category includes all physical capital resources (e.g. technology, equipment, location, access to raw materials, etc). The second category focuses on intangible assets related to the human resource, also called human capital resources (e.g. training, experience, judgement, intelligence, etc.). The last category classifies all resources related to the organizational capital, including formal and informal planning, coordinating systems, reporting structures, etc. (Barney, 1991). According Hamel and Prahalad (1993) the main source of gaining competitive advantages is the ability of the firm to combine production skills and corporate technologies in order to adapt quickly to changing opportunities. Therefore firms have to bridge the gap between opportunities and performance in order to create value (Prahalad, 1995; Zegveld, 2006; Hamel & Prahalad, 1993). As a result strategy is controlling and developing corporate resources in order to create new businesses.

From an industry-based perspective competitive advantages can only be gained with strategies that are not being implemented by competitors. And for gaining sustainable competitive advantages, strategies must be extremely difficult to copy. Therefore Barney

(1991) developed the VRIN model in order to understand the sources of sustainable competitive advantages. This model distinguishes the usefulness of the resources of a firm, focussing on four aspects (Barney, 1991):

- **V**aluable: resources are valuable if they increase the efficiency and effectiveness of the firm;
- **R**are: resources are rare if they are not widely distributed among competitors, preferable not distributed at all;
- **I**mperfectly imitable: resources are imperfectly imitable if they are not (easy) to copy by competitors. Barney distinguish three reasons:
    - Unique historical conditions;
    - Causal ambiguity, it is not clear for competitors what the link is between resources and competitive advantages;
    - Social complexity, interpersonal relations (social phenomenon).
- **N**o strategically equivalent substitutes: resources are not substitutable if there is no other equivalent resource available that enables competitors to implement the same strategies.

Contrary to the previous two perspectives technology development can play a significant role in developing corporate strategy (Zegveld, 2006). Nevertheless the magnitude of technology development on corporate strategy is determined on the four aspects of the VRIN model, as described above.

As a conclusion the characteristics of the resource-based strategic management perspectives are included in Table 21.

Table 21: Characteristics of the resource-based strategic management perspective (adapted from Zegveld, 2004)

Assumption	Goals	Performance drivers	Strategy process	Fundamental units of analysis	Impact on strategy process	Success
Firm as a bundle of competences	Sustainable advantage	Unique firm competencies	Create a vision build and exploit competencies to realize vision; strategic intent	Resources	Strategy from inside-out	Long term dominance

Perspective 4: Dynamic capabilities

Continuing on resource-based strategic management, dynamic capabilities emphasize the importance of developing skills in order to adapt and respond to changing opportunities. As the previous perspective has a relatively static view and therefore focuses on the resources a firm already owns, dynamic capabilities focus on the dynamic aspect. Dynamic capabilities focuses on the firm's ability to build, integrate and reconfigure competences in order to adapt and respond to rapidly changing opportunities (Teece, et al., 1997). This includes the dynamic or renewal of competences, e.g. innovative responses, time-to-market, technological change, etc and the organizational and strategic dynamics in order to achieve new resource configurations (Eisenhardt & Martin, 2000).

Every organization has its own dynamic capabilities, supplemented with common dynamic capabilities. Those common dynamic capabilities are called "best practices" and are applied by many organizations. According Eisenhardt and Martin (2000) the efficiency of dynamic capabilities are highly dependent on market dynamism, for which they distinguish two extreme types. Those two types are the following:

- Moderate dynamic markets: rely on existing tacit knowledge and rules (more or less a linear learning process in a stable market);
- High-velocity markets: rely on rapid creating situation-specific knowledge (more or less an iterative learning process in an ambiguous and changing market).

Dynamic capabilities rely on real-time information and intensive communication in order to understand, foresee and adapt to market changes. As a result market dynamism influences the evolution of the dynamic capabilities of a firm to a large extent. The evolution of the dynamic capabilities of a firm is caused by path dependencies, for which market dynamism is a derivative. Path dependencies are in this perspective highly dependent on learning (from mistakes), experience, repeated practices, coordination and reconfiguration. Those aspects are essential in order to ensure a continuous process of gaining sustainable competitive advantages. As an addition to moderate markets variation is a crucial aspect, while in high-velocity market selection is a crucial aspect. In order to gain long-term (sustainable) competitive advantages dynamic capabilities must be developed faster than the competition.

Comparable with the previous perspective, technology development plays a significant role in dynamic capabilities. As an addition to the importance of competences and capabilities described by the VRIN model, dynamic capabilities emphasize the importance of the dynamic learning process of technology change (Zegveld, 2006). Technology development in this perspective is recognized as a key competence of the firm.

As a conclusion the characteristics of the dynamic capabilities perspectives are included in Table 22.

Table 22: Characteristics of the dynamic capabilities perspective (adapted from Zegveld, 2004)

Assumption	Goals	Performance drivers	Strategy process	Fundamental units of analysis	Impact on strategy process	Success
Firms operating in rapid technolo-gical change	Continuous flow of advantages	Exploitation of firm-specific capabilities	Renew competencies to develop active congruence within changing environments	- Processes - Positions - Paths	Recognize and exploit firm-specific paths and trajectories	Asset accumu-lation and inimitability

The business model ontology (Osterwalder, 2004; Osterwalder & Pigneur, 2010)

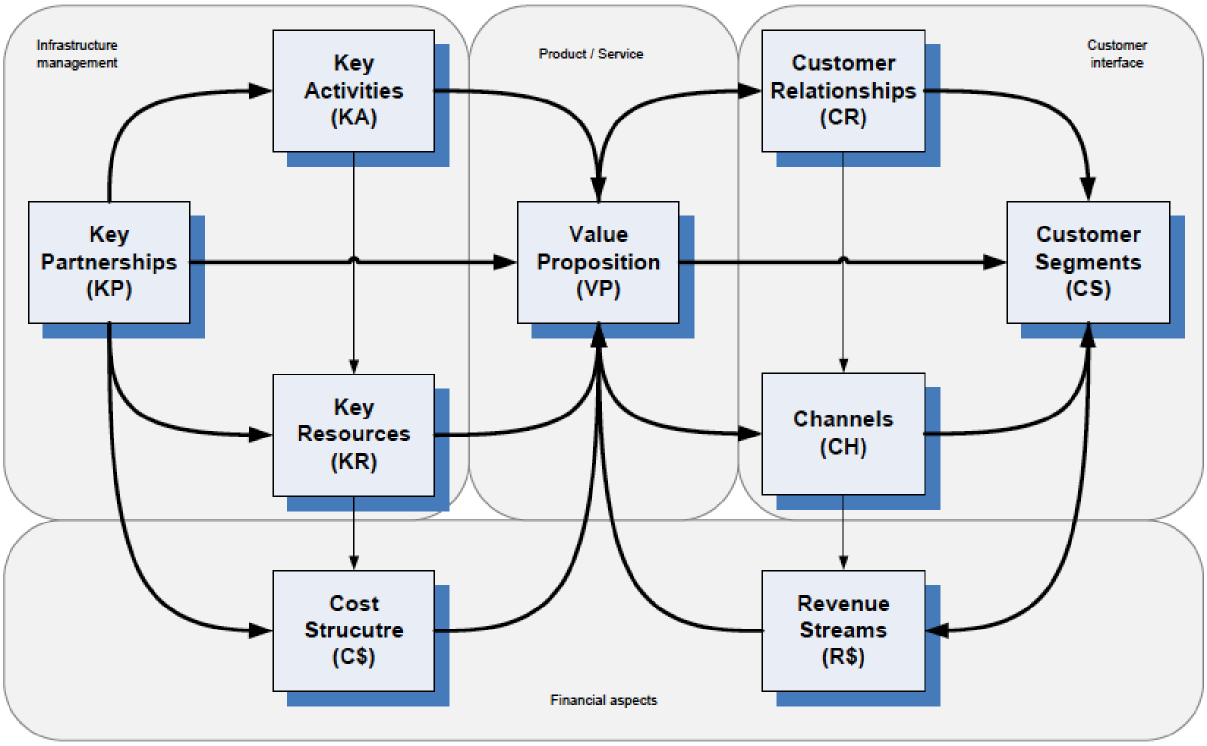

Figure 38: Osterwalder's nine blocks decomposition of a Business Model (adapted from Osterwalder, 2010)

Customer segments (CS)

This building block defines the customer segment(s) that an enterprise aims to reach and serve. This building block can be seen as the heart of any business model, as (profitable) customers are needed in order to survive as an enterprise for the long term. Although it is attractive for enterprises to serve as many customers as they can, a conscious choice between customer segments should be made. Customer segments can be recognized by the following characteristics:

- Serving customer needs requires a different offer;
- To serve the customer needs different distribution channels are needed;
- Customers require a different type of relationship with them;
- They are willing to pay for the added value provided by the organization;
- This segment has a substantially different profitability.

Customer segments indicate for whom the enterprise is creating value and which customers the most important ones are. Generally customer segments can be divided into the following basic segments:

- Mass market, reach the overall group of customers and therefore serving only their basic common needs;
- Niche market, provide tailored offers to specific customer requirements;
- Segmented, provide offers that are slightly different than other offers which are already available on the market (serving slightly different customer needs and problems);
- Diversified, serving different customers with parts of the same business model;

- Multi-sided platforms/markets, serve two or more customer segments in an integrated business model (both customer segments are needed in order to make the business model possible).

Diversified in the form of customer segments should not be confused with diversification on the strategy level.

Value Proposition (VP)

This building block focuses on the unique added value provided by the enterprise, for which a specific customer segment is willing to pay for. As a result this building block provides insight in what value the enterprise is offering to its customers, including solving problems and serving needs and wishes. Value propositions consist of the total range of provided products and services and can consist of qualitative (e.g. customer experience, design, etc) and quantitative (e.g. speed of service, prices, etc) values. According Osterwalder (2010) value can be created through a distinct mix of the following elements:

- Newness;
- Performance;
- Customization;
- Getting the job done;
- Design;
- Brand/Status;
- Price;
- Cost reduction;
- Risk reduction;
- Accessibility;
- Convenience/Usability.

The value proposition is mainly determined by the strategic position a firm wants or is forced to position itself.

Channels (CH)

This building block, channels, distinguishes all the channels that are used for reaching and communicating with its customer segments, in order to deliver value propositions. Channels are an important element in the customers experience and can therefore not be neglected. As a result the channels should be aligned with the added value that the enterprise is willing to deliver to its customers.

Channels can be divided into three categories, namely communication, sales and distribution channels, for which different types of channels exist. The different types of channels are included in Table 23.

Table 23: Different channel types available (adapted from Osterwalder, 2010)

Channel Types				
Own			Partner	
Direct		Indirect		
Sales Force	Web Sales	Own stores	Partner Stores	Wholesaler

Organizations should align their preferred channel type with their customer segment and the value proposition it aims to reach and serve. The purpose of this block is to find the perfect balance between the different channel types, as trade-offs has to be made.

Customer relationships (CR)

An organization should describe the type of relationship it establishes with its customers, which can range from automated to personal. The types of relationships should be aligned with the previous building blocks and integrated in the rest of the business model. Osterwalder distinguish six different relationships an organization can establish, namely:

- Personal assistance, based on interactions between humans (e.g. call centre);
- Dedicated personal assistance, couple a specific representative to a customer;
- Self-service, no direct relation with customers;
- Automated services, services are provided by automatic processes;
- Communities, bringing users together and therefore exchange knowledge (e.g. users can help other users instead of contacting the organization);
- Co-creation, involve users by building up the service or product (e.g. book reviews at an online book store).

Revenue streams (R$)

The revenue streams are a result of successful delivered value propositions to customers and are therefore the cash generators of an organization. Organizations should ask themselves “for what value is the customer willing to pay and for what price?”. Revenues streams in business models can be divided into two different types:

- Transaction revenues, based on single transactions which are only valid one-time;
- Recurring revenues, based on ongoing and recurring income.

The magnitude of the revenue streams can result from fixed or dynamic price mechanisms. Fixed prices are predefined on static variables, while dynamic prices are based on market conditions (result from negotiations). Examples of pricing strategies for this building block are: asset sale, usage fee, licensing, lending/renting/leasing, subscription fees, advertising, brokerage fees, etc.

Key resources (KR)

This building block describes the most important resources required to let the business model work. Those key resources can consist of physical, human, intellectual or financial assets, which can be owned by the organization or leased from key partners. From an inside-out strategy orientation key resources can result in sustainable competitive advantages in which technology development can play a major role.

Key activities (KA)

Key activities distinguish the most important actions an organization must perform in order to operate successfully. Like the key resources those actions are needed in order to deliver the desired value propositions, distribution channels, customer relationships and revenue streams. Dependent on the desired value proposition and required business model, key activities can vary widely among different organizations, although the purpose is the same. The purpose of those key activities must be creating, capturing and delivering value to its customers.

According Porter (1985) the key activities can be divided into primary and secondary (or support) activities. The primary activities add direct value to the organizations value proposition, while the secondary activities provide indirect value. The secondary activities are needed to make the primary activities possible. Porter explains those activities with the Value Chain, which is illustrated in Figure 39. The gross sales in this figure is the difference between the result of the building blocks "revenue streams" and "Costs Structure".

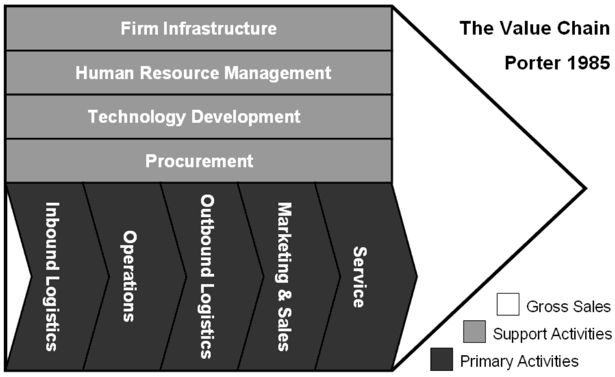

Figure 39: The Value Chain (Porter, 1985)

Key partnerships (KP)

Key partnerships describe the network of partners and suppliers, which are needed to perform the key activities, supply resources or deliver supplies. Those partners or suppliers are part of the key process performed by the organization in order to deliver the value proposition. The motivation for creating partnerships can be optimizing processes, gaining external economies of scale, reducing risk and uncertainty or acquiring resources and activities. Osterwalder (2010) distinguish four different types of partnership for this building block:

- Buyer-supplier relationships (relationship with suppliers in order to assure reliable supplies);
- Joint ventures (develop new businesses with a strategic partner);
- Coopetition (create a strategic partnership with a competitor);
- Strategic alliances (relations with non-competitors).

Cost structures (C$)

The last building block is the cost structure, which adds up the most important costs of the business model. In order to gain profits, revenues should exceed costs. Costs are related to all the resources, activities, etc. of the business model and for some organizations this building block is the driver to compete. Osterwalder distinguish two broad categories of cost structures:

- Cost driven, minimizing cost in every part of the business model;
- Value driven, focus on creating value for the selected customer segment.

In order to operate efficient a large amount of organizations are focussing on economies of scale and scope for this building block. Economies of scale decrease the average cost price per unit when the output increases. While economies of scope enables the organization to re-use several parts of the business model (e.g. distribution channels). Just like economies of scale, economies of scope enables the organization to spread the fixed costs over more output units and therefore decreases the overall costs price per unit. As a result cost structures can be divided into fixed and variable costs.

Business model innovation

Business models are seen as a key element of doing business, for which the business model innovation process can result from four different objectives. Those four objectives can be driven by strategic intent or by pressure of environmental forces. The four objectives for business model innovation are:

- *Satisfy the market*: the goal to serve unanswered, but existing market needs;
- *Bring to the market*: to provide new products, services or technologies to the market;
- *Improve the market*: to improve, unbundle, or transform an existing market by implementing a better business model;
- *Create a new market*: to develop a totally new market.

In order to design innovative business models the customers perspective should be taken into account, as they mainly determine the success of the business model (Balsters, 2008). It is therefore important to get a deep understanding about the customers and their environment, daily concerns, routines and aspirations. An important challenge of business model innovation is to develop a deeper understanding of what they really want and to recognize which customer to heed and which to ignore. Henry Ford once said: "*If I have asked my customers what they wanted, they would have told me 'a faster horse'*." (Osterwalder & Pigneur, 2010). This indicates that business model innovation should provide better solutions to their needs. Nevertheless, organizations can have multiple business models, which they should manage, update and align with strategic objectives.

Patterns in business models

This section describes the five most promising and successful business model patterns recognized in today's business environment. Business model patterns are defined as business models with similar characteristics, arrangements and behaviours between the building blocks, which are often used in today's business environment. According Osterwalder (2010) five different patterns can be recognized, which are explained in this section.

Pattern 1: Unbundling business models

According Hagel and Singer (1999) deregulation, new technologies and globalization will reduce the interaction costs in industries. Interaction costs are defined as transaction costs plus the costs that are related to the exchange of ideas and information. Interaction costs are related to organizations that perform different types of businesses within one organization. Hagel and Singer (1999) have recognized three significant different types of businesses, which are infrastructure businesses, customer relationship businesses and product innovation businesses (Hagel & Singer, 1999). Those three different businesses have their own competitive, economic and cultural imperatives (Treacy & Wiersema, 1995). Although those three different types of businesses can function under an umbrella organization, ideally their business models should be "unbundled" into single entities. Unbundling those business models result in avoiding unnecessary conflicts and trade-offs. While reflecting this pattern on the business model ontology, the bundles "infrastructure management", "product / service" and “customer interface” are unbundled into separate entities. Those separate entities consist again of their own business model.

Pattern 2: The long tail

According Anderson (2006) the democratization of tools of production (falling technology costs), democratization of distribution (decreasing inventory, transaction costs, etc) and the decreasing costs to connect supply with demand has enabled the long tail business model. The long tail business model is focussing on providing large amounts of niche products, also called “selling less of more” (Anderson, 2006). As most business models focuses on small amounts of products which they can sell against high volumes, the long tail business model focuses on a large number of products which they can sell in low volumes. This business model results in low inventory costs, but need strong platforms for providing easily niche content to interested buyers. The thought behind the long tail business models is illustrated in Figure 40.

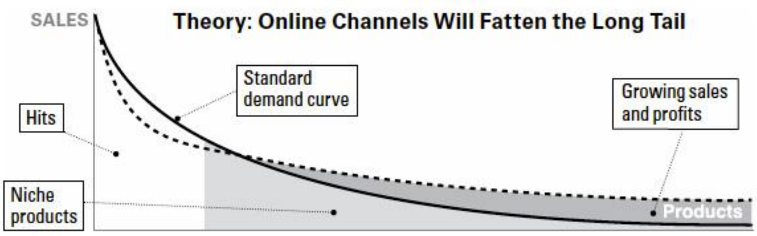

Figure 40: The Long Tail (Elberse, 2008)

Nevertheless, Bentley, Madsen and Ormerod describe that the long tail business model will not provide a guaranteed success, as the tail can be or become so small that the number of sales per product becomes almost one (Bentley, et al., 2009). This results in no best sellers, which provide the most revenues in this business model (Anderson, 2006). The long tail business model is often a preferred business model in transformations towards mass-individualization configurations, explained by the business evolution theory in Section 2.2 (Osterwalder & Pigneur, 2010).

Patterns 3: Multi-sided platforms

This business model brings two or more different customer groups together by implementing a multi-sided platform (Eisenmann, et al., 2006). The purpose of this business model is to create value by implementing interactions between the different customer groups. As a result multi-sided platforms can only create value if customers on both “sides” of the platform are available (Evans, et al., 2006). Furthermore, an important characteristic of the multi-sided platform is that the value of the model grows when it attract more customers, which is also known in economics and business as “network effect” or “network externalities”. Network externalities can lead to “lock-in” effects, which make the vendor dependent on the product or service (platform). “Lock-in” effects leads as a result to natural monopolies and therefore to extreme high switching costs, which “locks” the customer to the vendor. Although this business model already existed for a long period, through the rise of information technologies this model became increasingly popular (Osterwalder & Pigneur, 2010). Multi-sided platforms enable the customers to share their costs with customers on the other side of the platform.

Pattern 4: Free as a business model

The forth pattern focuses on providing free-of-charge offers for at least one of the significant customer segment. In this model the non-paying customer segment(s) are financed by other customer groups or by other parts of the business model (Anderson, 2008; Anderson, 2009). Nevertheless, different structures of "free" business models exist (Knowledge@Wharton, 2009), for which Osterwalder (2010) recognizes three main types:

- Free offers provided by multi-sided platforms (mainly advertising-based);
- Free basic product or service, but paying for options (also called "freemium" model);
- Bait & Hook model (also called "razor & blades" or "loss leader" model), offering inexpensive, free or attractive initial offers, which will result in future repeated purchases.

Pattern 5: Open business models

The last pattern is the open business model, which is becoming increasingly attractive in many industries. This model can be used by organizations to create and capture value through partnerships. Within open business models collaborations with partners happens from the "outside-in" or from the "inside-out". The outside-in approach means exploiting external assets, ideas, etc. within the organization, while the inside-out approach means providing external parties with assets, ideas, etc. which are not used within the organization (Chesbrough, 2006). This model is often used for open innovation, which makes unused products, technology development, intellectual property, and knowledge available for other organizations. Partnerships for exchanging innovations are mainly performed by joint ventures, spin-offs or licences.

Appendix B: Interview with M. Zegveld (in Dutch), confirming Chapter 2

Achtergrond informatie interview

Naam:	M. Zegveld
Functie:	Owner at TVA developments bv Partner Strategy & Change / value creation at IBM Voorheen ook associate professor faculteit Techniek, Bestuur en Management van Technische Universiteit Delft
Datum & Tijd	31-05-2010, 17:30 – 18:00
Type interview	Telefoon interview
Doel	Het doel van dit interview was het valideren van Hoofdstuk 2 (de rol van technologie in strategie en business modellen)

Per antwoord is er een samenvatting opgenomen.

*Deze samenvatting is **niet** geautoriseerd door de geïnterviewde.*

Interview

Het viel mij op dat technologie binnen strategisch management verschillend wordt benaderd, zoals u ook beschrijft in uw paper "Corporate strategy and technology". Het grote verschil zit hem in de manier van benaderen, namelijk "inside-out" of "outside in". Vanuit de "outside-in" perspectief heeft technologie een zeer beperkte functie en wordt de keuze ervan bepaald door omgevingsfactoren. In tegenstelling, heeft technologie in de "inside-out" perspectief wel een belangrijke functie, namelijk de "key recources" bepalen deels het kennen en kunnen van een organisatie. Desondanks concludeert u dat technologie alleen geen waarde heeft, maar dat vooral de applicatie van deze technologie benadrukt dient te worden.

Ik verwacht dat men in de praktijk, op corporate strategie niveau, een combinatie van beide perspectieven gebruikt.

1) Hoe heeft u dit ervaren?

Technologie heeft als los fenomeen maar een zeer beperkte waarde. Dit betekend dat technologie pas waardevol wordt als deze gekoppeld wordt of is aan een specifieke toepassing, markt, industrie, business case, etc. Hierbij wordt technologie vanuit de verschillende perspectieven inderdaad verschillend benaderd. Vanuit een inside-out perspectief wordt technologie vaak gezien als een basis om een concurrentie verschil te behalen, waarbij "intellectual property" een belangrijke asset is. Tevens is het in de praktijk zo dat beide perspectieven door elkaar heen worden gebruikt en dat strategische keuzes nooit vanuit 1 perspectief worden gemaakt ("Ik ken geen bedrijf dat niet vanuit beide perspectieven werkt”). Desalniettemin maken verschillende (grote) bedrijven, zoals Siemens en IBM, belangrijke strategische keuzes voor lange termijn investeringen op basis van hun eigen IP/technologie, waardoor technologie zeker een belangrijke rol kan spelen op strategisch niveau.

Op strategisch niveau is het belangrijk om een onderscheid te maken tussen grote/lange termijn investeringen en kleine/korte termijn investeringen. Afhankelijk van de categorie waarin een bepaalde technologie zich bevind wordt technologie op verschillende lagen binnen een organisatie behandeld. Gaat het om een “Must have”, ook wel “key technology” genoemd, dan zal de organisatie bepalen dit als eigendom te houden in de vorm van een “key resource” en zullen keuzes plaats vinden op strategisch niveau.

2) Wat vindt u dat de rol van technologie moet zijn op corporate strategie niveau?

Op dit niveau moeten hoofdzakelijk de “Key technologies” besproken worden in verdere details. De overige technologieën kunnen zeer beperkt aangehaald worden op een hoog niveau, maar zullen maar in zeer beperkte mate belangrijk of interessant zijn.

3) Als men een technologie wilt gebruiken om waarde te creëren waar moet dan voornamelijk op worden gelet?

Het belangrijkste hier is om met name te focussen op de mogelijke toepassingen van deze technologie. Het gaat er hierbij vooral om of je instaat bent om de technologie waardevol te maken voor je klanten. Tevens moet er op worden gelet of deze technologie “sustainable” gemaakt kan worden, zodanig dat deze technologie (en dus ook toepassing) voor een langere tijd uniek aangeboden kan worden. Hierbij kan technologie een belangrijke succes factor zijn, maar zeker niet de enige. Andere belangrijke succes factoren kunnen zijn: Klanten kennis, prijs structuur, organisatie, etc. Al deze factoren samen bepalen of je instaat bent om een waardevol product/service aan te bieden.

4) Wordt er op corporate strategie niveau een duidelijk onderscheid gemaakt tussen “breaktrough” en “incremental” technologie veranderingen?

Ja, zeker! Op corporate strategie niveau worden voornamelijk technologie georiënteerde investeringen besproken die radicaal zullen zijn. Dit zijn dan ook meestal de investeringen die zich kenmerken door hoge investeringskosten vooraf, lange termijn veranderingen en grote risico’s. Tevens hebben radicale technologieën veelal betrekking op het betreden van nieuwe markten. Dit in tegenstelling tot incrementele veranderingen die vaker onderdeel zijn van een groter programma en/of bestaande “Cash Cow”.

5) Als men technologie wilt gebruiken voor het vergroten van hun concurrentie verschil, is het dan verstandig om één type aanpak te kiezen (inside-out)?

Er is zeker niet één juiste aanpak. Dit is veelal afhankelijk van de omgeving waarin beslissingen gemaakt moeten worden. Als technologie de belangrijkste factor is van het succes, zou het denken vanuit de “inside-out perspectief zeer waardevol kunnen zijn. Dit betekend dat rondom de technologie (of IP) “competencies”, “capabilities”, markten, etc. moeten worden gebouwd om succesvol te zijn en blijven.

Maar als technologie niet de grootste succes factor zal zijn, b.v. 40% (wat al veel is voor technologie), dan gaat het niet alleen om capabilities en competencies. Dan moet er veel verder worden gekeken en zal er veelal met de klant moeten worden samengewerkt om het product of service tot een succesvol resultaat te brengen. Het hangt in dit geval af van vele verschillende factoren die bepalend zijn voor het succes.

Voorbeelden waarbij technologie dominant kan zijn is bij ICT projecten, ontwikkelingen in de farmaceutische industrie, kernenergie, etc. Bij deze voorbeelden bepaald technologie zeker de "competitive edge", ondanks dat andere factoren (zoals marketing) ook belangrijk zijn.

Verschillende auteurs (zoals Chesbrough, Rosenbloom, etc) benadrukken dat technologie alleen geen waarde meer heeft in snel veranderende markten, maar dat juist de combinatie technologie en business model belangrijk is voor het behalen van succes. Business modellen worden in gerelateerde literatuur gezien als een blue print voor strategie.

6) Wat vindt u van de formule Technologie + Business model = Innovatie?

De formule is een absolute versimpeling van de werkelijkheid en is in de praktijk zeer zeker geen reële formule. Desondanks is de achterliggende gedachte duidelijk, wat waarschijnlijk de reden is waarom deze formule is opgesteld. Deze formule geeft namelijk aan dat technologie niet alleen bepalend is, maar juist in combinatie met meerdere factoren. Tevens is het onduidelijk wat er wordt verstaan onder een business model, omdat hierover de laatste jaren veel is gepubliceerd waarbij zeer veel verschillende meningen en definities naar boven zijn gekomen.

Innovatie is veel meer dan wat er in deze formule is opgenomen. Innovatie is namelijk het in staat zijn om op een nieuwe innovatie manier geld te verdienen met een product, service, organisatie structuur, etc. Hierbij is het belangrijk dat er meer geld wordt verdiend dan dat er voorheen mee werd verdiend (in het geval van een verbetering). Dit betekend dat een formule voor innovatie minimaal de volgende variabele zou moeten bezitten:

- Technologie;
- Markt;
- Dienst;
- Organisatie.

Als conclusie geeft mr. Zegveld aan dat de formule in werkelijkheid een zeer complexe integraal zal zijn waarbij de bovenstaande variabele onderdeel uitmaken.

Osterwalder verdeeld een organisatie in drie lagen, namelijk de strategie laag, business model laag en proces laag. Tevens geeft mr. Osterwalder aan dat het vrij lastig kan zijn om de strategie en business model laag van elkaar te scheiden. Theorieën die de "inside-out" aanpak volgen lijken dichter tegen de business model laag aan te zitten dan de "outside-in" aanpak.

7) In welke laag binnen een organisatie (b.v. corporate level) zouden business modellen moeten worden ontworpen, behandeld, etc.?

Dit hangt voornamelijk af van de impact die het business model tot stand zal (moeten) brengen. Een organisatie hoeft namelijk niet te bestaan uit 1 business model, maar kan bestaan uit meerdere business modellen. Op het moment dat het business model een grote of cruciale impact zal hebben op wat dan ook zal het behandeld moeten worden op corporate level. Dit zal veelal betekenen dat business modellen behandeld dienen te worden op corporate level.

Gereflecteerd aan de theorie van Osterwalder lijkt technologie 3 verschillende rollen te kunnen vervullen, namelijk:

- *Supporting role: deze technologie zou voornamelijk moeten worden behandeld in de process laag;*
- *Key resource: Zeer belangrijk onderdeel van het business model (en eventueel strategie);*
- *Value proposition: Het aanbieden van een bepaalde technologie waarmee de organisatie zich onderscheid van de concurrentie.*

8) Bent u het eens met deze drie verschillende categorieën?

Het is onduidelijk hoe Osterwalder aan deze rollen komt, omdat zonder enige achtergrond informatie het moeilijk is om de relaties te kunnen bepalen. Maar ongetwijfeld zal Osterwalder hier een hele goede en vooral sterke reden voor hebben om dit te kunnen concluderen.

De eerste indruk is dat de value proposition een duidelijke outside-in benadering is, waarbij de waarde wordt bepaald door de omgeving. De key resources is daarentegen een duidelijke inside-out benadering, waarbij capabilities en competencies een belangrijke rol zullen spelen. Als laatste de supporting role is een strategische keuze die zou kunnen worden uitbesteed. Tevens lijken de eerste twee (supporting role en key resources) aan elkaar verbonden, waarbij een bepaalde technologie nooit beide rollen zou kunnen vervullen.

Reflecterend op de business evolutie theorie lijkt de Nederlandse energie markt een evolutie te ondergaan, namelijk naar "mass-individualization". Het vervullen van individuele klant behoeften lijkt een belangrijke rol te gaan spelen.

9) Wat betekend dit voor de rol van technologie?

De kans is groot dat ICT een belangrijke rol zal gaan vervullen om deze evolutie mogelijk te maken, zoals ook is gebeurd in andere sectoren (v.b. auto industrie). Dit betekend dat de kans groot is dat communicatie technologieën een cruciaal onderdeel kunnen gaan vormen binnen het huidige technologische systeem.

Een belangrijke externe factor waar alle actoren binnen de energie markt mee kampen is de komt van "smart grids". "Smart grids" zal vraag en aanbod beter op elkaar gaan afstemmen, waarbij duurzaamheid een belangrijke factor is.

10) Kort samengevat is "smart grids" het toevoegen van een ICT component aan het huidige elektriciteitsysteem. Hierdoor lijkt deze technologie zelfs belangrijk vanuit een "outside-in" perspectief. Hoe denkt u hierover?

Technologische veranderingen in de omgeving kunnen inderdaad krachten uitoefenen op een organisatie, zodanig dat de organisatie verplicht wordt zich aan te passen aan deze verandering. Binnen een outside-in perspectief kunnen daarom technologische veranderingen in de omgeving zeker een belangrijke rol spelen. Tevens heeft een organisatie wel altijd de keuze op welk niveau het systeem onderdeel zou moeten vormen van de organisatie.

De vraag is hierdoor bij Smart Grids in welke mate Smart Grids onderdeel zal gaan vormen van de organisatie. Wilt een organisatie bijvoorbeeld meer aanbieden dan de standaard eisen van Smart Grids, waardoor er een concurrentie voordeel kan ontstaan als het hoger wordt gewaardeerd door de klant? Of verwacht men geen meerwaarde te kunnen creëren met Smart grids, dan zal alleen aan de minimale eisen moeten worden voldaan. Dit betekent dat een bedrijf zich moet positioneren ten behoeve van deze externe kracht. Als men er voor kiest dat Smart Grids een belangrijk onderdeel zal gaan vormen, dan dient het bedrijf zich te focussen op die elementen uit Smart Grids waar het concurrentie verschil mee gemaakt kan worden.

11) "Smart grids" is de term op het hoogste niveau. Zou op strategie en business model niveau ook gekeken moeten worden naar de belangrijkste componenten van "Smart grids"?

Deze vraag is deels beantwoord met de vorige vraag, waarin al geconcludeerd werd dat de elementen (componenten) zeker belangrijk zouden kunnen zijn op strategisch niveau. De vraag die een organisatie zich hier zou moeten stellen is wat willen en wat kunnen we bereiken met Smart Grids. Het is dus sterk afhankelijk van de strategie die gekozen wordt of de componenten van Smart Grids besproken dienen te worden op strategisch niveau. Wordt er gekozen voor een strategie waarin Smart Grids een belangrijk onderdeel van vormt, dan moeten er rondom deze technologie competencies en capabilities gebouwd worden. Dit betekent dat er moet worden mee geïnvesteerd in deze technologie. Bepaald de organisatie dat Smart Grids niets meer is dan een "vehicle" om de doelstellingen te kunnen behalen, dan zouden er hele andere keuze gemaakt dienen te worden. Deze keuzes zullen dan zeker niet de details van Smart Grids bevatten.

De kunst is om te bepalen wat er kan worden bereikt met de eigen kennis, technologie, etc. om Smart Grids te gebruiken voor het creëren van hogere winsten. Dit betekend dat tijdens het ontwikkelen van het business model de verschillende onderdelen van Smart Grids verder onderzocht moeten worden indien er gekozen wordt om Smart Grids op te nemen in de organisatie.

Dit was de laatste vraag. Bedankt voor uw deelname aan mijn interview.

*Deze samenvatting is **niet** geautoriseerd door de geïnterviewde!*

Appendix C: System analysis of the Dutch electricity sector, a detailed insight

In this research, the Dutch electricity system is defined as the process of generation towards consumption, which is illustrated in Figure 41. De Vries (2009) divides the electricity system in a physical layer and an economic/institutional layer. The physical layer is divided into four blocks, namely generation, transmission, distribution and load, which distinguish the four main elements that makes the supply of electricity possible. The physical chain explains the main elements through which the electricity flows. Although new developments, like distributed electricity generation, disturb the one-directional process off the value chain, the largest part of the physical Dutch electricity system is still organized in this way. While the physical layer can be explained by the value chain theory, the economical/institutional layer is more complex and therefore a more system theory approach is needed. Due to the liberalization, the Dutch electricity value chain has attracted different actors that now control different parts of the Dutch electricity system. As a result the complexity of the sector, mainly described in the economical/institutional layer, has increased significantly.

Figure 41, gives a clear schematic overview about how the Dutch electricity system is organized. The double pointed arrows indicate the actor groups, described in the economical/institutional layer, that control the part of the physical layer. The single arrows indicate the direction in which electricity is traded.

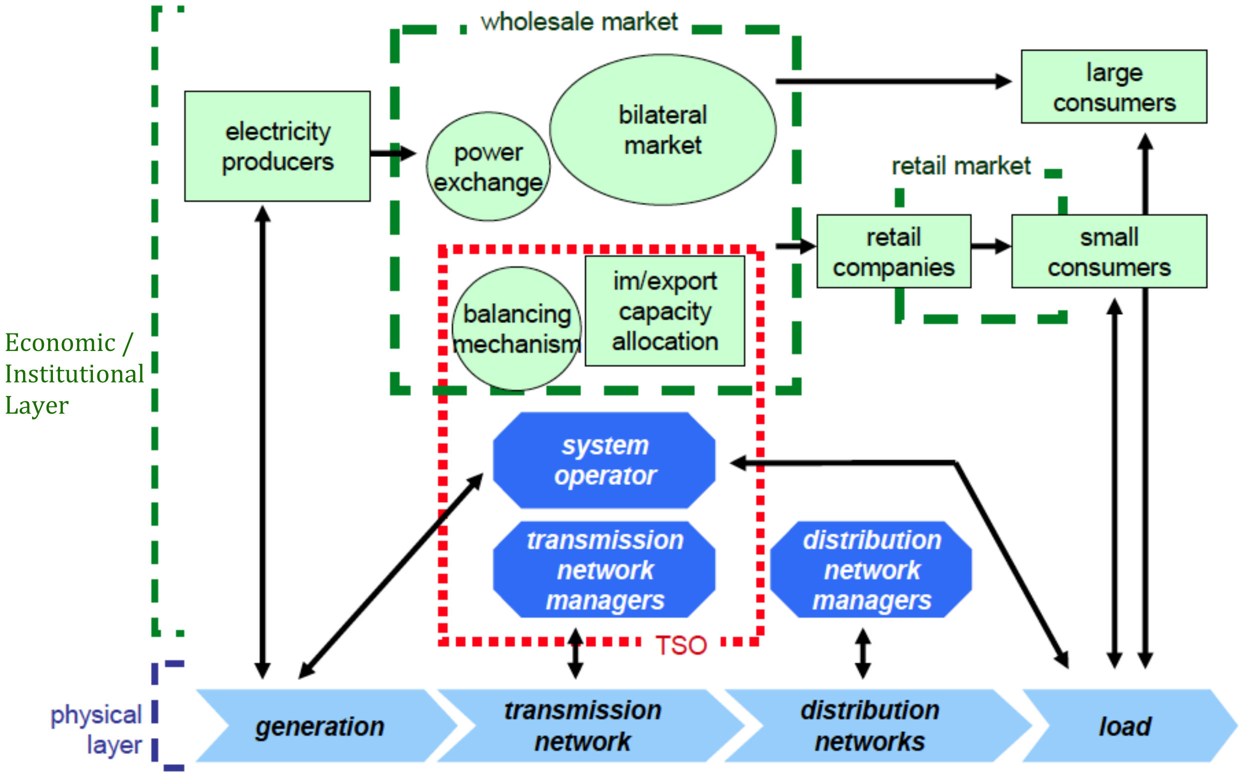

Figure 41: Dutch Electricity System (de Vries, et al., 2009)

When electricity was first introduced in the Netherlands around 1880, electricity flows were streaming in only one direction and only a few actors were involved in the electricity value chain (Rodel, 2008). Today, new technology developments, institutional changes and the tremendous growth of our electricity grid seems to change our grid into a bi-directional electricity grid in which a lot of actors are involved. The electricity grid was valuated in 2006 at 20 billion euro (Ongkiehong, 2006), which gives an indication about the size of the Dutch electricity grid in terms of money. Beside the increasing complexity of managing the Dutch electricity value chain, the Dutch electricity grid is recognized as one of the best technical designed grids of the world (seen from a technical point of view). Although this good position, the average downtime is increasing during the last years to an average of 35 minutes in 2005 (Ongkiehong, 2006). Besides producing only electricity different actors provide an entire range of services, which indicates the high level of integration. Nevertheless, the development of our electricity grid, the overall purpose has remained the same, namely supplying electricity to consumers in a reliable, safe and economic way (Ummels, 2009). In the following sections the different elements of the electricity system, included in Figure 41, are explained into more detail.

Electricity Generation

In the Netherlands we can distinguish two sources of electricity generation, namely central and decentral (also called distributed). Central electricity generation produces the bulk amounts and is mainly produced by large power plants using natural gas, coal, hydro or nuclear fusion as their primary fuel, for which coal and gas is the dominant fuel in the Netherlands. Central electricity generation is the traditional way of producing electricity and have been used already for decades. Technologies related to central electricity generation are proven to be generally affordable and reliable, and are therefore difficult to replace for alternative sustainable energy sources. Although those two main advantages resulted in a very strong position of existence, technologies related to central electricity generation have also three main disadvantages that have resulted in the development of renewable energy sources. The three main disadvantages of central electricity generation are (Ummels, 2009):

- Unsustainable for the future, as fossil fuel reserves are finite;
- Fuels are unequally distributed between countries, which result very often in political disturbance;
- Emission of greenhouse gases, especially CO_2.

The second category in which electricity can be generated is decentral electricity generation, also called distributed generation (DG). DG generally means generating relatively small amounts of electrical energy on different widely spread places in the electricity grid. Although DG consists of only relatively small generators, combining all small generators can function as a large one. Today, DG is recognized as a trend in the energy sector, in the form of renewable / sustainable energy sources (Veldhoven, 2007). DG developments were stimulated first by the Dutch Electricity Act of 1989, which resulted in today's electricity generation in a share of around 30%.

Although DG is partly completed with renewable energy sources, due to its environmental friendly way of generating energy, renewable energy production is still only presented for 2% of the total amount of energy supply in the Netherlands. The goal of the Netherlands is to increase the amount of renewable energy sources to 20% in 2020 (Ministry of Housing, 2010). Renewable energy technologies such as wind power, hydropower, solar power, bio-fuel and geothermal energy uses natural energy sources as their fuel for generating electricity (wind, sunlight, biomass, heat from the earth and water flows). Although renewable energy sources are from an environmental point of view highly preferable, there are two main disadvantages recognized from an economic and institutional point of view, namely (Ummels, 2009):

- Technologies related to renewable electricity generation are still (far) more expensive compared to conventional technologies. Therefore governmental support is needed to enable feasible business cases (e.g. long-term fixed prices for supplying energy from renewable energy sources into the power system, also called feed-in tariffs);
- The supply of renewable electricity generation is highly unpredictable and therefore less manageable.

In the Netherlands the market for electricity generation is fully privatized and therefore accessible for commercial activities. Although several companies (e.g. Nuon, Essent, E.ON Benelux, Electrabel, InterGen, DELTA) are active in the bulk (central) electricity generation in the Netherlands, a significant amount of electricity supply is complemented with import from neighbouring countries (Ongkiehong, 2006). The Netherlands has interconnections with Germany, Belgium and Norway and is currently developing an interconnection with England (project is called BritNed). All the large-scale generation units installed in the Netherlands are given by Figure 42 below.

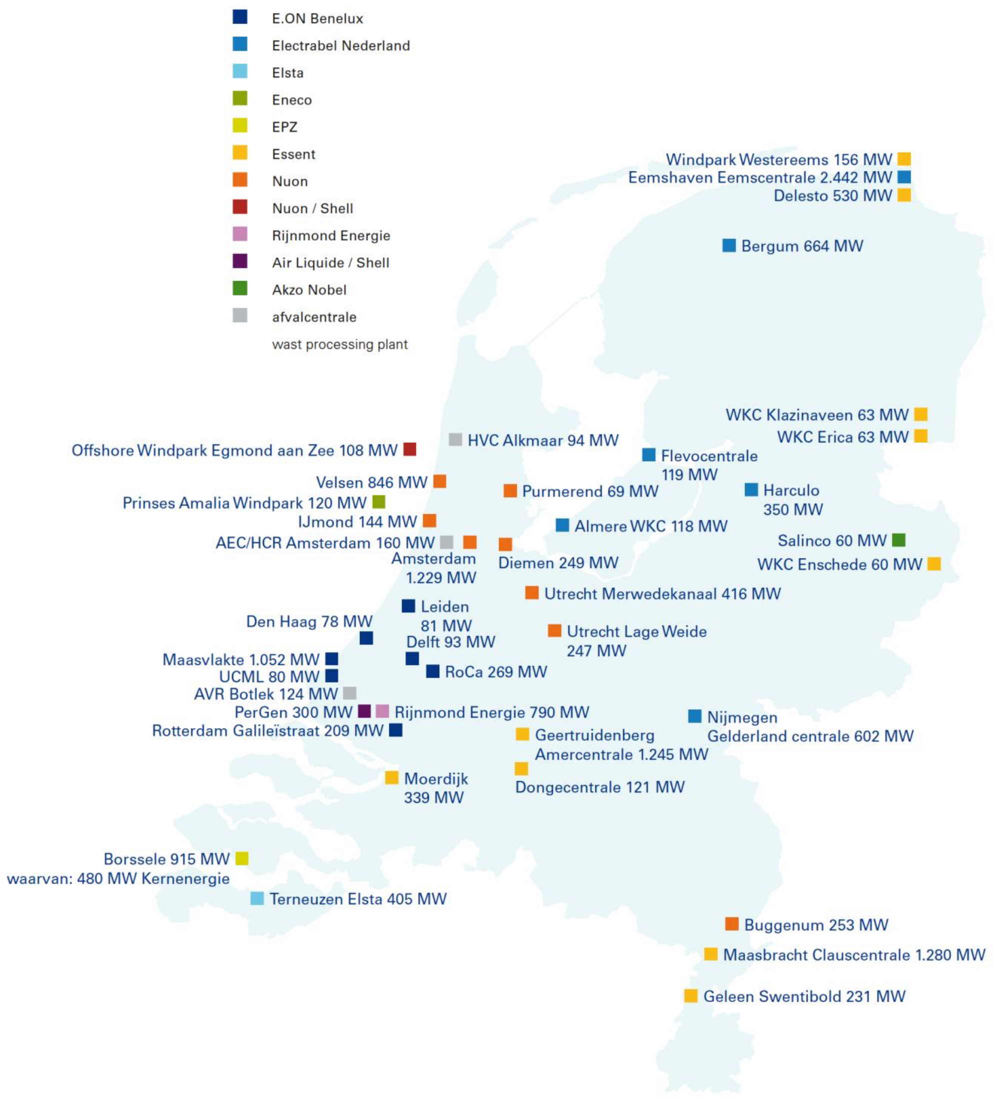

Figure 42: Large-Scale generation units, 2009 (EnergieNed, 2009a)

Energy producers primary sell their electricity on future or forward market in order to assure a continuous supply (Kirschen & Strbac, 2004). Therefore accurate forecasts and strict capacity planning and management are needed in order to minimize purchases on the spot market and energy peaks (Wals, 2001). Electricity providers deliver three different products to the electricity market, namely electricity, operating reserves and capacity reserves.

Although the electricity value chain is primary designed for matching real-time electricity supply and demand, in Europe also some storage options are installed. In this part of the value chain only large storage systems are distinguished, for which the main purpose is to store bulk amounts of energy. Large storage systems are more or less directly connected to the transmission grid. The two most used and known large storage systems are pumped hydroelectricity and compressed air (Lindley, 2010). In the Netherlands pumped hydroelectricity storage plays a very limited role, which is the case for most European countries except the Alp and Scandinavian countries. Also compressed air technologies plays a very limited role in the Netherlands, as pumped hydroelectricity and compressed air technologies are highly dependent on location and landscape and are therefore limited applicable in the Netherlands.

The main figures related to the Dutch electricity production are included in Table 24.

Table 24: key figures electricity production (adapted from EnergieNed 2009a)

Production	2008
Installed generating capacity (MW)	24.515
Max load high-voltage network (MW)	13.957
Total electricity production (million kWh)	112.780
Length electricity network (km)	262.519

Transmission network

The electricity grids can be divided into two categories, namely the transmission grid and distribution grid. The purpose of the transmission grid is to connect various power plants, distribution grids and cross-border grids and can be recognized as the backbone of the entire system. In the Netherlands the transmission grid is categorized as all power lines higher or equal to 110 kV and the distribution grids as all power lines lower or equal to 50 kV. The transmission grid is owned and managed by the Transmission System Operator (TSO), which is in the Netherlands the state owned company TenneT (TenneT, 2010b; TenneT, 2010d).

TenneT, the Dutch state owned TSO, operates and owns the complete Dutch transmission grid and its international connections. In Europe the high-voltage transmission grids are standardized into four voltage levels, which are 380 kV, 220 kV, 150 kV and 110 kV. These voltage levels are highly suitable for the transmission of large quantities of electricity. In the Netherlands the transmission grid connects 27 regional distribution grids, which are owned and operated by the Regional Grid Operators (RGO's). The main managerial task of TenneT on a daily basis is safeguarding the continuity of the electricity supply, by balancing demand and supply. The payment for those services provided by TenneT is part of the grid fee, which is charged to all parties connected to the national high-voltage transmission grid. Part of this grid fee, TenneT charges three different serves, namely connection, transport and system services, which have their own tariffs. The structure of the tariffs is regulated by law (Wijers, 1998), while the tariffs themselves are regulated by the Dutch government.

TenneT has three main roles, namely managing the transmission grids, system operator and managing the import and export of electricity. Within those roles TenneT has a natural monopoly position, due to the physical constraint of electricity networks. Although natural monopolies are the most efficient when having only one network, they also have different drawbacks. Therefore the policy goals for the Office of Energy Regulation (Energiekamer) are as follows (de Vries, et al., 2009):

- Establish optimal tariffs;
- Ensure equal access for all;
- Obtain optimal quality of service.

These goals are taken into account by the Office of Energy regulation while formulating the energy regulations, described under "regulation".

On international level, TenneT deals with the European Network of Transmission System Operators for Electricity (ENTSO-E) for European wide planning and operations, including the regulation for cross-border exchanges of electricity. The ENTSO-E association was founded in 2008 and operational since July 2009, which resulted in the integration of the already 6 different TSO associations. With the establishment of ENTSO-E Europe has one umbrella organisation that deals with the European rule setting process and network planning for electricity transmission. ENTSO-E stimulates the EU vision of an integrated European energy market (European Network of Transmission System Operations for Electricity, 2009). The main tasks of ENTSO-E can be summarized as follows:

- Design European standards for network codes and verify the implementation of those standards;
- Coordinate, plan and promote research and development in (cross-border) transmission networks;
- Security of supply, by monitoring the generation satisfactory;
- Design recommendations for European (cross-border) transmission regulations.

Figure 43 gives an overview of all the TSO's of the different countries or regions within the EU and countries or regions connected to the European electricity networks, which are involved in the activities of ENTSO-E.

Due to the liberalization and the stimulation of renewable energy sources, electricity producers can provide electricity on almost every physical location in the Netherlands. This has resulted in a high demand for connections on a few coastal sites and regions, due to the good environmental condition or other reasons to provide electricity. Although the building or placing process of new power plants, wind farms and CHP plants is going relatively fast, upgrading the transmission grids needs a significant more amount of time. This has resulted in areas in which more generating capacity is available than the transmission grids can handle, which result in congestion. TenneT has developed an innovative system for this problem, named congestion management. The basic idea is that in the case of overcapacity electricity generators must lower their production, while somewhere else more electricity must be produced in order to stay in balance. According TenneT (2009) this is attractive for both parties. The party that has to lower its production has already sold its capacity, but can now offer a lower price for not producing the full amount. The other party that has to produce more can just like in a normal case earn more by providing more. This system results in a win-win situation for all parties involved, due to the scarcity of the transmission grids based on a simple economic scarcity model (TenneT, 2010a). Nevertheless this system will in the end result in increasing prices for the end consumers. Although congestion management is described here under "transmission network" this can also be part of the wholesale market.

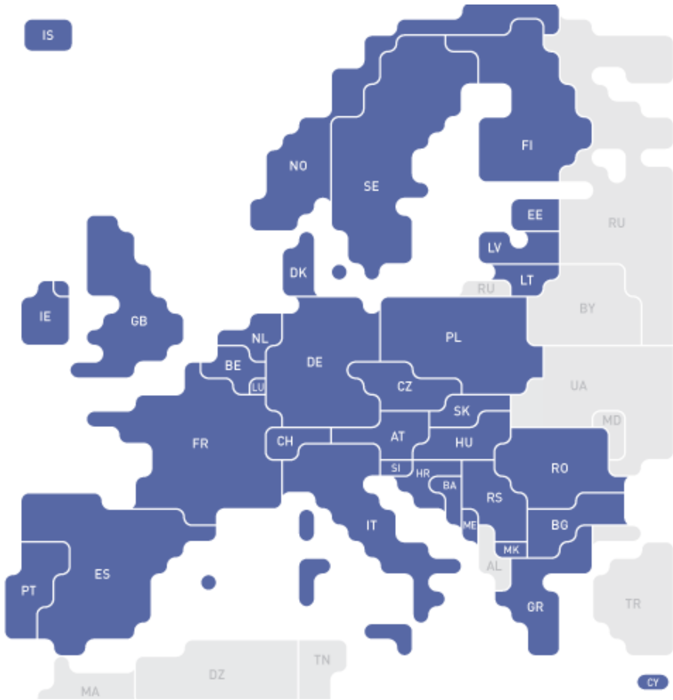

Figure 43: TSO's of the different countries/regions involved in the ENTSO activities (European Network of Transmission System Operations for Electricity, 2009)

Congestion management is based on a relatively simple economic philosophy, which is made complex due to the proposal of a new bill in which sustainable generation has a higher priority than non-sustainable generation. Although this bill is not yet a law, the bill already passed the House of Representatives and the expectation is that this will be implemented soon in the Dutch Electricity Act 1998 after approval by the Senate (TenneT, 2010e). This means for the congestion management system that when we have to lower electricity generation in an area in which we have overcapacity in terms of electricity generation we must take priorities into account (e.g. wind power systems has a higher priority than coal power systems). Although sustainable generators have a higher priority, according the new bill, we must also take the following criteria into account (Rijk, 2009):

- To what extent it is possible to store the electricity provided by renewable energy sources;
- The level of renewable energy usages for hybrid production plants;
- The level of greenhouse gas emissions;
- The degree in which negative external effects are avoided by reducing emissions of CO_2.

Furthermore, in today's environment, the generation companies together with the consumers determine the total load flow in the electricity networks.

Programme Responsible Party

An important actor related to the trade of electricity and the management tasks of TenneT is the Programme Responsible Party (PRP). This party is responsible for the purchases of electricity and therefore all the activities related to it, namely predicting, managing and administrating the expected electricity consumption using the electricity grid. This party is also the risk owner when imbalances occur, for which TenneT (TSO) will charge penalties (TenneT, 2010c). PRP's provide their individual electricity programs (e-programs) each day to TenneT. With this information TenneT will assure that the expected/demanded electricity flows can take place and measures the actual electricity production and consumption. When the actual electricity production and consumption does not match with the total sum of the electricity programs provided by the PRP's, TenneT will charge the imbalance to them, for every MWh of deviation. PRP's are not necessary the same actor as the electricity supplier. For the large electricity suppliers this is generally the case (e.g. Eneco, Nuon, Essent, etc.), but for the small electricity suppliers this generally not the case. Small electricity suppliers are mostly using one PRP as a group of small suppliers (e.g. PVNED). The ownership of the PRP is then shared among the different suppliers involved, which is allowed according Article 31 of the Dutch Electricity Act 1998.

PRP's can have two types of recognition, namely full recognition or trade recognition. Full recognition means that a recognised legal entity has program responsibility for grid connections, while trade recognition is limited to trade between PRP's. The list (PR Register) that includes all the responsible parties is public accessible on the website of TenneT. Currently, April 2010, there are 31 legal entities that have a full acknowledgement and 29 legal entities that have only a trade acknowledgment on the Dutch electricity market.

Wholesale & Retail market

The Dutch wholesale market consists of four different market segments, namely Power exchange, bilateral market, balancing mechanism and import/export capacity allocation. The most important activity of the first market segment (power exchange) is the spot market, for which electricity is traded on an hourly basis for the next day. The second market segment (bilateral market) is to trade electricity directly between traders and therefore without the intervention of the trade market (also called over-the-counter (OTC)). This market segment include also the option to produce the electricity yourself and therefore buying directly the electricity internally. The third market segment (balancing market) is a specific market in which only TenneT trades, in order to balance its transmission network. The last option is to import or export electricity from foreign countries. The Netherlands consist of four import/export connections, namely with Germany, Belgium, Norway and after finishing the BridNed project also the United Kingdom. The wholesale market in Europe and therefore also the Netherlands can be recognized as a decentralized market in which the system operator (TenneT) has only a technical function. Commercial activities related to the supply and demand of electricity is met somewhere else, described in this section.

Next to the wholesale market also a retail market exist in the Dutch electricity system. The retail market is the intervention between the wholesale market and small consumers. On the retail market energy retailers serve small consumers in order to prevent the necessity of all individual consumers on the wholesale market.

Power Exchange market

In a liberalised market exchanges are essential, because they offer transparent and open platforms in which market parties can trade anonymously. In the Netherlands there is one official power exchange, namely the Amsterdam Power Exchange (APX), which is currently merging together with ENDEX (APX-ENDEX, 2010). The merger can be seen as a preliminary process in order to realize the EU vision of an integrated European energy market. As ENDEX is an exchange for trading bilateral contracts this exchange is explained below under the “bilateral market”.

The most important activity on the APX is the spot market, which means that the market is cleared every hour of the day. As electricity storage is not yet been commercially attractive, the value and therefore the prices are much higher during peak hours than during off-peak hours. This results in high volatile spot prices, which explains the demand for bilateral contracts. However, spot markets are highly attractive for the short-term electricity exchange. The APX is 100% owned by TenneT.

Exchanges on the APX are regulated, for which the core activity is providing customers a (digital) spot market trading platform. Through this platform trading on three different types of markets is possible, namely (APX Group, 2010):

- Day-Ahead market (core activity);
- Intraday market;
- Strips market.

Day-Ahead auction is the core activity of the Dutch electricity exchange market. On this market trading takes places one day before the actually delivery of the electricity. The market price changes each hour and is therefore calculated for the hour of the following day. On this market, hourly contracts and flexible block contracts can be bought or sold. This market consist of a minimum and maximum electricity price, for which the minimum price is 0,001 €/MWh and the maximum price is 3000 €/MWh.

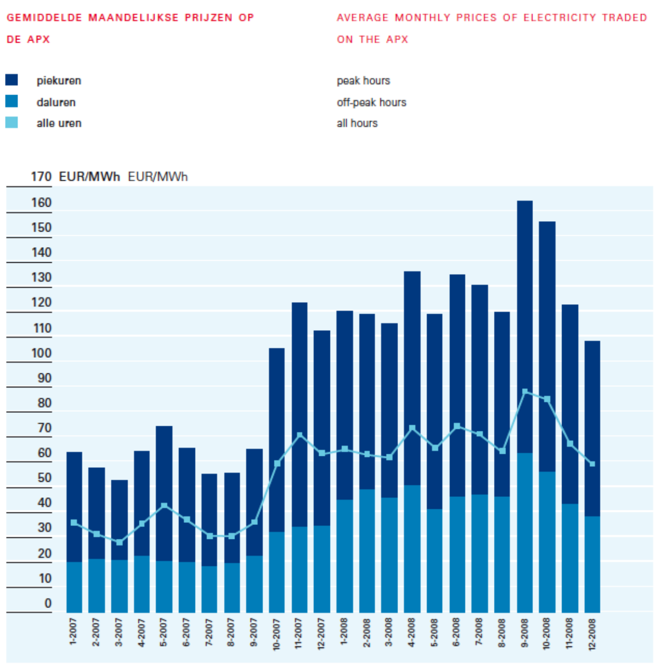

Figure 44: Average monthly prices of electricity traded on the APX (EnergieNed, 2009a)

Intraday market is a relatively new market, which is introduced in the Netherlands in September 2006. This market enables a continuous trade, in which electricity can be bought or sold with intervals of 15 minutes, 1 hour blocks or 2 hours blocks. The intraday market is mainly used for reducing risks, which are associated with imbalance prices charged by TenneT (the Dutch TSO). The minimum electricity price for this market is -3000 €/MWh and the maximum electricity price is 3000 €/MWh. This market opens for trading one day ahead and closes 2 hours prior to delivery.

Strips market is a market that is closely related to the Intraday market and exist already before the Intraday market was established. Also this market enables a continuous trade, but is based on only blocks of 12, 24 or 48 hours. On this market different products are available which are either two days prior to delivery open for trading or one weekend ahead. The minimum electricity price for this market is 0,001 €/MWh and the maximum electricity price is 3000 €/MWh.

The average monthly prices traded on the APX are included in Figure 44.

Bilateral market

This is the primary used market in the Netherlands, namely 85% of the total electricity supply is sold on this market (de Vries, et al., 2009). Bilateral markets, also called Future market or Over-The-Counter (OTC) markets, can best be explained by generating companies that sell their electricity directly or through a platform (ENDEX) to their customers, by making use of long-term contracts (futures). Those contracts safeguard the supply of electricity for a certain period in time, containing a fixed price.

In the Netherlands we have one official trade market for futures, namely ENDEX N.V., which was founded and funded in 2002 by several major players in the financial and energy market. Within this market contracts are open for trading ≤ 6 months ahead. The Dutch electricity products available on this market are (Endex, 2010):

- Power NL Futures (base load 20:00- 08:00, peak load 08:00-20:00);
  - 5 calendars ahead;
  - 6 quarter ahead;
  - 6 months ahead.

- Power NL 16 hrs peak load (base load 23:00- 07:00, peak load 07:00-23:00).
  - 4 calendars ahead;
  - 6 quarter ahead;
  - 6 months ahead.

Balancing mechanism (Single Buyer market)

An important activity within the electricity system is the accurate prediction of the electricity demand (explained above at the Programme Responsible Party). Although we have learned to make relative good forecasts of the electricity demand, it is still impossible to make a precise forecast at every moment in time. For that reason TenneT, as the responsible actor, uses a balancing mechanism. In this market operating reserves are in the standby mode, which can be offered by the generating companies. Generating companies with a contracted and provided capacity of ≥ 60 MW are even obliged, according the Grid Code, to offer all their available capacity to TenneT. This includes the capacity that they can produce more, but also less. This capacity is offered to TenneT as Regulating and Reserve Power (RRP) by means of bids. TenneT accepts three different types of offering power, namely regulating, reserve and emergency power. At almost every moment in time, those three types of capacity are needed (in the current market setting) in order to provide a high level of reliability, which is one of the primary public goals. In today's Dutch electricity system, the total amount of electricity that is handled on this mechanism is between 1,5% and 3,5%, with an average of 2% (Veen, 2007) of the total electricity consumption per day. As only TenneT is able to trade on this market, this market is also called "single buyer" market.

Import and Export capacity allocation

Import and Export of electricity becomes increasing important to serve our increasing demand for electricity and the EU vision of an integrated European energy market (European Network of Transmission System Operations for Electricity, 2009; Ongkiehong, 2006). As electricity prices in neighbouring countries are lower than in the Netherlands, interconnections with neighbouring countries are even highly preferred. Electricity prices in neighbouring countries are lower due to the different primary fuels for electricity generation and resources available in those countries, which has a large historical background. A good example is the case between the Netherlands and Germany, which is the primary country for import (see Figure 45). In Germany the main fuel for electric generation is coal, while in the Netherlands the price-setting generator is gas, which is indirectly related to oil prices (de Vries, et al., 2009). As the oil price is currently historically high and sharply increasing over the last years, the price for electricity is much higher in the Netherlands than in Germany. Nevertheless the introduction of tradable CO_2 emission can result in faster increasing electricity prices in Germany in the near future, because gas plants needs less than coal plants.

The Netherlands has currently interconnections with Germany, Belgium and Norway and after finishing the BridNed project also with the United Kingdom (BridNed, 2010; European Network of Transmission System Operations for Electricity, 2009). Figure 45 shows the total amount of import and export of electricity in term of GWh, for which the total deficit in 2008 was around 15 TWh. TenneT operates the interconnection and its auctions together with the TSO from the other country.

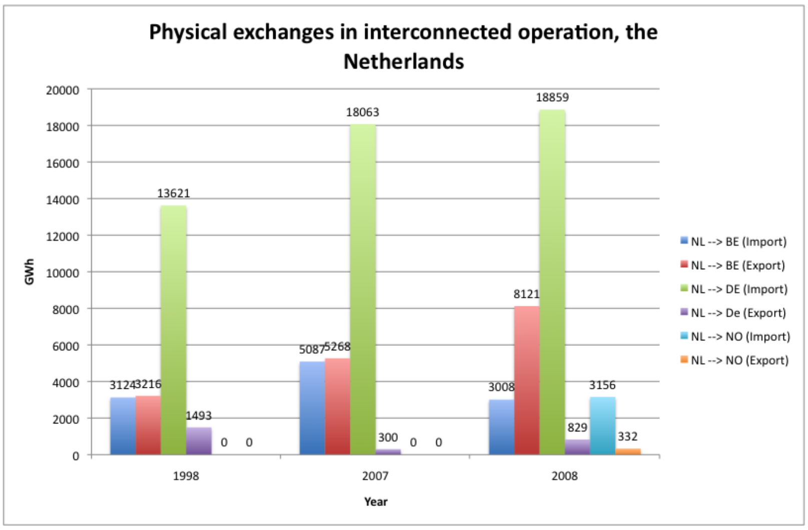

Figure 45: Physical exchanges in interconnected operation, the Netherlands (European Network of Transmission System Operations for Electricity, 2009)

Retail market

The retail market is a relative stable and easy market from a consumer perspective. On this market electricity retail companies provide electricity to small consumers, for which they trade on the wholesale market. On the retail market we can distinguish two different types of contracts, namely variable contracts and fixed contracts. Variable contracts means that electricity prices are adapted to the market prices every half-year and last for the signed period, while fixed contracts gives a fixed electricity price for the whole contracted duration.

Since 1 July 2004, the supply of electricity for small consumers is not regulated anymore, which means that retail companies can set their own electricity prices and that consumers can switch between retailers. Nevertheless, price settings must satisfy the Dutch Electricity Act, article 95b, which means that if prices are unreasonable (difference between costs and price is too high) the Office of Energy Regulation (Energiekamer) can intervene by setting a maximum electricity price. In the Netherlands we call this "vangnetregulering".

A second important article of the Dutch Electricity Act 1998 is number 95c, which include the regulation of supplying electricity back into the grid. This article obligates all energy retailers to accept electricity flows back into the grid, which are generated by sustainable energy sources. The retailer must provide the consumer, which now function as supplier, a reasonable price for this service. Also in this case the Office of Energy Regulation monitors the prices and intervenes where necessary. In the current situation (2010) retailers provide their customers the same price as they charge for delivering electricity for the first fixed amount of kWh (e.g. Greenchoice, Eneco and Essent the first 5000 kWh). After passing the first fixed amounts of kWh the price decreases due to transportation costs.

Distribution network

In contrast to the transmission grids, the Dutch distribution grids are owned and managed by several Regional Grid Operators (RGO's). This actor is often called Distribution System Operators (DSO's), but this term is mismatched for the case in the Netherlands, as the RGO's have no system responsibility. In the Netherlands 8 RGO's are active, which are visualized in Figure 46. From this figure we can easily recognize the three largest operators, which are ENEXIS, Liander N.V., Stedin. The Dutch RGO's are owned by local governments and just like TenneT separated from all commercial activities, for which the unbundling process is currently (2010) in progress. The process of unbundling the physical and service functions on distribution level must be finished before January 1, 2011 (NMa Energiekamer, 2010; Weterings, 2008a; de Vries, et al., 2009)

As part of the Dutch law, related to the unbundling process, RGO's should be juridical separated from the commercial activities (services) in a separate firm. This includes a separation of the location and identification of both organizations, in order to prevent unfair competitive advantages. However, according the latest developments (NOS, 2010), this law allows RGO's to be part of a larger energy firm. This larger firm can include other competitive activities provided by legal persons. In this way we can say that the larger company is split up into a monopoly and therefore un-risky part and a competitive risky part.

The main difference between a network manager on the transmission level and a network manager on the distribution level is the added task of system operator. In the current setting, the system operator task belongs to the TSO and can therefore not be performed at the distribution level (NMa Energiekamer, 2009). This means that the distribution operators are not allowed to perform any other task than managing the distribution networks. According the Dutch Electricity Act 1998 and the system code RGO's are not allowed to install energy storage solutions for peak shaving, contingency reserves, etc, as this can be seen as a service.

1. RENDO Netwerken
2. Cogas Infra en Beheer
3. Liander (before: Continuon Netbeheer)
6. Stedin (Before: Eneco)
7. Westland Infra
8. Stedin (Before: ONS Netbeheer)
9. DELTA Netwerkbedrijf
12. NRE Netwerk
13. ENEXIS (Before: Essent Netwerk)
14. ENEXIS (Before: InfraMosane)

Figure 46: Dutch Regional Grid Operators (EnergieNed, 2009b)

Distribution grids in the Netherlands consist of three different voltage categories, namely high-voltage also known as transition voltage (50 kV), medium voltage (25 kV and 10 kV) and low voltage (230/400 V). The main purpose of the distribution grids is to connect a large amount of customers to the electricity supply. Until recently distribution grids are not only important anymore for distributing electricity from transmission grids to end-users or customer, but also for connecting distributed electricity generators. This development has a significant impact on both the technical systems and managerial systems (Deconinck, 2010; Rodel, 2008). Distributed electricity generation enables the connection of small renewable energy sources to the electricity grid. Another important development in the distribution grids on the customer side is the development in which customers can manage their own demands (van Eck, 2007).

Consumption (load)

Within the Dutch electricity sector consumers are divided into two categories, namely small and large consumers. Large consumers are categorized as all connections higher then 3*80 A and small consumers lower or equal to 3*80 A. As large consumers are considered to have a good bargaining position and are trading electricity direct on the wholesale market, the Office of Energy Regulation (Energiekamer) does not monitor the prices for this group. Bargaining or trading good electricity prices is therefore their own responsibility. For small consumers, which are active on the retail market, the Office of Energy Regulation does monitor all prices and intervenes when necessary (NMa Energiekamer, 2010).

An important aspect of the European law, strengthened by the Third Energy package (described under “regulation”), is the consumer protection related to their energy consumption. As a requirement of the Third Energy Package, consumers must be informed about their energy consumption on a regularly basis. With this information consumers will get to understand their energy consumption pattern and are able to manage their energy consumption to their own needs (e.g. cost reduction), for which they can easily shift between energy providers. The solution is recognized to be "smart meters" and therefore the EU is requiring smart meters to be installed at all consumers (de Vries, et al., 2009). Although the smart meter consist of several basis functionalities which make all the European requirement possible, within the Netherlands several functions are added in order to also fulfil all the Dutch individual needs. The complete requirements of the Dutch smart meters are included in the NTA 8130 (Nederlands Elektrotechnisch Comité (NEC), 2007).

The Dutch government is stimulating sustainable developments for energy generation and energy savings (Ministry of Housing, 2010). At the consumer side this resulted in an increasing demand for distributed electricity generation, like solar panels, small wind turbines, micro-CHP's, etc. Although the demand for those technologies is increasing, without the (financial) incentives of the government, policy privileges and the rise of fossil fuel prices the changes of success would be relatively low (Foreest, 2008; Taylor & van Doren, 2002).

The main figures related to the Dutch electricity consumption are included in Table 25.

Table 25: key figures electricity consumption (adapted from EnergieNed 2009a)

Consumption	2008
Total electricity consumption (million kWh)	113.829
• *Part small consumers*	*36.646*
• *Part large consumers*	*77.183*
Total number of customers	7.810.000
Average electricity price small consumers (€/kWh)	0,21
Average electricity price households (€/kWh)	0,25

Regulation

The Dutch law that contains the guaranteeing of the existence of electricity is included in the Dutch Electricity Act 1998 (Wijers, 1998). This act is the end responsibility of the Ministry of Economic Affairs. The Ministry of Economic Affairs has charged the Office of Energy Regulation (Energiekamer) with regulating the Dutch Electricity Act 1998, as part of the Netherlands Competition Authority (NMa) (NMa Energiekamer, 2010). The Dutch Electricity Act 1998 is limited by regulating the monopoly activities only (such as network management for TSO and RGO) and therefore the free economic activities (generation and supply of electricity) are no longer regulated by this law. This law also requires a legal separation between network managers and all commercial activities. Next to this law, network managers can together create codes as part of the Dutch electricity regulation system, which has to be officially approved by the director of the Office of Energy Regulation (Art. 31 and 36 of the Dutch Electricity Act. 1998).

The Dutch electricity regulation distinguishes three different types of codes, which are technical codes, tariff codes and information codes. The structure and the relation between those codes are illustrated in Figure 47. Those codes are designed to give substance to the Dutch Electricity Act 1998 and describe how network manager should act among other network managers and members connected to their networks. The technical codes consist of three sub-codes, namely network code, metering code and system code. The Network code describes how network managers should operate their grids. The metering code describes the conditions that have to be fulfilled in order to provide reliable metering of the electricity supply and demand (including the allocation of metering responsible parties). The last technical code, system code, describes how system services should be delivered. In the tariff codes the costs of the grids are determined, in order to distribute the costs among all network users. Within this code a distinction is made between transport, connection and system services. Finally, the information code describes which information should be shared among market parties. Although the Dutch Electricity Act 1998 requires the existence of those codes, the conditions included in those codes are not part of the legislation, but only part of the regulation (NMa Energiekamer, 2010).

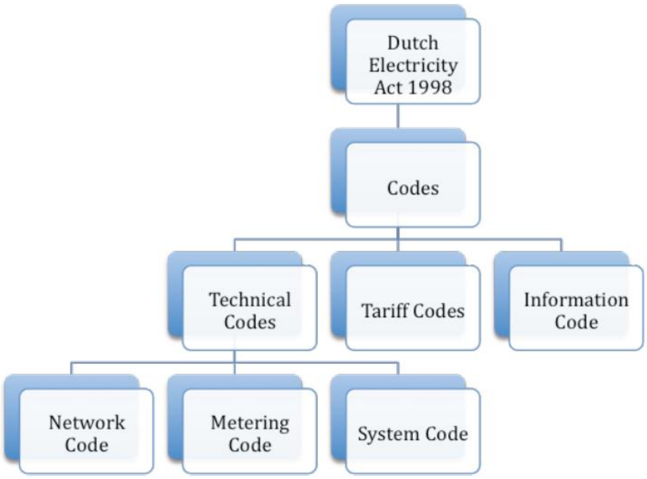

Figure 47: Code regulation structure

Due to the monopolistic nature of the network activities, (indirect) regulation is needed to guarantee the economic viability of the network business (Scheepers & Wals, 2007). In the Netherlands the indirect regulation for RGO's is provided with incentives in order to operate the network efficiently, while guaranteeing a certain quality level. The main purpose of this mechanism is to take the role of competition, which is missing in natural monopolies. The incentive mechanism used in the Netherlands is a price-gap regulation. This mechanism allows tariffs to increase with only a few percentages per year, which stimulates efficiency. The percentages the tariff can increase is calculated from the inflation factor plus the quality factor minus the efficiency factor (Meijer, 2009). This basically means that the higher the operational efficiency and quality of the networks, the higher the tariffs that can be charged by the RGO's. The efficiency factor is determined by the yard stick competition (benchmarking) principle, which compares the achievements made by the RGO with the sector average. The quality factor is determined by three main aspects, namely; continuity of supply, voltage (or power) quality and customer service quality. RGO's should find the best balance between those two factors, in order to optimize their profits. Furthermore, the wholesale and retail prices are regulated by price restrictions. For this mechanism a discussion is going on in which the question arises whether sufficient investments are made in price-restricted markets and if a capacity mechanism is not better for the consumer (de Vries, et al., 2009).

At European level, April 2009, a new package of regulations and directives were adopted by the European Union, called the Third Energy Package. The objective of this package was to strengthen the consumer rights, improving the security of supply and to create effective competition, in order to create a better integration of the European energy market and to maximize European welfare. In order to do so, a key goal was to remove the strategic advantage energy companies had from combining production and trade activities with network ownership. Therefore TSO's within the EU are now fully unbundled from competitive activities. The Third Energy Package, related to only the electricity market, consists of (de Vries, et al., 2009):

- Establishing an Agency responsible for the cooperation between different energy regulators of the different EU countries (regulation (EC) No 713/2009);
- Conditions in order to access the network of cross-border exchanges (regulation (EC) No 714/2009);
- Concerns related to common rules for the internal markets among different countries in electricity, in order to realize the EU vision of an integrated European energy market (directive 2009/72/EC).

As a result (first point) a new established agency of the European Union was created on 13 July 2009, called the Agency for the Coordination of Energy Regulators (ACER). The main purpose of this agency is to improve and create harmony between the different performed regulations, executed by the national regulators. The main tasks of this agency can be enumerated as follows (Pottering & Erlandsson, 2009):

- Advisory and monitoring role: focussed on European network rules and other energy related issues;
- Regulate ENTSO (described under transmission network);
- Decisive authority over cross-border capacity, when mutual countries cannot agree with each other.

Although the European Union and its agencies have a huge impact on the national laws of the member states, related to the energy sector, the European directives leave much room for own implementation. Therefore on the implementation level totally different solutions can be recognized between the different member states. Member states interpret and implement the European guidelines and directives in their own strategic advantage, for which their main concern is their own position in the EU future (de Vries, et al., 2009). Also the status of competition is far from textbook ideal and differs between those member states. The status is somewhere between pre-liberalized and perfect retail competition.

To conclude the regulation part, in the Netherlands we have three levels of regulation, which are included in Table 26.

Table 26: The three levels of Dutch electricity regulation

1	Law	Dutch Electricity Act 1998 & Third Energy Package
2	Code	Network Codes, System Codes, Metering Codes, Information codes and Tariff codes.
3	Contract	Everything that is not included in the law or codes can be negotiated between the network manager and the user.

Appendix D: Overview energy transition scenarios

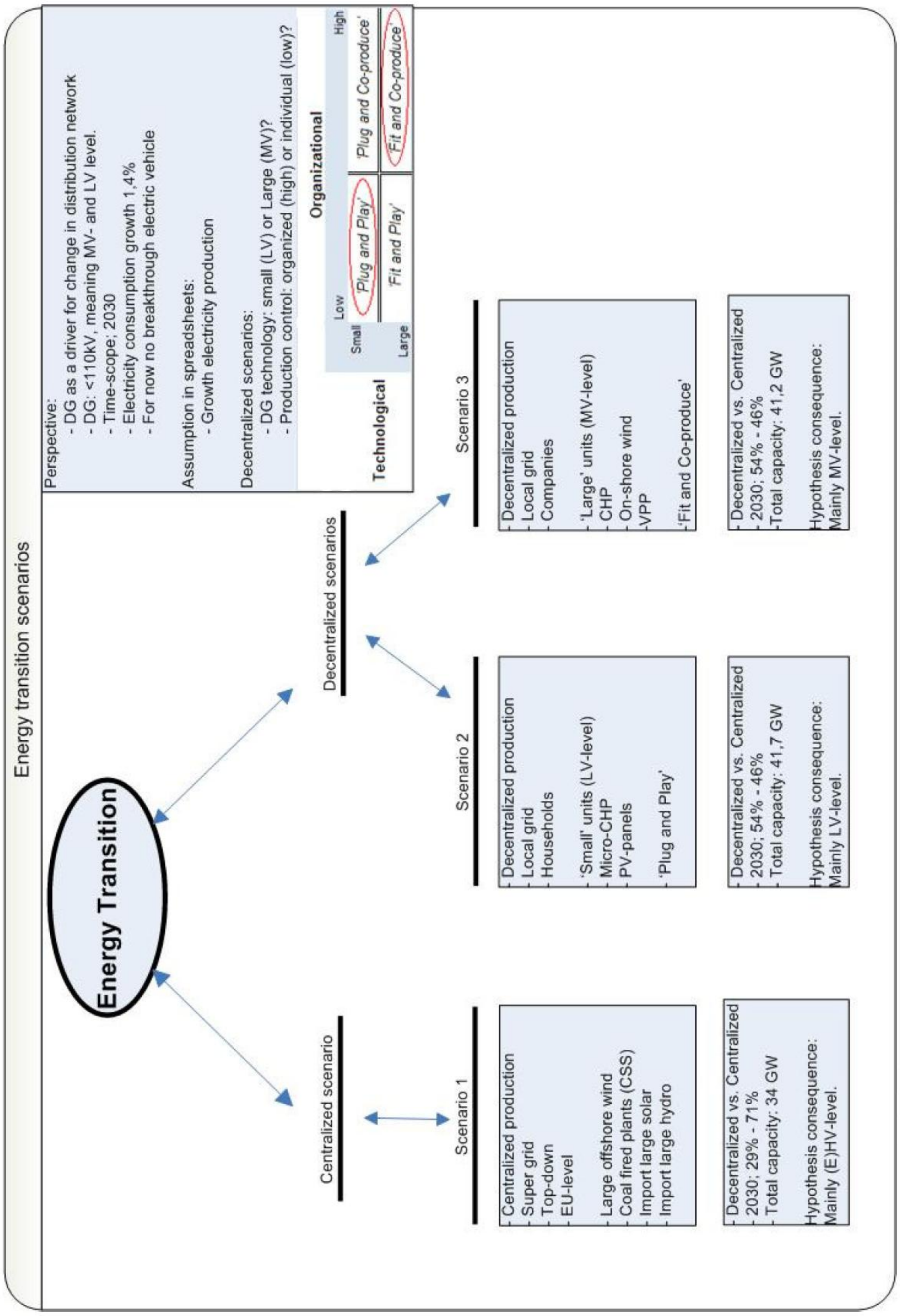

Figure 48: Overview energy transition scenarios (Meijer, 2009)

Appendix E: Applications & alternative technologies, a detailed insight

Applications

Application 1: Electric Energy Time Shift

This application focuses on purchasing inexpensive electric energy during periods when the price is relatively low (mostly off-peak periods), so it can be sold or used during expensive periods (mostly on-peak periods) when the price is relatively high. This application is also known as arbitrage. Although the word arbitrage is often used in primary and secondary literature, in many cases this term is mismatched and therefore not used for this thesis. The term arbitrage comes from the financial definition and means "*the **simultaneous** purchase and sale of identical or equivalent commodities or other instruments across two or more markets in order to benefit from a discrepancy in their price relationship*" (Eyer & Corey, 2010). For this application the energy is not bought and sold simultaneous, but on different points in time, and therefore arbitrage is a mismatched term for this application.

The primary goal of this application is to reduce energy costs and therefore the variable (non energy related) operating costs and costs related to efficiency are of primary interest. The total store, purchase and discharge costs should not exceed the total benefits derived from discharging the energy, which is a price advantage.

An secondary advantage of this application is that it indirectly support the integration of renewable energy on a large scale. If our renewable energy sources provides large amounts of energy the price is relatively low and when we have a shortage of energy the price is relatively high, so indirectly we stimulate storing energy and therefore renewables.

Application 2: Ancillary services

Ancillary services are necessary in order to support the delivery of electricity from supplier to customer, while maintaining the reliability and integrity of the transmission and distribution network. Ancillary services are in this thesis seen as one application, but includes more sub-applications that can be combined to some extent. The sub-applications are included below in Table 27.

Table 27: Ancillary services

Nr.	Sub-application	Comments
1	Load following	Address daily temporal (5 – 30 minutes) variations in load (currently mainly done with central power).
2	Area regulation	Address daily temporal (up to several minutes) variations in load (currently mainly done with central power).
3	Regulation, reserve and emergency power	Those three different capacity products can only or must be offered to TenneT (TSO). TenneT uses those products to maintain or restore the balance between supply and demand for electricity.
4	Voltage support	The purpose is to compensate for reactive effects in the

		electricity system in order to restore or maintain system voltage (historically done by generation resources, but new alternatives are made possible).
5	Spinning reserve	All generators must have a few percent of immediate reserve capacity in order to restore or maintain a blackout of the largest generator. Therefore those generators must run below their rated value.
6	Black start	This application provides the ability to energize parts of the electricity grid without relying on assistance of external energy source after a blackout occurred.
7	Frequency control	Significant increases or decreases in load or generation will cause the voltage to drop and the frequency to slow down (e.g. motor speed up or down). Storage can supplement the electricity system in this situation.
8	Intra PTU	When the electricity system is in imbalance TenneT trades on the imbalance market by buying or selling PTU's. As a PTU has a block form, which cannot be the case in practice, the difference can be balanced with storage.

According Kivya and Ostergaard (2009) a detailed investigation indicates that the batteries included in electric drive vehicles (EDV's) are ideally suited for providing different ancillary services to the Danish electricity grid. Those batteries are limited applicable for energy applications, but can deliver high power for limited amounts of time (power applications). These characteristics make the batteries included in EDV's well suited for ancillary services, which indicates the need for double-sided business models. Although EDV's are out of scope for this thesis it is interesting to know that stationary placed batteries can be replaced by EDV batteries (lithium-ion) which brings two different customer segments together and therefore costs related to the batteries can be reduced.

Application 3: Congestion management (grid system application)

The demand for electricity increases, which results in a continuous building process of new energy production facilities. For these facilities the electricity grid needs to be aggravated and expanded. As the construction of production facilities is much faster than upgrading the electricity grid, congestion may occur (Ministry of General Affairs, 2010). For this reason the Dutch electricity system includes a system called "congestion management", which is explained in Section 3.1.2. Although this system generally applies for congestion on a transmission level, the increasingly demand for distributed generation, the obligation for grid operators to connect renewable energy when asked for and the new bill in which sustainable energy will gain a higher priority in case of congestion (Section 3.1.2.), congestion on a distribution level is also conceivable. BSS can provide support for congestion management on a distribution level by increasing the efficiency of the grid usage.

Application 4: Distribution upgrade deferral

This application involves delaying and preferable avoiding entirely utility investments in distribution system upgrades. As the maximum peak load determines the system's load carrying capacity and therefore the design rating, peak shaving by making use of small amounts of storage is the key theme for this application. The total amount of small storage facilities can be used in order to provide enough incremental capacity to defer large amounts of utility investments in the distribution systems. Therefore the total costs related to ratepayers can be reduced, allows capital for other projects, improves the utilization of utility assets, and reduces the financial risks related to system upgrades. According Eyer and Corey (2010) the highest loads occur only a few days in a year, for just a few hours totally per year, which determines the high investments needed in distribution systems. A second advantage related to this application is the fact that reducing system loads will extend the life time of all the equipment, with emphasize on aging underground power cables and transformers (Eyer & Corey, 2010). Those two advantages seem not only to provide an economic feasible business case, but will also make the electricity grid itself sustainable.

Application 5: Electric service power quality

The fifth application adds value to the power quality delivered to the load, by protecting the load from short-duration events that influences the quality of power. This means that this application, and therefore also the supported technology, should perform power to the system for just a few seconds to about one minute (Eyer & Corey, 2010). The occurrences of poor power quality includes the following four events that may occur:

- Variation in the voltage magnitude (e.g. short-term dips or spikes, longer term sags or surges);
- Harmonics (this means that voltages or currents are present at frequencies which is not the primary frequency);
- Variations in the primary frequency (50 Hz);
- Low power factor (this means that the current and the voltage are significantly out of phase with each other).

Application 6: Balancing forecast errors (Renewable integration)

The disadvantage of most renewable energy sources (e.g. wind power) is that the output is unpredictable to some extent. In the Netherlands, 24 hours before the actually production of the energy the programme responsible parties have to hand in their energy programs, which they can change until one hour before the actual delivery. At 24 hours before the actual delivery the forecast error standard deviation is around 13% and 1 hour before the actual delivery around 5% for wind power (Ummels, 2009). As the spot market closes one hour before the actual delivery, the remaining forecast errors must be solved on the balancing market. As explained in Section 3.1.3 the balancing market is operated by TenneT only, for which the imbalance prices are much higher than the prices provided by the other markets. Therefore this BSS application can reduce the costs for a renewable energy producer, by balancing the unpredictable forecast errors.

Application 7: Micro/independent grid

Micro-grids are relatively small local grids that can function for a certain time period independently from the public electricity grid. The advantage of such a grids is that specific local goals can be achieved, e.g. reliability, cost reduction, carbon emission reduction, diversification of energy sources, power quality, etc. The philosophy behind micro-grids is that a micro grid can be seen as a "building block" of the electricity grid, which we can connect with each other by making use of intelligent networks. This transformation will change the network architecture towards a layer-based electricity grid, which can be managed on several layers. Layer-based architecture enables a "smarter" way of managing the electricity grid for which two-way communication is an important element. In those micro-grids electricity storage is seen as an essential element for the feasibility (Netbeheer Nederland, 2009).

Application 8: Demand charge management (incl. community storage)

This application focuses on BSS technologies installed at the customer or end user side, in order to reduce their overall electricity costs. This cost reduction is made available due to reducing demand charges, which means that electricity demand is reduced during specific periods (time shift), normally during expensive peak periods. Demand charged management enables customers to individually manage their own electricity needs.

For this application a clear distinction can be made in the Netherlands between two customer segments, namely large customers and small customers. Large customers are active on the wholesale market for which this application works as intended. Small customers are generally active on the retail market for which there is only a limited financial (day and night tariff) incentive to make use of this application, as explained in Section 3.1.3.

Although the utility customer directly benefits from this application, design costs, transaction cost, technology uncertainty, etc. hampers the adaption of this application in practice (Eyer & Corey, 2010). Therefore the success of this application is dealing with major challenges, especially when customers are dealing with relatively small peak loads. One possible solution noticed in scientific literature, in order to become feasible, is to partner with an aggregator. This solution is often called "community electricity storage" (ESA, 2009a).

Alternative technologies

Centralized / Bulk storage

In order to store large amount of energy for longer periods in time, we use centralized / bulk storage facilities. Those technologies are on average cheaper than decentralized storage facilities, but heavily dependent on the available space and environmental conditions. As a result those technologies are mainly connected to the transmission grid and are therefore less feasible for balancing the distribution grid. Nevertheless two different types of technologies exist for centralized/bulk storage, namely pumped hydroelectricity and compressed air.

1. Pumped hydroelectricity

Conventional pumped hydroelectricity facilities uses two different water reservoirs, as illustrated in Figure 49. The main purpose of this technology is to pump water during off peak hours or at periods when we have overcapacity (in the case of renewables) from the lower reservoir up to the upper reservoir. When required, e.g. during peaks or when we have undercapacity, the water flows in the reversed direction in order to generate electricity. As Figure 50 illustrates, the available output is mainly dependent on the volume and the height.

This technology is available at almost any scale, but nevertheless mostly used for large-scale high-power purposes, with discharge times of several hour up to several days. Typical hydro plants of this size have capacities of around 100 MW (Ibrahim, et al., 2008) and an efficiency level between 70 – 85 %. In April 2009, over 90 GW of pumped hydroelectricity capacity was operational worldwide (ESA, 2009b).

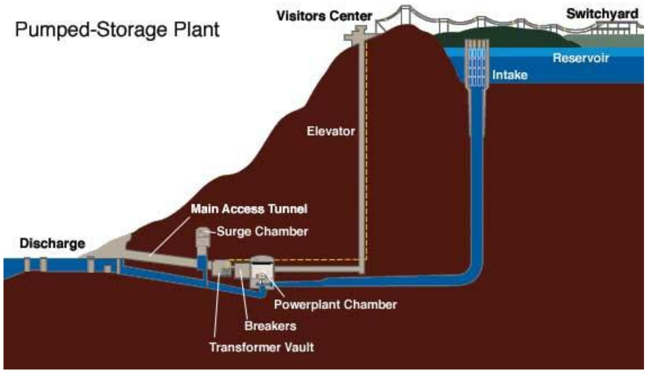

Figure 49: Illustration of a pumped hydroelectricity storage facility (The Ohio State University, 2007)

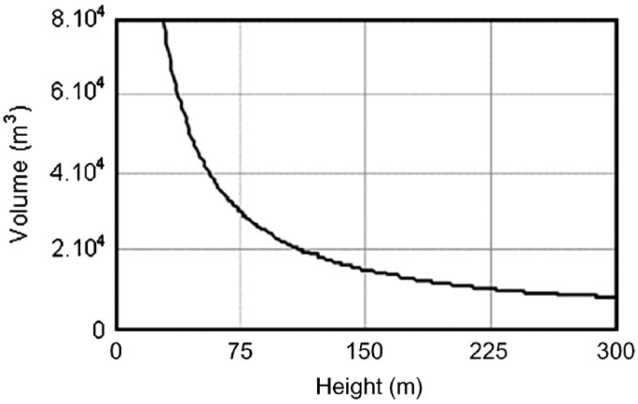

Figure 50: Water volume needed at a given height to store 6 MWh (Ibrahim, et al., 2008)

2. Compressed Air Energy Storage (CAES)

CAES uses a compressor for compressing air, which can be stored in underground mines or caverns, as illustrated in Figure 51. The compressing process is mostly done during off-peak times and in the case of overcapacity (e.g. due to renewables). When we need the stored energy, we can let the compressed air flow into the pressure turbines, which is connected to a generator, in order to convert the compressed air back into electricity. The estimated efficiency of this technology is between 50 – 80%.

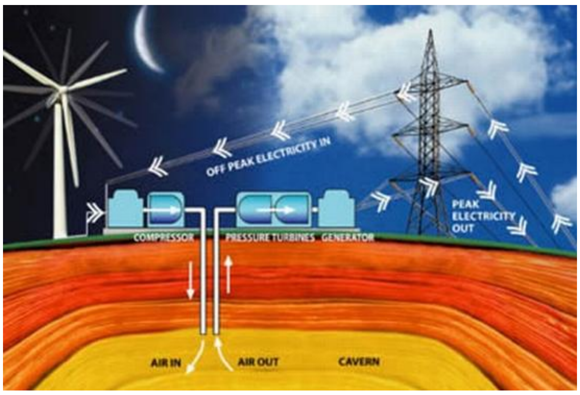

Figure 51: Compressed Air Energy Storage (Global Energy Network Institute, 2010)

Thermal Energy Storage

Thermal Energy Storage refers to a number of different technologies that store energy in thermal reservoirs, which can be used later on for generating energy. We can recognize two different types of thermal reservoirs, the first is being maintained at lower temperatures, and the second is maintained at higher temperatures. Figure 52 illustrates a thermal energy storage facility, which stores heat from a solar thermal energy plant. This system can be used for several purposes, namely converting the steam back into energy, using the heat during cold days, etc.

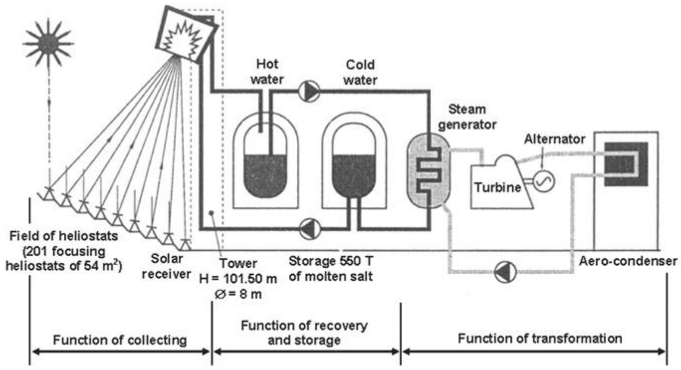

Figure 52: Thermal Energy Storage (Ibrahim, et al., 2008)

The technology behind the storage of thermal energies is the ability of water to store large amounts of cold or heat, also called the heat of fusion. Heat of fusion indicates how much heat thermal energy a substance must absorb before it changes from a liquid to a solid state, or vice versa. In the case of water we can store a relatively large amount of energy in a small amount of water.

Fuel cells – Hydrogen energy storage

The fuel cell storage system consists of three main elements. The first element is the electrolyzer, which consumes electricity (off-peak or in the case of renewables at overcapacity) in order to produce hydrogen through water electrolysis. The second element is the hydrogen buffer tank in order to store the produced hydrogen. The third element is the fuel cell that uses the stored hydrogen and the oxygen from the air to generate electricity in the case of undercapacity or during peak-hours. Figure 53 gives an overview about how a fuel cell works. The fuel cell consists of two electrodes, namely the "anode" and "cathode", which are separated by an electrolyte. On the left side the hydrogen is fed into the "anode" and on the right side the oxygen (or air) enters the "cathode". Stimulated by the catalyst, the hydrogen atom splits itself into an electron and a proton, which take both a different path to the "cathode". The electron flow will be utilized as an electric current before it flows to the "cathode". The proton will flow through the electrolyte were it comes again together with the electron. At the "cathode" the electron and the proton will reunite, which result in hydrogen again. As a result the hydrogen and the oxygen comes together and unite in a molecule of water. Therefore water and heat is the only "waste" product of this technology. Nevertheless, the combination of a fuel cell and an electrolizer for energy storage is a low-efficiency solution, as it will have an efficiency of around 35% maximum (the combination). Furthermore the investment costs are still extremely high and the expected life expectancy is very limited, in particular for high power applications (Ibrahim, et al., 2008).

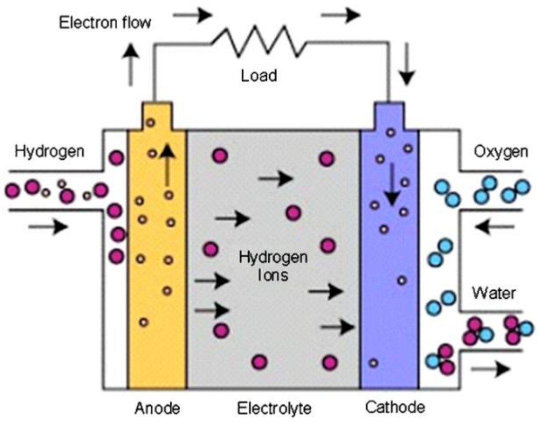

Figure 53: Fuel Cell (Ibrahim, et al., 2008)

Flywheels

Flywheel energy accumulators consist of a massive flywheel connected to a generator and special (mostly magnetic) brackets, placed inside a housing at low vacuum or at very low pressure to reduce self-discharge losses. The generator/motor is connected to the utility grid, in order to store or produce electricity. The main advantages of flywheels are that this technology requires little maintenance, long lifetime and produces no waste. Nevertheless the main disadvantages are the high weight and self discharge (around 30 – 40% per hour). On average flywheels have an efficiency of around 90% (ESA, 2009b; Ibrahim, et al., 2008). Figure 54 provides an illustration of a flywheel.

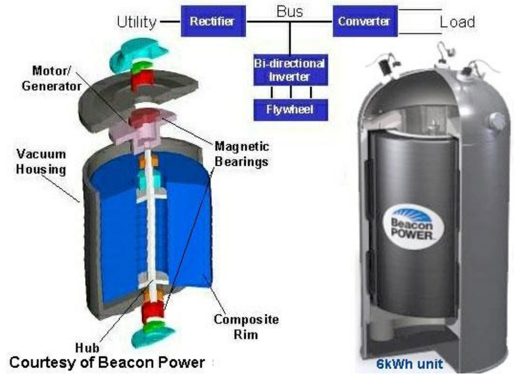

Figure 54: Flywheels (ESA, 2009b)

Super capacitor

The super capacitor is a combination of a normal capacitor and an electrochemical battery, although in this device no chemical reaction will take place. As no chemical reaction takes place, the cycling capacity is increased enormously compared to that of batteries. Energy storage in this device takes place through an electric field between two electrodes, as illustrated in Figure 55. As a result this device works the same as a normal capacitor, except that an electrolyte ionic conductor replaces the insulating material. This replacement has resulted in a superior energy/volume ratio and better discharge time constancy, compared with normal capacitors (5 – 15 Wh/kg). Nevertheless the costs have also increased.

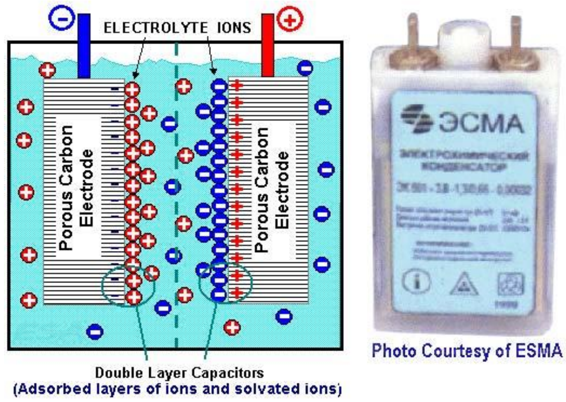

Figure 55: Super capacitor (ESA, 2009b)

Superconducting magnetic energy storage (SMES)

SMES systems store energy in a magnetic field by inducing direct current (DC) into a coil made of superconducting cables. Those cables have a resistance of almost zero and are made of niobiumtitane (NbTi) filaments, which must operates under its superconducting critical temperature. As a result the total SMES system consist of three main elements. The first element is the superconducting coil itself in which the energy is stored. The second element is the power conditioning system, which uses an inverter/rectifier in order to transform the direct current (DC) into alternating current (AC) and vice versa. The third element is the cooling device, which ensure that the system operates under the critical temperature.

SMES systems have a great instantaneous round-trip efficiency of almost 95%, which means that the energy for the cooling device is not calculated into this figure. As this system is completely free of mechanical parts and has a very fast response time (< 100 ms), this technology is ideal for regulating network stability. Nevertheless the refrigeration system can make the total system quite costly and therefore less attractive. Another disadvantage of this technology is that if we want to use it for massive storage projects it requires very large coils (up to 100m in diameter), which generates tremendous electromagnetic forces.

The detail characteristics of the above alternative technologies are included in appendix F.

Other non-storage alternatives

Next to the different alternative storage technologies also two other solutions can provide or disable the need for some applications mentioned in the previous section. Those two solutions are (1) demand side management and (2) grid reinforcement, which are explained into more detail below.

1. Demand side management

The main focus of the above technologies, including BSS, is creating flexibility by means of storage. In this case energy supply (generation) and demand (consumption) is not affected, but only a delay in transportation of energy is created. Another possibility to create flexibility is adapting demand to supply, which is against the thought of how the electricity market is organized nowadays. In the current market setting supply is following demand, while in the case of demand side management demand will follow supply. The reason behind this is the thought that due to an increasing amount of renewable energy sources demand will become increasingly difficult to control, as renewables are mainly dependent on weather conditions. Nevertheless, the consumer demand can be controlled to some extent by fluctuating energy prices or regulation. Considering this radical structure, an energy company, grid operator or other third party will get the possibility to switch off or on specific (housing) equipment as air-conditioners or freezers, in order to control demand. As this is development is relatively new, in the Netherlands different pilot projects and research projects are currently in process. The expectation of the different actors in the Dutch electricity market is that this solution will be the cheapest solution in order to adapt a large amount of renewable energy sources, as it is mainly based on software instead of hardware. Different examples of current pilot projects in the Netherlands are the following:

- PowerMatching City hoogkerk (www.powermatchingcity.nl);
- PowerMatcher (ww.powermatcher.net);
- Proeftuin Smartgrids (municipality Zoetermeer);
- Amsterdam Smart City (amsterdamsmartcity.com);

The main disadvantages of this solution are concerning privacy issues, because the system operator will get a clear insight in individual consumer behaviour (Meijer, 2009). Nevertheless current available research indicates that only a relatively small amount of energy can be controlled by making use of demand side management (Kester & Zondag, 2006; Energy Intelligent Europe, 2010).

2. Grid reinforcement

The conventional way of solving transport problems, caused for example by connecting decentralized generators, is grid reinforcement, e.g. "heavier" grid components and thicker or parallel cables. Current grids are designed for handling the maximum peak load that may occur, which is very often 10 times higher than the average load (Ibrahim, et al., 2008). As this peak load only occurs a few times per year, this investment is quite inefficient. By making the grid smarter we can prevent the absolute need for tremendous investments in additional grid reinforcements, which is nevertheless a cost/benefit trade-off. Although grid reinforcements need a high upfront investment, the life expectancy is more than 40 years, which result in a sustainable business case for grid operators. If we compare this life expectancy with all the technologies described above, which have a life expectancy of 5 – 10 years (Meijer, 2009), the resulting net present value of this alternative is quite good, including low risks.

Appendix F: Battery Characteristics

Battery Storage Systems

nr.	Type		Rating[1]	Power	Capacity	lifetime	self-discharge	efficiency cycle	typical discharge time	Footprint kWh/m² kW/m²	Wh/kg W/kg	Status	system costs
Unit			L/M/H	kW	kWh	Cycles	%/Month	%	hour			Phase	€/kWh
1	Chemical	Lead-Acid	M/H	up to 20.000	1 - 40.000	200 - 1.200	2 - 5	75 - 80	0,5 - 5		20 - 40 75 - 300	mature	200 - 900
2	Chemical	Lithium-ion (Li-ion)[2]	M/H	5.000	3.000	> 5.000 (5 - 10 years)	1	95	0,5 - 6	- 30 - 80	75 150 - 300	Development	~ 900
3	Chemical	Metal-air	H	1 - 10	1 - 10	100	7 - 10	40 - 50	1 - 8		(?) 150 - 500	Mature	(?)
4	Chemical	Nickel Cadnium (NiCd) & Nickel-metal hybride (NiMH)	M/H	up to 30.000	1 - 40.000	1.000 - 3.000	0,5 - 2	60 - 70	0,2 - 1		(?)	Mature	(?)
6	Chemical	Sodium-sulfur (Na-S)	H	100 - 30.000	1 - 50.000	1.000 - 4.000	0	80 - 85	8		100 - 200 150 - 250	Developed / Mature	225 - 400
7	Chemical	Zinc-bromine (Zn-Br)	M/H	10 - 250	50 - 500	1.000	0	65 - 75	0,5 - 3		70 - 90 60 - 140	Mature	1500
8	Chemical	Vanadium Redox flow battery	H	5 - 500	50 - 2.000	5.000 - 12.000	0	80 - 87	1 - 8		20 - 40 180	Development / Developed	100 - 500
9	Chemical	Regenesys flow battery	H	- 15.000	- 120.00	1.500 - 3.000	0	70 - 85	1 - 8		20 - 28 (?)	Development / Developed	600 - 3.000
Alternatives													
10	Chemical	hydrogen fuell cell		(?)	(?)	(?)	(?)	< 50	(?)		(?)	Research	(?)
11	Mechanical	Compresses Air Energy Storage (CAES)	H	0,1 - 1.000.000	0,1 - 3.000.000	> tens of years	0	50 - 80	hours		(?)	Developed	30 - 115
12	Mechanical	Pumped Hydro	H	0,1 - 2.700.000	0,1 - 100.000.000	> tens of years	0	70 - 85	hours		(?)	Mature	3,5
13	Mechanical	Flywheels	L/M	100 - 2.000	1 - 10	$10^5 - 10^7$	30-40%/hour	90	seconds - minutes		1 - 10 200 - 1.500	Mature	1.500
14	Electromagnetic	Supercapacitor	L	10 - 100	1 - 100	$10^5 - 10^7$	20 - 30	90	seconds		4 - 20 0,1 - 10	Development / Developed	10.000
15	Electromagnetic	Superconducting magnetic Energy Storage (SMES)	L	1.000 - 100.000	0,1 - 3	> tens of years	< 1	95	seconds		7 120	Developed	300 - 2.000

[1]L/M/H: L: Power Quality, is only applied for seconds or less
M: Bridging power, is used for seconds to minutes only
H: Energy management, Storage facility for decoupling of generation and consumption of electric energy

[2] Expert consultation Siemens AG (2010)

Adapted from: Senternovem, 2006
Divya, 2009
ESA, April 2009
Expert consultation Siemens AG (2010)

NOTIFICATION: data is collected from different sources

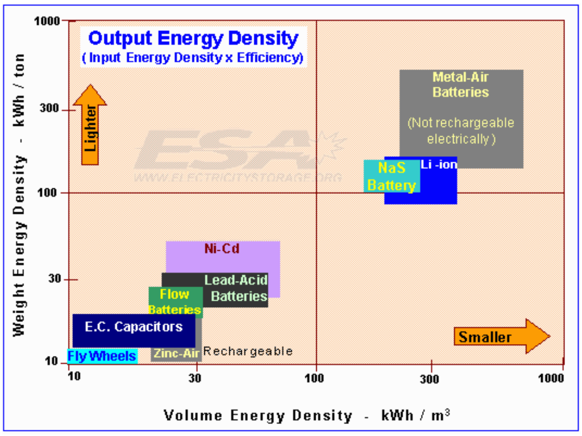

Figure 56: Size & Weight (ESA, Technologies, 2009b)

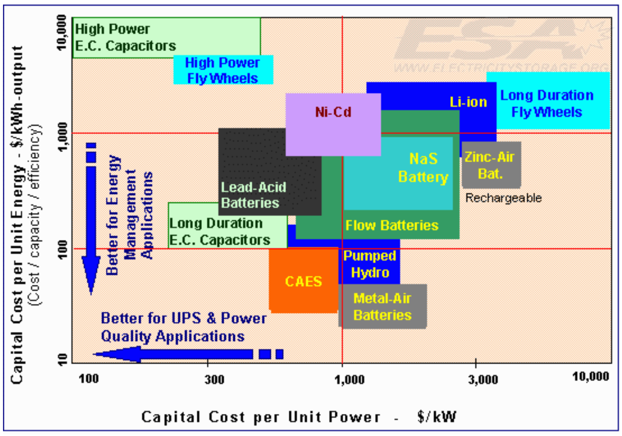

Figure 57: Capital Costs (ESA, Technologies, 2009b)

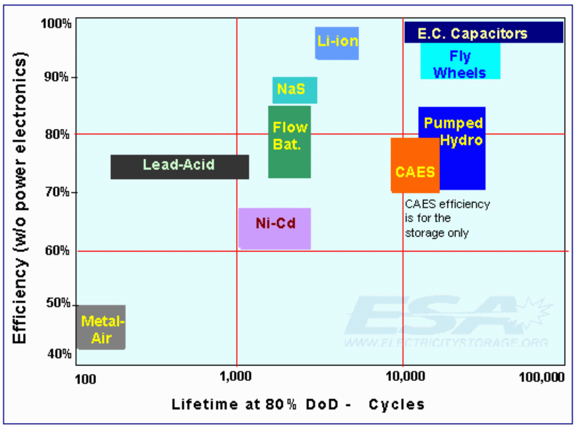

Figure 58: Life efficiency (ESA, Technologies, 2009b)

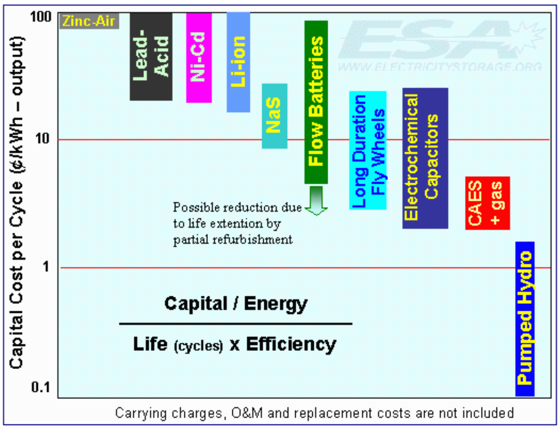

Figure 59: Per cycle cost (ESA, Technologies, 2009b)

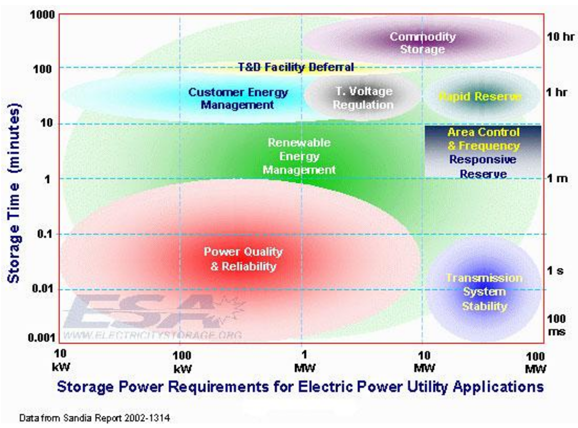

Figure 60: Storage Power Requirements for Electric Power Utility Applications (ESA, Technologies, 2009b)

Storage Technologies	Main Advantages (relative)	Disadvantages (Relative)	Power Application	Energy Application
Pumped Storage	High Capacity, Low Cost	Special Site Requirement		●
CAES	High Capacity, Low Cost	Special Site Requirement, Need Gas Fuel		●
Flow Batteries: PSB VRB ZnBr	High Capacity, Independent Power and Energy Ratings	Low Energy Density	◐	●
Metal-Air	Very High Energy Density	Electric Charging is Difficult		●
NaS	High Power & Energy Densities, High Efficiency	Production Cost, Safety Concerns (addressed in design)	●	●
Li-ion	High Power & Energy Densities, High Efficiency	High Production Cost, Requires Special Charging Circuit	●	○
Ni-Cd	High Power & Energy Densities, Efficiency		●	◐
Other Advanced Batteries	High Power & Energy Densities, High Efficiency	High Production Cost	●	○
Lead-Acid	Low Capital Cost	Limited Cycle Life when Deeply Discharged	●	○
Flywheels	High Power	Low Energy density	●	○
SMES, DSMES	High Power	Low Energy Density, High Production Cost	●	
E.C. Capacitors	Long Cycle Life, High Efficiency	Low Energy Density	●	◐

●	Fully capable and reasonable
◐	Reasonable for this application
○	Feasable but not quite practical or economical
None	Not feasable or economical

Figure 61: Technology Comparisons (ESA, Technologies, 2009b)

Appendix G: Interview protocol (in Dutch)

Version: Electricity Providers and Grid Operators (key actors)

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Interview vragen betreft het potentiële succes van Batterij Opslag Systemen in het Nederlands elektriciteitssysteem

Vanuit verschillende bronnen wordt (batterij) opslag systemen gezien als een cruciaal element van de volgende generatie infrastructuren, veelal bekend als "Smart Grids". Daarom worden er in verschillende landen, zoals Amerika en Japan, al verschillende batterij opslag systemen getest in de praktijk. Dit heeft bij Siemens Nederland, maar ook bij andere partijen, de behoefte gecreëerd om een wetenschappelijk onderzoek op te starten betreft het potentiële succes van deze technologie in het Nederlandse elektriciteitssysteem.

In samenwerking met Siemens Nederland N.V. is dit afstudeeronderzoek opgestart, waarbij het doel is om de potentie van Batterij Opslag Systemen in het Nederlandse elektriciteitssysteem vanuit een strategisch oogpunt te beoordelen. Dit betekent dat tijdens het oplossen van het vraagstuk rekening wordt gehouden met technische, economische en institutionele veranderingen, die voor het grootste gedeelte het succes bepalen.

Naam:
Functie:
Actor:
Bedrijf:

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Algemene informatie betreft de uitvoering van het interview

Gebruik voice recorder

Tijdens het interview zal de onderzoeker u vragen of het gesprek opgenomen mag worden d.m.v. een voice recorder. De opname stelt de onderzoeker in staat de gesprekken nogmaals af te luisteren tijdens de analyse van de gecollecteerde data, waardoor belangrijke details gewaarborgd blijven. Tevens zorgt de voice recorder er voor dat het gesprek persoonlijk blijft, omdat de onderzoeker maar minimale notities hoeft te maken en zich daarom volledig op het gesprek kan richten.

Vertrouwelijk behandelen

Zowel de opname als uw antwoorden zullen vertrouwelijk worden behandeld. Dit betekent dat de opname niet zal worden verspreidt en daarom door niemand anders zal worden beluisterd dan de onderzoeker zelf. Wel zal er een samenvatting per interview en per vraag worden toegevoegd aan de bijlage van het eindrapport (afstudeerverslag).

Aan het eind van het interview zal de onderzoeker u twee vragen stellen die het mogelijk maken om anoniem te blijven en / of u in staat stelt om een controle uit te voeren voordat de samenvatting definitief wordt toegevoegd aan de bijlage.

Ondanks dat dit onderzoek in samenwerking met Siemens Nederland N.V. is opgestart zal er geen andere informatie dan de genoemde samenvatting hierboven worden doorgespeeld aan Siemens Nederland N.V. Hierdoor zal Siemens Nederland N.V. geen commercieel voordeel kunnen behalen uit dit onderzoek (onderzoek wordt openbaar gemaakt en met u gedeeld), waardoor u vertrouwelijk kunt praten.

Contact informatie onderzoeker

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Pagina 2 van 13

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Vraag 1

Verwacht u dat “Batterij Opslag Systemen” een cruciale rol gaan spelen binnen het Nederlandse elektriciteitssysteem?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 2

Voor welke van de onderstaande applicatiegroepen acht u “Batterij Opslag Systemen” geschikt?

Applicatiegroep	Uitleg	Antwoord
Power applications	Kortstondig energie leveren, tot max. 30 minuten	Ja / Nee
Energy applications	Langdurig energie leveren, > 30 minuten	Ja / Nee

Vraag 3

Wat ziet u als de belangrijkste driver achter de ontwikkeling en de behoefte naar “Batterij Opslag Systemen”?

Toelichting

Vraag 4

Wat ziet u als de belangrijkste succes factor(en) en uitdagingen voor het succes van “Batterij Opslag Systemen”?

Toelichting

Pagina 3 van 13

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Vraag 5

Tijdens mijn onderzoek zijn een aantal belangrijke trends geïdentificeerd. In welke mate zouden Batterij Opslag Systemen een rol kunnen spelen in de onderstaande veranderingen/trends?

Verandering	**Mate van bijdrage**				
	Niets	Zeer weinig	Neutraal	Enigszins	Veel
Algemene/globale trends					
Demografische veranderingen	o	o	o	o	o
Verstedelijking	o	o	o	o	o
Klimaat veranderingen (inclusief reduceren CO_2 uitstoot)	o	o	o	o	o
Globalisering	o	o	o	o	o
Financiële crisis	o	o	o	o	o
Energie sector					
Intelligente netwerken (Smart Grids)	o	o	o	o	o
Intelligente huizen (Smart Homes)	o	o	o	o	o
Voldoen aan individuele behoeften (“Mass-individualisation”)	o	o	o	o	o
Emissiehandel	o	o	o	o	o
Decentrale productiefaciliteiten	o	o	o	o	o

Pagina 4 van 13

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Vraag 6

Beoordeel de volgende toepassingen naar mate u verwacht dat deze een onderdeel zal gaan vormen van het elektriciteitssysteem, d.m.v. Batterij Opslag Systemen.

Toepassing	**Mate van verwachting**				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Verschuiving in tijd (v.b. Peak shaving)	0	0	0	0	0
Secondaire diensten (veelal bekend met Engelse termen)					
Load Following	0	0	0	0	0
Area regulation	0	0	0	0	0
Regulation, Reserve and Emergency power	0	0	0	0	0
Voltage support	0	0	0	0	0
Spinning reserve	0	0	0	0	0
Black Start	0	0	0	0	0
Frequency control	0	0	0	0	0
Intra PTU	0	0	0	0	0
Congestiemanagement (distributie niveau)	0	0	0	0	0
Uitstellen van distributienet investeringen	0	0	0	0	0
Power quality	0	0	0	0	0
Integratie van duurzame energie bronnen, met name het balanceren van voorspellingsfouten	0	0	0	0	0
Microgrids / onafhankelijke netten	0	0	0	0	0
Opslag bij klanten, incl.: Individueel vraag matching Elektriciteit gemeenschappen	0	0	0	0	0

Pagina 5 van 13

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Vraag 7

Verwacht u dat de bovenstaande lijst compleet is of ziet u nog andere toepassingen?

Toelichting

Vraag 8

Voor welke actor in het Nederlandse elektriciteitssysteem ziet u de meeste voordelen van deze applicaties?

Actor	Mate van voordeel				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Producenten	0	0	0	0	0
TSO TenneT	0	0	0	0	0
Regionale netbeheerders	0	0	0	0	0
Consumenten	0	0	0	0	0
Programma verantwoordelijke	0	0	0	0	0
Handelaren (Wholesale market)	0	0	0	0	0
Retailers (Suppliers)	0	0	0	0	0

Vraag 9

Verwacht u dat deze technologie (incl. de mogelijke toepassingen) bijdraagt aan een van de onderstaande doelstellingen?

Doelstelling	Mate van verwachting				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Prijs reductie voor energie	0	0	0	0	0
Het behalen van een grotere afzet (groei van uw klanten groep en/of hun afname)	0	0	0	0	0
Maakt het mogelijk u verder te onderscheiden van uw concurrenten	0	0	0	0	0

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Vraag 10

Past deze technologie (incl. de mogelijke toepassingen) binnen de strategie van uw bedrijf?

Mate waarin deze technologie waarde bijdraagt aan uw bedrijfsstrategie				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 11

Verwacht u dat deze technologie effect zal hebben op uw bedrijfsactiviteiten en de manier waarop u business doet?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 12

Ziet u deze technologie als een belangrijk toekomstig onderdeel van uw bedrijfsbezittingen?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 13

Verwacht u dat er enige samenwerkingsverbanden ontstaan door de introductie van deze technologie? b.v. hardware is in het bezit van een andere actor dan de actor die gebruik maakt van de service.

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 14

Verwacht u dat deze technologie invloed zal hebben op uw klantensegment en relaties?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 15

Verwacht u dat deze technologie het mogelijk maakt om interne kosten te reduceren en/of inkomsten te vergroten? Zo ja, aan welke kosten en/of inkomsten zou dan moeten worden gedacht?

Omschrijving	Mate van verwachting				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Kosten reductie	O	O	O	O	O
Inkomsten verhoging	O	O	O	O	O

Pagina 8 van 13

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Toelichting

Vraag 16

Tijdens mijn onderzoek zijn een aantal criteria/doelstellingen van het Nederlandse elektriciteitssysteem en uw bedrijf geïdentificeerd. In welke mate verwacht u dat Batterij Opslag Systemen zou kunnen bijdragen aan de volgende criteria/doelstellingen?

Criteria/doelstelling	**Mate van bijdragen**				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Betrouwbaarheid / Beschikbaarheid	O	O	O	O	O
Veiligheid	O	O	O	O	O
Economisch verantwoord	O	O	O	O	O
Maatschappelijk verantwoord ondernemen	O	O	O	O	O
Betaalbaarheid	O	O	O	O	O
Reduceren van energietarieven	O	O	O	O	O
Kwaliteit	O	O	O	O	O
Reduceren voorspellingsfouten	O	O	O	O	O
Energie efficiëntie	O	O	O	O	O
Leveringszekerheid	O	O	O	O	O
Duurzaamheid	O	O	O	O	O
Veroudering van fysieke delen van het elektriciteitsnetwerk, verspreiden investeringen	O	O	O	O	O
Liberalisering & privatisering (delen van het elektriciteitssysteem)	O	O	O	O	O
Transparantie in het elektriciteitssysteem	O	O	O	O	O

Pagina 9 van 13

TUDelft
Technische Universiteit Delft

Vraag 17

Verwacht u weerstand vanuit (andere) actoren op de ontwikkeling en/of introductie van deze technologie (incl. de applicaties)?

Actor	Mate van weerstand				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
EU	0	0	0	0	0
NMa Energiekamer (en het ministerie van economische zaken)	0	0	0	0	0
Programmaverantwoordelijke	0	0	0	0	0
Handelaren (Wholesale market)	0	0	0	0	0
Retailers (suppliers)	0	0	0	0	0
Meterverantwoordelijke	0	0	0	0	0
Producenten	0	0	0	0	0
TSO TenneT	0	0	0	0	0
Regionale netbeheerders	0	0	0	0	0
Klanten / Consumenten	0	0	0	0	0

Toelichting

Vraag 18

Voorziet u enige problemen in de huidige wet en regelgeving betreffende de introductie van deze technologie in het Nederlandse elektriciteitssysteem?

Toelichting

Pagina 10 van 13

TU Delft
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Vraag 19

In welke categorie zou u Batterij Opslag Systemen categoriseren?

Categorie	**Keuze**
Radicale technologie	Ja / Nee
Incrementele technologie	Ja / Nee

Toelichting

Vraag 20

Hoe groot schat u de kans in dat Batterij Opslag Systemen onderdeel zal gaan uitmaken van het Nederlandse elektriciteitssysteem? En op welke termijn verwacht u dit?

Omschrijving	**Mate van verwachting**				
	0 - 20%	20 - 40 %	40 – 60 %	60 – 80 %	80 – 100 %
Kans	O	O	O	O	O
	1 - 5 jaar	5 – 10 jaar	10 – 15 jaar	15 – 20 jaar	> 20 jaar
Termijn	O	O	O	O	O

Vraag 21

Speelt technologie in uw bedrijf een belangrijke rol in strategische beslissingen?

Ja	Nee

Toelichting

Pagina 11 van 13

TU Delft
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Vraag 22

Als bewijs zou ik graag dit interview (samenvatting per vraag) willen toevoegen in de bijlage van mijn afstudeeronderzoek. Heeft u bezwaar als ik uw naam bij het interview vermeld?

Ja	Nee

Vraag 23

Wilt u, voordat ik dit interview toevoeg aan mijn bijlage, dat ik u eerst in de gelegenheid (2 weken) stel om de samenvatting te controleren?

Ja	Nee

Vraag 24

Zou u graag een uitnodiging ontvangen voor mijn afstudeerpresentatie? De verwachting is dat deze plaats zal vinden half/eind augustus.

Ja	Nee

Vraag 25

Wat zou u graag ontvangen na voltooien van mijn onderzoek?

Niets	Alleen resultaten	Resultaten en samenvatting	Gehele scriptie
O	O	O	O

Pagina 12 van 13

Heeft u nog overige tips, opmerkingen, commentaar, etc?

Bedankt voor uw deelname aan mijn interview. Ik zal afhankelijk van uw interesse wederom contact met u opnemen om de resultaten te delen.

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Version: Other actors

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Interview vragen betreft het potentiële succes van Batterij Opslag Systemen in het Nederlands elektriciteitssysteem

Vanuit verschillende bronnen wordt (batterij) opslag systemen gezien als een cruciaal element van de volgende generatie infrastructuren, veelal bekend als "Smart Grids". Daarom worden er in verschillende landen, zoals Amerika en Japan, al verschillende batterij opslag systemen getest in de praktijk. Dit heeft bij Siemens Nederland, maar ook bij andere partijen, de behoefte gecreëerd om een wetenschappelijk onderzoek op te starten betreft het potentiële succes van deze technologie in het Nederlandse elektriciteitssysteem.

In samenwerking met Siemens Nederland N.V. is dit afstudeeronderzoek opgestart, waarbij het doel is om de potentie van Batterij Opslag Systemen in het Nederlandse elektriciteitssysteem vanuit een strategisch oogpunt te beoordelen. Dit betekent dat tijdens het oplossen van het vraagstuk rekening wordt gehouden met technische, economische en institutionele veranderingen, die voor het grootste gedeelte het succes bepalen.

Naam:
Functie:
Actor:
Bedrijf:

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Algemene informatie betreft de uitvoering van het interview

Gebruik voice recorder

Tijdens het interview zal de onderzoeker u vragen of het gesprek opgenomen mag worden d.m.v. een voice recorder. De opname stelt de onderzoeker in staat de gesprekken nogmaals af te luisteren tijdens de analyse van de gecollecteerde data, waardoor belangrijke details gewaarborgd blijven. Tevens zorgt de voice recorder er voor dat het gesprek persoonlijk blijft, omdat de onderzoeker maar minimale notities hoeft te maken en zich daarom volledig op het gesprek kan richten.

Vertrouwelijk behandelen

Zowel de opname als uw antwoorden zullen vertrouwelijk worden behandeld. Dit betekent dat de opname niet zal worden verspreidt en daarom door niemand anders zal worden beluisterd dan de onderzoeker zelf. Wel zal er een samenvatting per interview en per vraag worden toegevoegd aan de bijlage van het eindrapport (afstudeerverslag).

Aan het eind van het interview zal de onderzoeker u twee vragen stellen die het mogelijk maken om anoniem te blijven en / of u in staat stelt om een controle uit te voeren voordat de samenvatting definitief wordt toegevoegd aan de bijlage.

Ondanks dat dit onderzoek in samenwerking met Siemens Nederland N.V. is opgestart zal er geen andere informatie dan de genoemde samenvatting hierboven worden doorgespeeld aan Siemens Nederland N.V. Hierdoor zal Siemens Nederland N.V. geen commercieel voordeel kunnen behalen uit dit onderzoek (onderzoek wordt openbaar gemaakt en met u gedeeld), waardoor u vertrouwelijk kunt praten.

Contact informatie onderzoeker

Naam:	ing. R.F.M. (Randolf) Weterings
Opleiding:	Technische Universiteit Delft Faculteit: Technologie, Bestuur en Management Programma: MSc. Management of Technology
Telefoon:	+31 (0)6 52 30 81 94
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Pagina 2 van 13

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Vraag 1

Verwacht u dat "Batterij Opslag Systemen" een cruciale rol gaan spelen binnen het Nederlandse elektriciteitssysteem?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 2

Voor welke van de onderstaande applicatiegroepen acht u "Batterij Opslag Systemen" geschikt?

Applicatiegroep	Uitleg	Antwoord
Power applications	Kortstondig energie leveren, tot max. 30 minuten	Ja / Nee
Energy applications	Langdurig energie leveren, > 30 minuten	Ja / Nee

Vraag 3

Wat ziet u als de belangrijkste driver achter de ontwikkeling en de behoefte naar "Batterij Opslag Systemen"?

Toelichting

Vraag 4

Wat ziet u als de belangrijkste succes factor(en) en uitdagingen voor het succes van "Batterij Opslag Systemen"?

Toelichting

Pagina 3 van 13

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Vraag 5

Tijdens mijn onderzoek zijn een aantal belangrijke trends geïdentificeerd. In welke mate zouden Batterij Opslag Systemen een rol kunnen spelen in de onderstaande veranderingen/trends?

Verandering	Mate van bijdrage				
	Niets	Zeer weinig	Neutraal	Enigszins	Veel
Algemene/globale trends					
Demografische veranderingen	0	0	0	0	0
Verstedelijking	0	0	0	0	0
Klimaat veranderingen (inclusief reduceren CO_2 uitstoot)	0	0	0	0	0
Globalisering	0	0	0	0	0
Financiële crisis	0	0	0	0	0
Energie sector					
Intelligente netwerken (Smart Grids)	0	0	0	0	0
Intelligente huizen (Smart Homes)	0	0	0	0	0
Voldoen aan individuele behoeften ("Mass-individualisation")	0	0	0	0	0
Emissiehandel	0	0	0	0	0
Decentrale productiefaciliteiten	0	0	0	0	0

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Vraag 6

Beoordeel de volgende toepassingen naar mate u verwacht dat deze een onderdeel zal gaan vormen van het elektriciteitssysteem, d.m.v. Batterij Opslag Systemen.

Toepassing	**Mate van verwachting**				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Verschuiving in tijd (v.b. Peak shaving)	0	0	0	0	0
Secondaire diensten (veelal bekend met Engelse termen)					
Load Following	0	0	0	0	0
Area regulation	0	0	0	0	0
Regulation, Reserve and Emergency power	0	0	0	0	0
Voltage support	0	0	0	0	0
Spinning reserve	0	0	0	0	0
Black Start	0	0	0	0	0
Frequency control	0	0	0	0	0
Intra PTU	0	0	0	0	0
Congestiemanagement (distributie niveau)	0	0	0	0	0
Uitstellen van distributienet investeringen	0	0	0	0	0
Power quality	0	0	0	0	0
Integratie van duurzame energie bronnen, met name het balanceren van voorspellingsfouten	0	0	0	0	0
Microgrids / onafhankelijke netten	0	0	0	0	0
Opslag bij klanten, incl.: Individueel vraag matching; Elektriciteit gemeenschappen	0	0	0	0	0

Pagina 5 van 13

TU Delft
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Vraag 7

Verwacht u dat de bovenstaande lijst compleet is of ziet u nog andere toepassingen?

Toelichting

Vraag 8

Voor welke actor in het Nederlandse elektriciteitssysteem ziet u de meeste voordelen van deze applicaties?

Actor	Mate van voordeel				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Producenten	0	0	0	0	0
TSO TenneT	0	0	0	0	0
Regionale netbeheerders	0	0	0	0	0
Consumenten	0	0	0	0	0
Programma verantwoordelijke	0	0	0	0	0
Handelaren (Wholesale market)	0	0	0	0	0
Retailers (Suppliers)	0	0	0	0	0

Vraag 9

Verwacht u dat deze technologie (incl. de mogelijke toepassingen) bijdraagt aan een van de onderstaande doelstellingen?

Doelstelling	Mate van verwachting				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Prijs reductie voor energie	0	0	0	0	0
Het behalen van een grotere afzet (groei van uw klanten groep en/of hun afname)	0	0	0	0	0
Maakt het mogelijk u verder te onderscheiden van uw concurrenten	0	0	0	0	0

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Vraag 10

Past deze technologie (incl. de mogelijke toepassingen) binnen de strategieën van de netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate waarin deze technologie waarde bijdraagt aan de strategieën				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 11

Verwacht u dat deze technologie effect zal hebben op de bedrijfsactiviteiten van de netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

Vraag 12

Ziet u deze technologie als een belangrijk toekomstig onderdeel van de bedrijfsbezittingen van netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
O	O	O	O	O

Toelichting

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Vraag 13

Verwacht u dat er enige samenwerkingsverbanden ontstaan door de introductie van deze technologie? b.v. hardware is in het bezit van een andere actor dan de actor die gebruik maakt van de service.

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
0	0	0	0	0

Toelichting

Vraag 14

Verwacht u dat deze technologie invloed zal hebben op het klantensegment en relaties van de netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate van verwachting				
Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
0	0	0	0	0

Toelichting

Vraag 15

Verwacht u dat deze technologie het mogelijk maakt om interne kosten van de netbeheerders (inclusief TenneT) en/of energieleveranciers te reduceren en/of inkomsten te vergroten? Zo ja, aan welke kosten en/of inkomsten zou dan moeten worden gedacht?

Omschrijving	**Mate van verwachting**				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Kosten reductie	0	0	0	0	0
Inkomsten verhoging	0	0	0	0	0

Pagina 8 van 13

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Toelichting

Vraag 16

Tijdens mijn onderzoek zijn een aantal criteria/doelstellingen van het Nederlandse elektriciteitssysteem geïdentificeerd. In welke mate verwacht u dat Batterij Opslag Systemen zou kunnen bijdragen aan de volgende criteria/doelstellingen?

Criteria/doelstelling	**Mate van bijdragen**				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
Betrouwbaarheid / Beschikbaarheid	0	0	0	0	0
Veiligheid	0	0	0	0	0
Economisch verantwoord	0	0	0	0	0
Maatschappelijk verantwoord ondernemen	0	0	0	0	0
Betaalbaarheid	0	0	0	0	0
Reduceren van energietarieven	0	0	0	0	0
Kwaliteit	0	0	0	0	0
Reduceren voorspellingsfouten	0	0	0	0	0
Energie efficiëntie	0	0	0	0	0
Leveringszekerheid	0	0	0	0	0
Duurzaamheid	0	0	0	0	0
Veroudering van fysieke delen van het elektriciteitsnetwerk, verspreiden investeringen	0	0	0	0	0
Liberalisering & privatisering (delen van het elektriciteitssysteem)	0	0	0	0	0
Transparantie in het elektriciteitssysteem	0	0	0	0	0

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Vraag 17

Verwacht u weerstand vanuit (andere) actoren op de ontwikkeling en/of introductie van deze technologie (incl. de applicaties)?

Actor	Mate van weerstand				
	Helemaal niet	Niet erg	Neutraal	Enigszins	Erg
EU	0	0	0	0	0
NMa Energiekamer (en het ministerie van economische zaken)	0	0	0	0	0
Programmaverantwoordelijke	0	0	0	0	0
Handelaren (Wholesale market)	0	0	0	0	0
Retailers (suppliers)	0	0	0	0	0
Meterverantwoordelijke	0	0	0	0	0
Producenten	0	0	0	0	0
TSO TenneT	0	0	0	0	0
Regionale netbeheerders	0	0	0	0	0
Klanten / Consumenten	0	0	0	0	0

Toelichting

Vraag 18

Voorziet u enige problemen in de huidige wet en regelgeving betreffende de introductie van deze technologie in het Nederlandse elektriciteitssysteem?

Toelichting

Pagina 10 van 13

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Vraag 19

In welke categorie zou u Batterij Opslag Systemen categoriseren?

Categorie	Keuze
Radicale technologie	Ja / Nee
Incrementele technologie	Ja / Nee

Toelichting

Vraag 20

Hoe groot schat u de kans in dat Batterij Opslag Systemen onderdeel zal gaan uitmaken van het Nederlandse elektriciteitssysteem? En op welke termijn verwacht u dit?

Omschrijving	Mate van verwachting				
	0 - 20%	20 - 40 %	40 – 60 %	60 – 80 %	80 – 100 %
Kans	O	O	O	O	O
	1 - 5 jaar	5 – 10 jaar	10 – 15 jaar	15 – 20 jaar	> 20 jaar
Termijn	O	O	O	O	O

Vraag 21

Speelt technologie in uw bedrijf een belangrijke rol in strategische beslissingen?

Ja	Nee

Toelichting

Pagina 11 van 13

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Vraag 22

Als bewijs zou ik graag dit interview (samenvatting per vraag) willen toevoegen in de bijlage van mijn afstudeeronderzoek. Heeft u bezwaar als ik uw naam bij het interview vermeld?

Ja	Nee

Vraag 23

Wilt u, voordat ik dit interview toevoeg aan mijn bijlage, dat ik u eerst in de gelegenheid (2 weken) stel om de samenvatting te controleren?

Ja	Nee

Vraag 24

Zou u graag een uitnodiging ontvangen voor mijn afstudeerpresentatie? De verwachting is dat deze plaats zal vinden half/eind augustus.

Ja	Nee

Vraag 25

Wat zou u graag ontvangen na voltooien van mijn onderzoek?

Niets	Alleen resultaten	Resultaten en samenvatting	Gehele scriptie
O	O	O	O

Pagina 12 van 13

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Heeft u nog overige tips, opmerkingen, commentaar, etc?

Bedankt voor uw deelname aan mijn interview. Ik zal afhankelijk van uw interesse wederom contact met u opnemen om de resultaten te delen.

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Appendix H: Collected data, interviews (in Dutch)

Nr.	Actor	Name	Function interviewee	Datum Interview
	Grid Operators			
1	TenneT	Dr. G. Van der Lee	Business Planner	21-06-10
2	Enexis	Prof. dr. ir. H. Slootweg	Innovation Manager	15-06-10
3	Stedin	Ir. I. Wijgerse	Innovation Specialist Smart Grids	24-06-10
4	Alliander	Ir. M. Bongaerts & Y. Van Vlimmeren	Innovation Manager & Graduate Student	21-06-10
5	E-Laad	Drs. ing. J. De Reuver	R&D Manager	17-06-10
	Suppliers			
6	Eneco	Dr. ir. M. Houwing	Strategy Consultant	23-06-10
7	Eneco	M. Blokpoel	Senior Innovation Officer	28-06-10
8	Essent	Ir. K. Biezen	Manager Electric Transportation	18-06-10
	Other Actors			
9	Cofely	Ir. L. Straathof	Business Developer Smart Grids	11-06-10
10	ECN	Ir. M.J.J. Scheepers	Program Manager Smart Grids	22-06-10
11	TNO	Ing. H.R. Veldkamp	Senior Business Consultant	23-06-10
12	KEMA	Ir. J. Raadschelders & Ir. P. de Boer	Principal Consultant Energy Storage & Consultant	02-07-10
13	Office of Energy Regulation	Dr. ir. H. Schotman	Senior Member of Staff	07-07-10
14	Municipality of Rotterdam	Drs. A. Van Huffelen & ir. B. Duursma	Alderman for Sustainable Development, Inner City and Public Spaces & Projectleader Sutainable Mobility	21-07-10

LET OP de antwoorden zijn geen letterlijke antwoorden, maar samenvattingen!

Dit zijn alleen samenvattingen op de antwoorden die gegeven zijn, emoties (verdere intenties achter de antwoorden) zijn hier niet of beperkt in opgenomen.

De antwoorden op de open vragen zijn per actor group door elkaar gehusseld, zodat de anonimiteit gewaarborgd blijft.

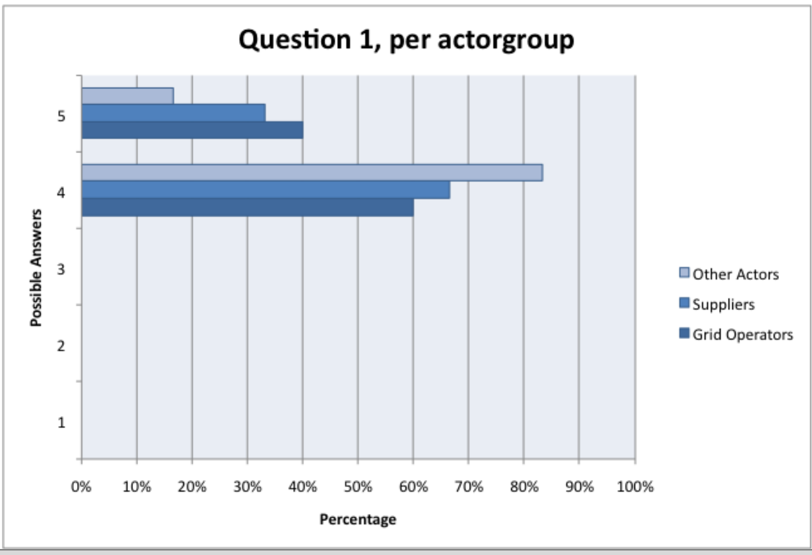
Research question 1 (Q1, 2, 19, 20)

What are their future perspectives about the environmental forces and the role of BSS?

Interview Question 1

Verwacht u dat "Batterij Opslag Systemen" een cruciale rol gaan spelen binnen het Nederlandse elektriciteitssysteem?

Mate van verwachting				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)



Toelichting "Grid Operators"
Het antwoord hangt af van het termijn. Over enkele decennia wel, maar met enkele jaren zeker nog niet. Het bovenstaande antwoord is gebaseerd op een lange termijn visie. Als we echt duurzaam willen worden zal opslag een belangrijke rol gaan spelen, maar deze ontwikkeling zal nog wel ~ 30 jaar in beslag gaan nemen. 3 belangrijke aandachtspunten: • Mobiliteit (Auto, Motor, Brommer, etc.), potentieel is gigantisch (op dit moment rijden er zo'n 6,5 miljoen auto's in Nederland!). • In woningen, om lokaal balanceren toe te passen. • Second life van de batterijen, waarbij de netbeheerder tweedehands accu's koopt, omdat deze nog wel geschikt zijn voor nettoepassingen. Waarschijnlijk geen cruciale, maar wel een belangrijke rol. Tevens is de mate waarin Batterij Opslag Systemen een rol gaan spelen afhankelijk van de acceptatie in het Nederlandse elektriciteitssysteem. Het Nederlandse elektriciteitssysteem is een zeer betrouwbaar systeem dat met hoge investeringen en terugverdientijden van rond de 40 jaar ruimte moet gaan geven aan opslagtechnieken die de huidige systeemwerking volledig zullen gaan veranderen. Een andere factor die invloed zal gaan hebben op hoe belangrijk deze technologie zal worden in de toekomst is de ontwikkeling van alternatieve technologieën. Het Nederlandse elektriciteitssysteem zal ook met opslag gewoon moeten kunnen functioneren alsof

opslag geen onderdeel uitmaakt van het systeem, want wat gebeurd er als de batterij helemaal vol zit of juist helmaal leeg is? Hierdoor zal het geen cruciale rol gaan spelen, maar wel een belangrijke rol in de ondersteuning van duurzame energiebronnen.

Mijn verwachting is dat opslag in Nederland op alle niveaus (laag-, midden- en hoogspanning) belangrijker gaat worden in de toekomst, zeker met de verdere doorvoering van duurzame energiebronnen. We ontkomen er niet meer aan.

Ik weet niet of ik het cruciaal zou kunnen noemen, maar BOS gaat zeker een rol spelen in het toekomstige elektriciteitsnetwerk. Hierbij moet in eerste instantie worden gedacht aan elektrische auto's. Zodra stationaire BOS financieel aantrekkelijk wordt zal het vanzelf onderdeel gaan uitmaken van Smart Grids, wegens de goede functionaliteiten.

Toelichting "Electricity Providers"

Hierbij zullen een aantal factoren van belang zijn:

- Vormgeving;
- Kostprijs ontwikkeling;
- Vraag naar flexibiliteit, waarbij batterij opslag systemen grote concurrentie heeft van alternatieve oplossingen (v.b. demand side management).

De vraag voor mij blijft of deze technologie echt massaal ingezet zou moeten worden en of we het doel niet beter op een andere/betere manier moeten en kunnen realiseren.

Mijn mening is vooral gebaseerd op de toekomst verwachting van elektrische auto's. Ik verwacht dat batterijen in elektrisch vervoer als eerste het elektrische systeem significant zullen beïnvloeden, waarna de rest (b.v. statische batterijen) vanzelf zal volgen.

Naast de implementatie van elektrisch vervoer verwacht ik dat Batterij Opslag Systemen (BOS) ook belangrijk zullen worden voor het verder en efficiënter ontwikkelen en implementeren van decentrale duurzame energie opwekking (met name kleinschalig wind en zonne-energie op bv. daken).

Toelichting "Other Actors"

Batterij Opslag Systemen zullen in de toekomst zeker een grote rol gaan spelen om het "cellen" denken mogelijk te maken. Locale opslag units zijn nodig om deze cellen onafhankelijk van elkaar te kunnen laten functioneren.

De Batterij Opslag Systemen zullen hierdoor zowel in stationaire vorm als in elektrische auto's voorkomen, wat onderdeel zal worden van het toekomstige elektriciteitsnetwerk.

Hier speelt voornamelijk mee hoe er naar smart grids wordt gekeken, waarbij de volgende 3 ontwikkelingen een belangrijke rol spelen: (1) we gaan onze elektriciteit op ander plekken in het elektriciteitsnetwerk opwekken, (2) we krijgen een toenemende mate van opwekking die niet meer vraag volgend is (zowel klein- als grootschalig) en (3) er ontstaat een nieuw type elektriciteitsvraag (b.v. elektrisch vervoer en warmte pompen) waarvan men verwacht dat deze gelijktijdig wordt aangezet of ingeplugd.

Voor deze ontwikkeling bestaan 3 mogelijke oplossingen om problemen te voorkomen, die technisch, maatschappelijk en economisch overwogen dienen te worden, namelijk: (1) Net flink verzwaren, (2) gestuurd gaan schakelen en (3) opslag.

Nu kunnen batterijen voor 2 toepassingen worden ingezet, namelijk:

- Energie management, wat een zeer dure optie is.
- Stabiliseren van het net (ancillary services), waar BOS juist aantrekkelijk zal zijn. Een goed voorbeeld is het vsync project. Maar ook eilandbedrijf zal interessant kunnen zijn.

Hier moet ook goed worden gekeken naar de alternatieven die bestaan!

Op Micro en Meso niveau, niet op macro niveau. Vanuit de task force intelligente netten zijn er 3 scenario's geschetst: (1) Nederland als producent van basislast, (2) Nederland als leverancier van grote hoeveelheden regelbare decentrale energie (tot 5MW) en (3) Nederland volledig decentraal. In het eerste scenario zal BOS absoluut niet interessant zijn. In het tweede scenario minimaal, maar in het derde scenario wel degelijk. Omdat de werkelijkheid ergens tussenin zal zitten "enigszins".

De verwachting is dat op de lange termijn opslag steeds belangrijker zal gaan worden (op alle niveaus in het elektriciteitsnetwerk). Hierbij houden wij rekening met de ontwikkelingen in het netwerk en een dalende prijs voor opslag systemen.

Het totale elektriciteitsverbruik neemt toe, waardoor we de netwerken zwaarder belasten. Dit in combinatie met duurzame energie, leidt tot een vraag naar oplossingen, die onder andere door opslag kunnen worden geleverd. Dit betekend niet dat we niet zonder kunnen, maar opslag maakt het vele malen efficiënter. Dit is te vergelijken met iedere andere waardeketen. Opslag zal nodig zijn in combinatie met vraagsturing en misschien ook wel met andere technologieën. Hierdoor twijfelen wij tussen enigszins en erg, vanwege het woord "cruciaal" in de vraag.

Ik zie een rol voor Batterij Opslag Systemen (BOS) ontstaan en dan met name voor spannings-kwaliteit. Of deze technologie gebruikt zal gaan worden voor het balanceren van het distributie-netten ben ik nog niet van overtuigd. Desondanks verwacht ik dat als deze technologie gebruikt zal gaan worden het zeker niet de enige technologie zal zijn en er dus alternatieven ontstaan.

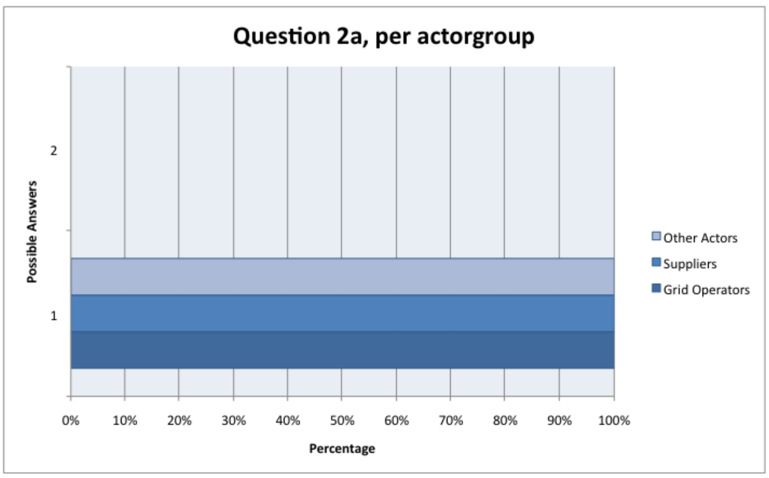
Het zal een belangrijk onderdeel gaan vormen van het elektriciteitssysteem, maar het zal niet de factor zijn die er voor gaat zorgen dat wij in de toekomst een goed functionerend elektriciteitssysteem hebben

Interview Question 2

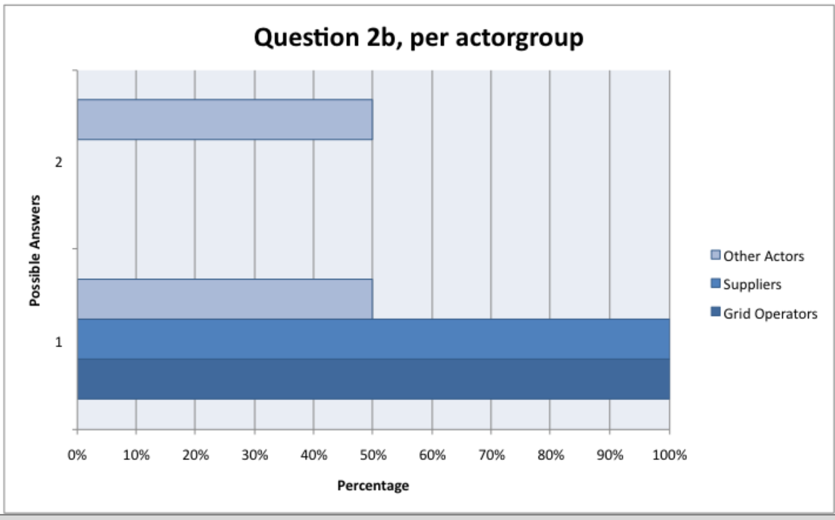
Voor welke van de onderstaande applicatiegroepen acht u "Batterij Opslag Systemen" geschikt?

Applicatiegroep	Uitleg	Antwoord
Power applications	Kortstondig energie leveren, tot max. 30 minuten	Ja (1) / Nee (2)
Energy applications	Langdurig energie leveren, > 30 minuten	Ja (1) / Nee (2)

a) Power applications



b) Energy applications



Toelichting "Grid Operators"

Het is een modulaire techniek. Als je ze parallel schakelt krijg je meer power en als je ze in serie schakelt meer energie. Dit zal dus van geval tot geval gaan verschillen.

Voor beide is BOS geschikt, maar zeker voor "energy applications" zal de technologie nog wel (veel) verder moeten worden ontwikkeld, zodanig dat het ook financieel aantrekkelijk wordt.

Toelichting "Electricity Providers"

a) Hierbij denk ik vooral aan piek beheersing bij grote afnemers. Hier zit zeker waarde.

b) In de toekomst zou dit een reële optie kunnen worden, maar dit hangt alles af van de haalbaarheid die nu nog te valt te betwisten. Ik ben dus wat voorzichtig over de haalbaarheid.

Toelichting "Other Actors"

Uiteraard is dit afhankelijk van de technologische ontwikkeling. In eerste instantie zal de nadruk liggen op "Power Applications" en zodra de technologie het mogelijk maakt zullen "Energy Applications" ook interessant worden. Technologie is hier dus echt de bottleneck.

b) De technologie is hier op korte termijn niet voor geschikt, wat voorlopig ook zo zal blijven. Gas zal hiervoor voorlopig een beter alternatief zijn, wat vele male goedkoper is en goed te regelen. Kolen centrales zijn hier minder goed voor geschikt (lange op- en afregeltijd).

Om een idee te krijgen van de investering die gedaan moet worden per gigajoule opslag kan de volgende aanname worden gehanteerd: Gas opslag : < 10 €/Gj, Waterkracht opslag 100 €/Gj, Thermische opslag 1000 €/Gj, Batterij opslag 50.000 - 100.000 €/Gj. De ontwikkeling moet dus nog wel heel veel verder zijn wil het concurrerend worden voor energie applications. Met uitzondering van niches, bv. In Duitsland krijg je een hogere vergoeding wanneer je elektriciteit zelf gebruikt uit PV modules ,dan wanneer je het terug voed in het net. Dit is dus mede afhankelijk van politieke invloed.

b) Deze technologie maakt het zelfs mogelijk om "megawatten" op te slaan om vervolgens enkele uren energie te kunnen leveren.

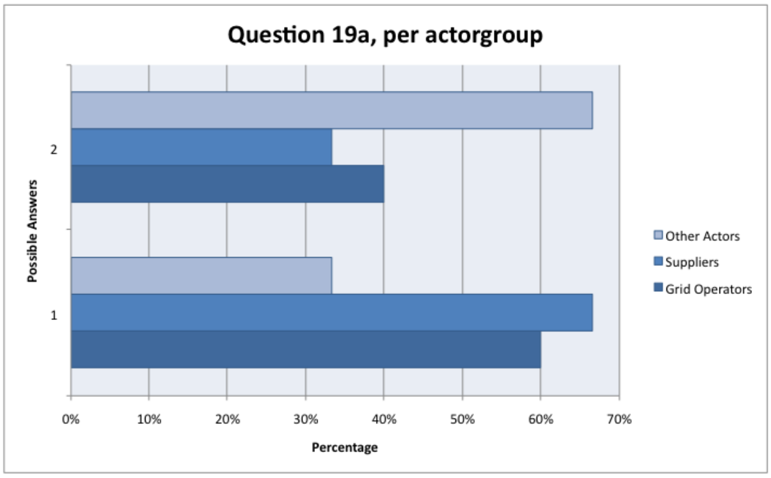
b) Ik sluit niet uit dat dit niet mogelijk is, maar ik verwacht dat de meest waardevolle applicaties zich zullen bevinden in het domein van "Power Applications".
Kan beide, maar in eerste instantie zullen de power applicaties meer potentie hebben.

Interview Question 19

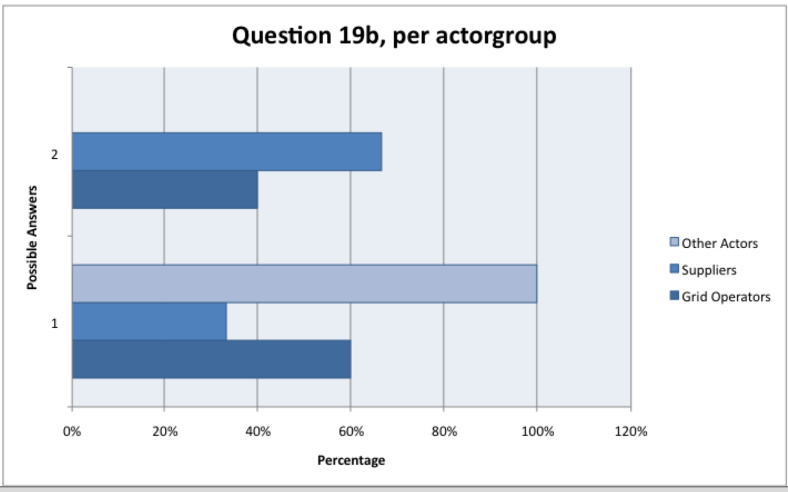
In welke categorie zou u Batterij Opslag Systemen categoriseren?

Categorie	Keuze
Radicale technologie	Ja (1) / Nee (2)
Incrementele technologie	Ja (1) / Nee (2)

a) Radicale technologie



b) Incrementele technologie



Toelichting "Grid Operators"
Zeker radicaal. De hele sector inclusief het fundamentele systeem wordt opgeschut door deze technologie, zowel technische als institutioneel. Eigenlijk tussenin, maar dan wel eerder richting incrementeel dan radicaal. Dit is een definitie vraag. Ik zie deze technologie als een incrementele technologie die samen met andere incrementele technologische veranderingen een radicale verandering gaan bewerkstelligen in het huidige elektriciteitssysteem. De combinatie zou dus wel radicaal kunnen worden opgevat. In de toekomst als het een significante rol zal gaan spelen in het Nederlandse elektriciteitsysteem zeker radicaal, omdat het gehele systeem dal zal veranderen. Nu nog incrementeel, maar ik verwacht zeker een reële kans op een doorbraak in deze technologie. En dan met name in combinatie met nanotechnologie, waar nog gigantische winsten te behalen zijn.

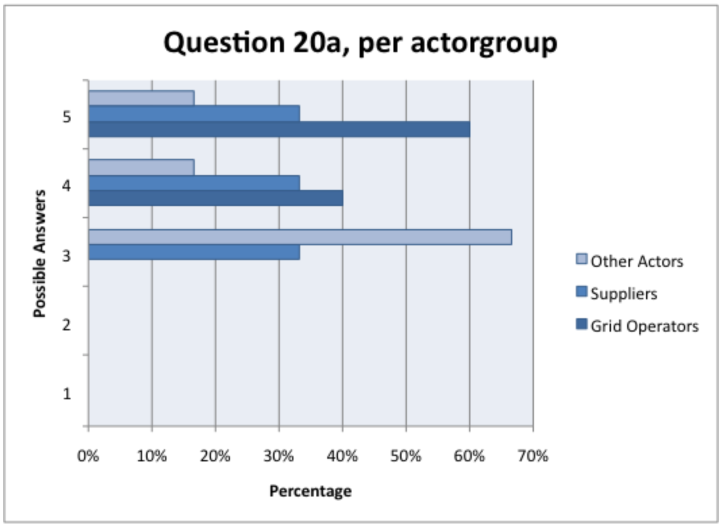
Toelichting "Electricity Providers"
Radicaal is vooral gebaseerd op het elektrische vervoer, niet zo zeer op de verandering in het elektriciteitssysteem.
Toelichting "Other Actors"
Dit is afhankelijk van het tijdpad, namelijk met de huidige technologie is het zeker niet radicaal en dus incrementeel. Maar als er een technologische doorbraak komt op dit gebied (veel grotere energiedichtheid en goedkoper) dan zal het zeker gaan verschuiven naar radicaal. Dit zullen incrementele veranderingen zijn, omdat het niet in 1 keer hoeft te worden ingezet. Deze technologie zal geleidelijk aan ingezet gaan worden. Over een lange termijn periode zou je het eventueel wel radicaal kunnen zien. In eerste instantie incrementeel. Dit kan veranderen in radicaal als er een grote doorbraak zal plaatsvinden in de technologie, maar voorlopig verwacht ik alleen nog maar incrementele verbeteringen. Technologisch gezien zeker radicaal, want het is geen technische verandering voortbouwend om een bestaande technologie. De implementatie zal incrementeel zijn. De ontwikkeling van batterij opslag systemen is al een heel lang traject Batterij opslag systemen is een stap, maar er zullen nog meerdere moeten volgen om het systeem echt te verduurzamen

Interview Question 20

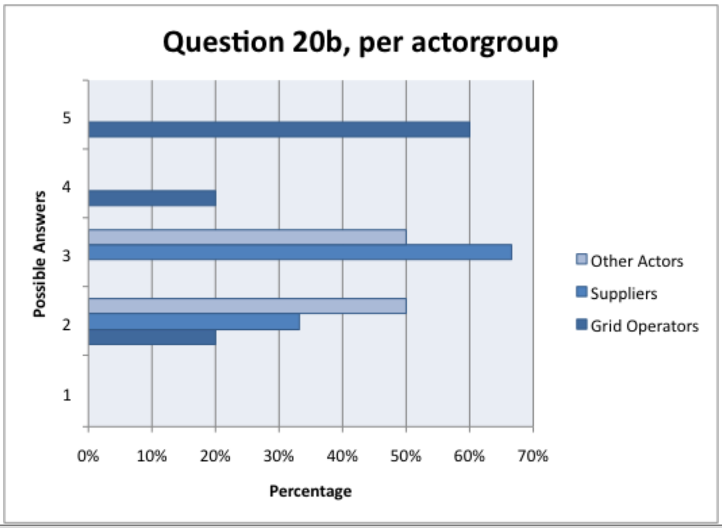
Hoe groot schat u de kans in dat Batterij Opslag Systemen onderdeel zal gaan uitmaken van het Nederlandse elektriciteitssysteem? En op welke termijn verwacht u dit?

Omschrijving	**Mate van verwachting**				
	0 - 20% (1)	20 - 40 % (2)	40 – 60 % (3)	60 – 80 % (4)	80 – 100 % (5)
Kans	0	0	0	0	0
	1 - 5 jaar (1)	5 – 10 jaar (2)	10 – 15 jaar (3)	15 – 20 jaar (4)	> 20 jaar (5)
Termijn	0	0	0	0	0

a) Kans



b) Termijn



Toelichting "Grid Operators"
Tussen de 10 en 15 jaar zal je verschil zien ontstaan, maar het veranderen van het gehele systeem, omdat we "grootschaliger" kunnen gaan opslaan, zal meer dan 20 jaar in beslag gaan nemen. Korte termijn 0-20%, lange termijn 80-100%
Toelichting "Electricity Providers"
En dan vooral in "netbeheerderland" Ook hier voornamelijk geredeneerd naar elektrisch vervoer. Ik verwacht dat de eerste signalen binnen 1 tot 5 jaar opgemerkt zullen worden, maar de echte grote introductie zal pas plaatsvinden tussen 5 – 10 jaar.
Toelichting "Other Actors"
Echte smart grids zullen niet eerder komen dan 2020, waarvoor het niet perse noodzakelijk is dat BOS onderdeel daarvan uitmaakt. b) Mijn verwachting is dat het nog zo'n 5 – 10 jaar zal duren voordat deze technologie zich zal bevinden in de "s-curve".

Research question 2 (Q3, 4, 5)

Can BSS provide a significant answer to the changing environmental forces?

Interview Question 3

Wat ziet u als de belangrijkste driver achter de ontwikkeling en de behoefte naar "Batterij Opslag Systemen"?

Toelichting "Grid Operators"
De transitie naar een duurzame energievoorziening. Willen we echt duurzaam worden zullen we zowel onze energievoorziening als onze mobiliteit moeten verduurzamen. Hierbij speelt "smart grids" een belangrijke rol in het samenbrengen, wat "smart grids" in de toekomst ook precies mag gaan inhouden. Tevens zullen inter-connecties naar andere landen ook belangrijker gaan worden, maar dit zal weinig kunnen betekenen voor onze duurzame mobiliteit oplossingen. De komst en succes van inter-connecties is hierbij dus sterk afhankelijk van de toekomst van elektrische auto's. Het aanbod van de Lithium-ion batterijen vanuit landen zoals China, waar men gigantisch investeert in het ontwikkelen van deze technologie (Technology-Push). Met deze gigantische investeringen moet er haast wel een succesvol product uitkomen. Decentrale opwekking, waarbij de netcomponenten een gelijktijdigheidfactor van 1 hebben (output wordt bepaald door omgevingsfactoren, zoals bijvoorbeeld hoeveelheid zon of wind, en valt daarom niet of nauwelijks te regelen). De vraag naar elektrische auto's zal er voor gaan zorgen dat de kostprijs van BOS zal gaan afnemen en de efficiency zal gaan toenemen. Hierdoor zal deze technologie naar verwachting in de toekomst wel een feasible business case (kunnen) gaan opleveren. Alle andere toepassingen van BOS zullen meeliften op de ontwikkeling die gerealiseerd wordt met deze elektrische auto's. Ook de ontwikkeling van batterijen in mobile applicaties, zoals laptops en telefoons, zullen de ontwikkeling van BOS ondersteunen. De volgende belangrijke driver is de vraag naar (decentrale) duurzame opwekking en duurzaam verbruik. Hiervoor zal BOS een belangrijk onderdeel gaan vormen, maar zeker niet de enige. **Driver**: Vanuit de auto industrie (invoering elektrische auto's) zal de kostprijs van de batterij drastisch afnemen. De batterij zou ook als "second life" kunnen worden hergebruikt in het elektriciteitsnetwerk. In dit geval is de batterij niet meer goed genoeg om het maximale vermogen te leveren voor de auto, maar zeker nog geschikt voor toepassingen in het elektriciteitsnetwerk. **Behoefte**: De toename van duurzame energiebronnen en dan met name zon-PV op woningen. Toenemende mate van duurzame energie opwekking, waarbij de output niet meer vraag volgend is.
Toelichting "Electricity Providers"
Twee belangrijke drivers: • Managen van uitschieters in de vraag • Toename van duurzame energie, waardoor de vraag naar flexibiliteit toeneemt. • Elektrisch vervoer Het verder verduurzamen van de samenleving, waarbij elektrische vervoer en decentraal duurzaam opwekken een belangrijke rol zullen gaan spelen. Voor beide ontwikkelingen zal (batterij) opslag onderdeel gaan uitmaken.

Toelichting "Other Actors"
De behoefte om te ontkoppelen in de tijd. De achterliggende gedachte hierbij is dat groepen (particulieren, bedrijven, actoren binnen een stad, etc) zullen gaan samenwerken om locaal hun energie duurzaam te kunnen opwekken en managen. Dit scheelt in distributie en transport kosten, maar ook in de verliezen die gepaard gaan met het distributie- en transportnet. Hierdoor zal dit scenario in de toekomst economisch de beste oplossing bieden voor gebruikers. Tevens gaat hierdoor de bedrijfszekerheid omhoog, omdat er dichtbij vanuit verschillende manieren in gevoed kan worden in het geval van een calamiteit. • Stabiel houden van het net • Zelfhelende netten (self healing grids) • Decentrale energie voorziening en de daarbij behorende meet- en regelzekerheid en noodzaak. • Elektrische mobiliteit • Renewables • Asset optimalisatie • Toenemende decentrale opwekking (ook op consument niveau) Later misschien ook (op consument niveau) het slim om willen gaan met energie, maar dan moet er nog een grote verandering in de denkwijze plaatsvinden bij de consument. • Verduurzamen van het elektriciteitssysteem op een zo goedkoop mogelijke manier (er moet een duidelijke behoefte zijn) • Ontwikkeling vanuit andere technologische producten, zoals de elektrische auto, telefoons, laptops, etc. Hierdoor ontstaan kansen, wat niet perse "drivers" hoeven te zijn.

Interview Question 4

Wat ziet u als de belangrijkste succes factor(en) en uitdagingen voor het succes van "Batterij Opslag Systemen"?

Toelichting "Grid Operators"
Levensduur, kosten, omvang, gewicht etc. van de batterij. De technologische ontwikkeling die de batterij zelf nog moet gaan doormaken is hierbij dus het cruciale element van het succes. Hier geldt wel dat naarmate de behoefte groter wordt zal hier minder op geïnnoveerd hoeven te worden. V.b. als de benzine duurder wordt, door welke reden dan ook, zal de behoefte ontstaan naar elektrische auto's. Maar ook als het koper en aluminium duurder wordt zal bij de netbeheerders de behoefte ontstaan om te investeren in batterijen, zodat investeringen in het netwerk uitgesteld kunnen worden. De batterij optie moet dus beter worden dan zijn alternatieven. Eigenlijk het zelfde als de vorige vraag, namelijk de technologische ontwikkeling en in welke mate de vraag naar decentrale opwekking blijft toenemen. Tevens is een belangrijke succes factor "de stimulering van deze ontwikkelingen door de overheid" en dan met name de continuïteit van subsidies. - Kosten reductie - Het terugverdienmodel - Verbetering van de efficiëntie De ontwikkeling van de technologie gerelateerd aan de kostprijs. De kostprijs is nu nog veel te hoog voor

een feasible business case en zal daarom drastisch omlaag moeten.

De belangrijkste succesfactor zit primair in de ontwikkeling van de prijs per kW die opgeslagen kan worden. Hierbij verwacht ik dat de komst van en behoefte naar de elektrische auto's de ontwikkeling zal gaan versnellen.

Toelichting "Electricity Providers"

- Veiligheid (met name het veilig managen van de batterij, zeker in auto's)
- De beschikbare en toekomstige alternatieve (b.v. de mogelijkheid tot sturing van wasmachines, etc.)
- Kosten verbetering (belangrijkste)
- Schaarste van de grondstoffen
- Kip en ei probleem voor elektrische vervoer. Gaan we eerst de elektrische auto ontwikkelen of eerst genoeg oplaad punten uitrollen?
- De penetratie waarmee decentrale duurzame energie opwekking deel zal gaan uitmaken van onze energie behoefte, i.c.m. de ontwikkeling die deze technologieën nog zullen gaan doormaken.
- De ontwikkeling die de batterij zal moeten gaan doormaken de komende jaren.
- De mate waarin elektrisch vervoer werkelijkheid zal gaan worden. Hierdoor zal de vraag naar batterijen flink toenemen, waardoor de prijs zal gaan dalen, zodanig dat er positieve business cases ontstaan.

Toelichting "Other Actors"

Het vermogen tot samenwerking van de betrokken partijen (gekoppeld aan een lange termijn visie). Hierbij is het belangrijk dat deze partijen verder durven te kijken dan wat nu mogelijk is en wat alternatieve oplossingen te bieden hebben. Tevens is het moeilijk voor leken om te bepalen welke risico's gepaard gaan met deze alternatieve toekomstige oplossing, zeker omdat de grote van het succes afhankelijk zal zijn van vele externe factoren (b.v. de mate waarin de olie prijs zal stijgen).

- Technische specificaties moeten verbeteren
- Kosten moeten omlaag
- De vraag die moet ontstaan naar mogelijke (toekomstige) functionaliteiten en mogelijke combinaties moeten BOS aantrekkelijk gaan maken (voor welke applicaties is BOS uniek of beter dan zijn concurrenten en wat is de waarde van die applicaties!?!)
- Kosten per cycle
- Capaciteit
- De aantal cycles die behaalt kunnen worden

Total cost of ownership (TCO). De verwachting is dat de prijs van deze technologie flink zal gaan dalen, maar bewijs dit eerst maar eens. Daarna zullen pas de echte grote stappen genomen worden. Vervolgens zullen we dan ook nog moeten gaan testen hoe deze technologie zich zal gaan gedragen in de praktijk.

Een utility is ongelofelijk conservatief, wat logisch is omdat ze investeringen doen voor ongeveer 50 jaar. Het is dus logisch dat utilities eerst bewijs willen, voordat ze nieuwe technologieën gaan toepassen (reliability, feasibility, maintainability, etc).

- Prijs in vergelijking tot het vermogen en de capaciteit
- Efficiëntie
- De baten die gehaald kunnen worden uit deze technologie

Wet en regelgeving die het mogelijk moeten gaan maken. Dit heeft deels invloed op het laten samenkomen van de vraag en het aanbod. Prijs moet omlaag en de performance (b.v. energie dichtheid) moet omhoog

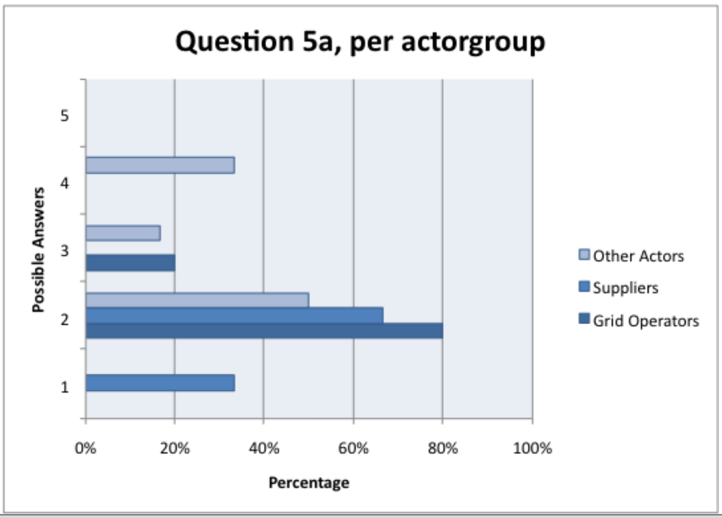
- De ontwikkeling van negatieve factoren in het elektriciteitssysteem, zoals toenemende storingsminuten, instabiliteit, etc.
- De waarde van energie (evt. in relatie tot tijd), hoe zal dit zich gaan ontwikkelen?

Interview Question 5

Tijdens mijn onderzoek zijn een aantal belangrijke trends geïdentificeerd. In welke mate zouden Batterij Opslag Systemen een rol kunnen spelen in de onderstaande veranderingen/trends?

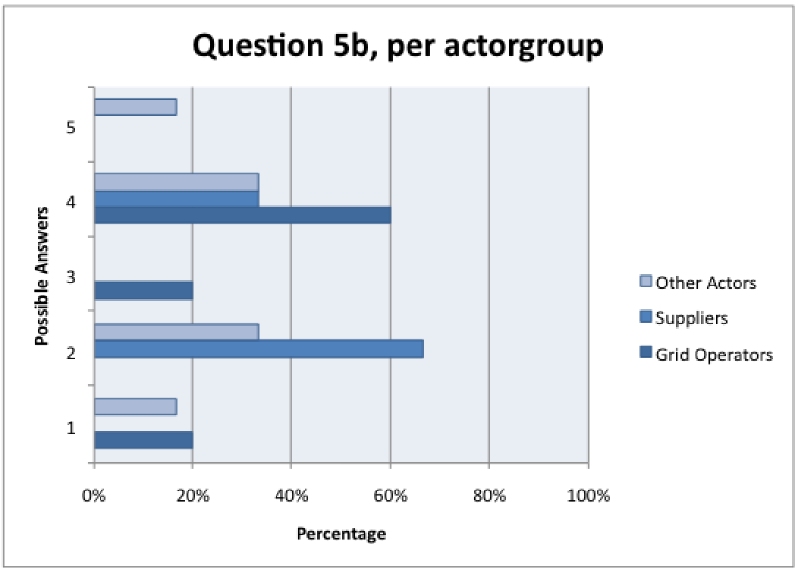
Verandering	**Mate van bijdrage**				
	Niets (1)	Zeer weinig (2)	Neutraal (3)	Enigszins (4)	Veel (5)

a) Demografische veranderingen



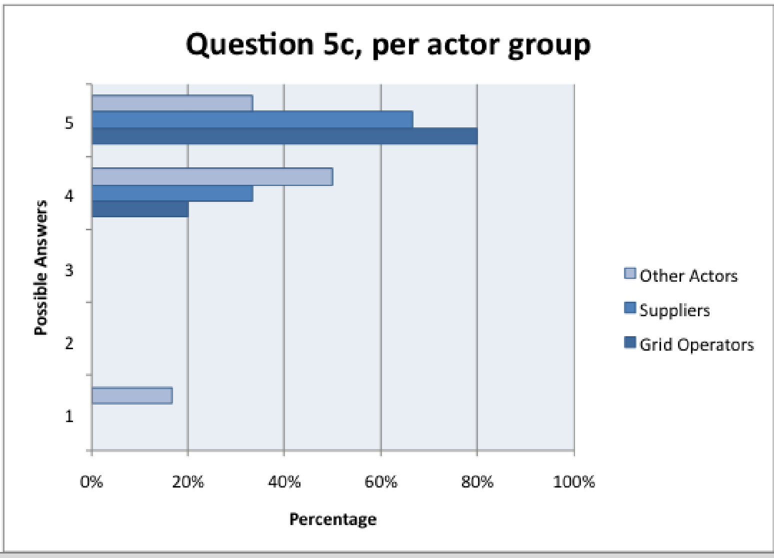
Toelichting "Other Actors"
Betrouwbaarheid zal belangrijker worden voor deze groep Kenmerken van deze trend is dat (1) de reisafstand kleiner wordt, maar wel frequenter (interessant voor E-auto's), (2) de ouderen gaan meer gebruik maken van internet wat ook meer vraagt van onze energievoorziening en (3) zorg op afstand wat deels gebeurt via internet. Dus afhankelijk van de technologisch ontwikkeling richting enigszins. Dit gaat gepaard met een veranderd type gebruikerspatroon, waaraan een bepaald type energiepatroon verbonden is (v.b. piekverschuiving). Hier zou BOS een rol kunnen gaan spelen, maar dit is wel een afgeleide van (wat trouwens voor de meeste hier geldt).

b) Verstedelijking



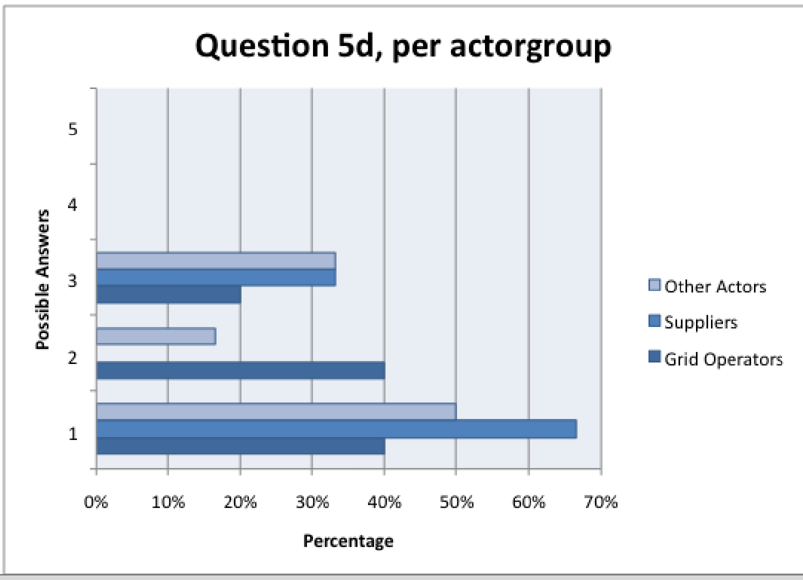
Toelichting “Grid Operators”
Dit resulteert in een grotere behoefte naar elektrische auto’s en dit maakt het vele male moeilijker om de energievoorziening te verduurzamen (hoge bevolkingsdichtheid is altijd lastig voor ons). Dit kan twee kanten op gaan. (1) Als we deze technologie (BOS in de meterkast bij mensen thuis) zouden kunnen inzetten om minder vaak de straten open te breken zou dat zeer positief zijn. Ook zou deze technologie kunnen helpen de capaciteitstarieven te reduceren, indien deze technologie slim wordt ingezet. (2) Aan de andere kant zullen deze systemen het straatbeeld minder fraai maken als we ze zouden moeten plaatsen in openbare ruimtes wat een negatief effect heeft.
Toelichting “Electricity Providers”
Voor nieuwbouw wijken, waarbij decentrale opwekking een belangrijke rol speelt zou ik het me voor kunnen stellen. Daarentegen voor relatief oudere wijken zie ik dit maar minimaal, waardoor het overal resulteert in “zeer weinig”.
Toelichting “Other Actors”
Beperken distributienet uitbreiding

c) Klimaat veranderingen (inclusief reduceren CO2 uitstoot)



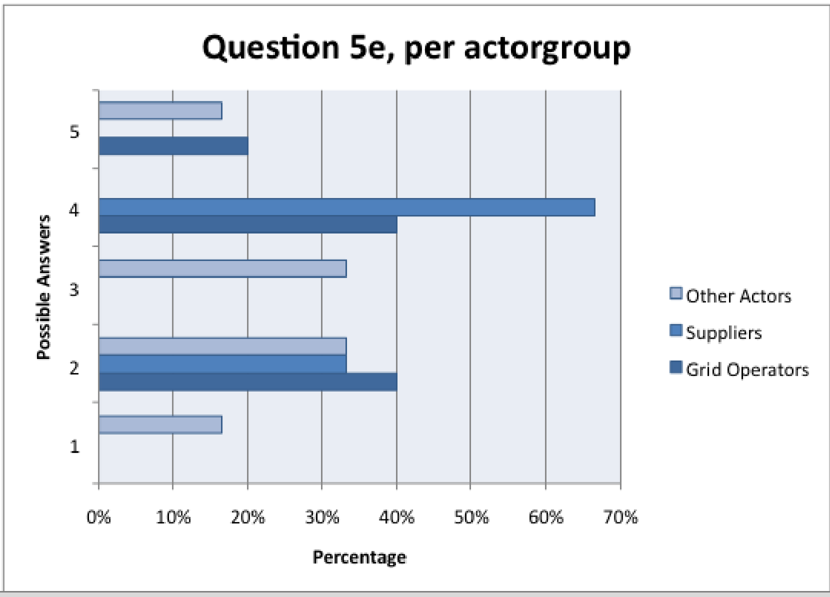
Toelichting “Grid Operators”
Dit is afhankelijk van de politieke keuzes die we maken, dus veel impact. Dit zou vooral in combinatie gaan met duurzame energie opwekking die efficiënter en dus “groener” ingezet zou kunnen worden.
Toelichting “Other Actors”
Ik geloof niet in de relatie klimaat veranderingen met CO_2 zoals deze nu wordt gemaakt Afgeleide van de toenemende vraag naar renewables.

d) Globalisering



Toelichting "Other Actors"
juist de bulk opslag zal hier kunnen bijdrage Er zijn verschillende methodes om balans te creëren in de Europese markt, al verwacht ik dat BOS hier maar een zeer beperkte rol in kan vervullen. BOS zal waarschijnlijk meer van toepassing zijn op distributienet niveau en niet of met mindere mate op transmissie en inter-connectie niveau. Dit zal eerder betekenen dat inter-connecties een belangrijkere rol zullen gaan spelen, waardoor dit een negatief effect zou kunnen hebben.

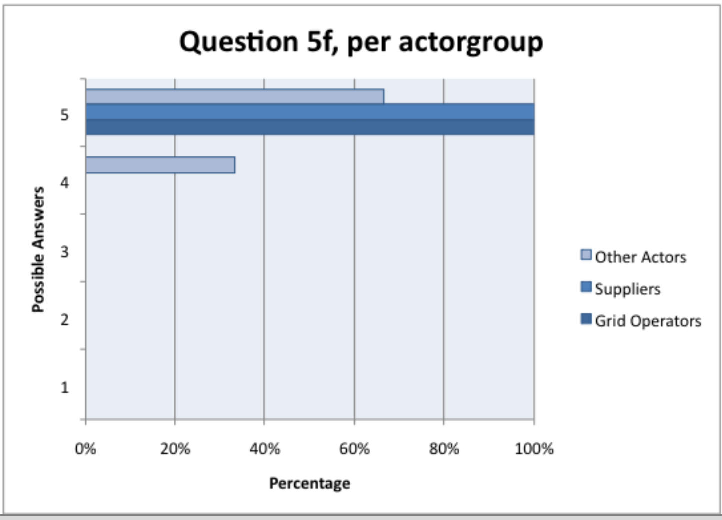
e) Financiële crisis



Toelichting "Grid Operators"
Maar wel negatief! We hebben minder geld over voor verduurzamen en de basis materialen worden goedkoper omdat de behoefte naar deze materialen is gedaald (b.v. koper en aluminium). De financiële crisis is dus voor BSS slecht, net als voor bijna alle innovaties. Maar dan wel een **negatief effect**. De crisis hindert de ontwikkeling en de introductie van deze

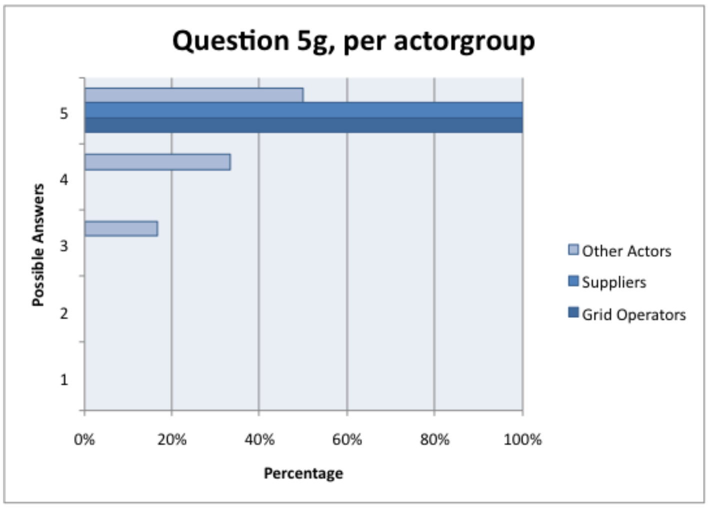
technologie, omdat we minder geld ter beschikking hebben. De financiële crisis zou goed uit kunnen pakken voor duurzaamheid op de lange termijn. De overheid krijgt er namelijk makkelijker duurzame doelstelling doorheen, b.v. General motors is geholpen op voorwaarde dat ze duurzamere auto's zouden gaan produceren. Dit zou ook kunnen gelden voor BOS. De Amerikaanse overheid heeft zelfs al een flink geld bedrag vrijgemaakt voor "Smart Grids", waar "storage" en dus BOS onderdeel van uitmaakt.
Toelichting "Electricity Providers"
Verwacht zeker geen positief effect/stimulans door de crisis op de ontwikkeling van Batterij Opslag Systemen, maar eerder een uitstel/afstel van investeringsbeslissingen (negatief effect).
Toelichting "Other Actors"
Energie prijzen hebben voor een groot gedeelte bijgedragen aan het ontstaan van deze crisis Dit kan twee kanten opgaan. Ja, want door de crisis investeren we vanuit de overheid in infrastructuren en innovaties. Nee, omdat er een crisis is hebben we geen geld.

f) Intelligente netwerken (Smart Grids)

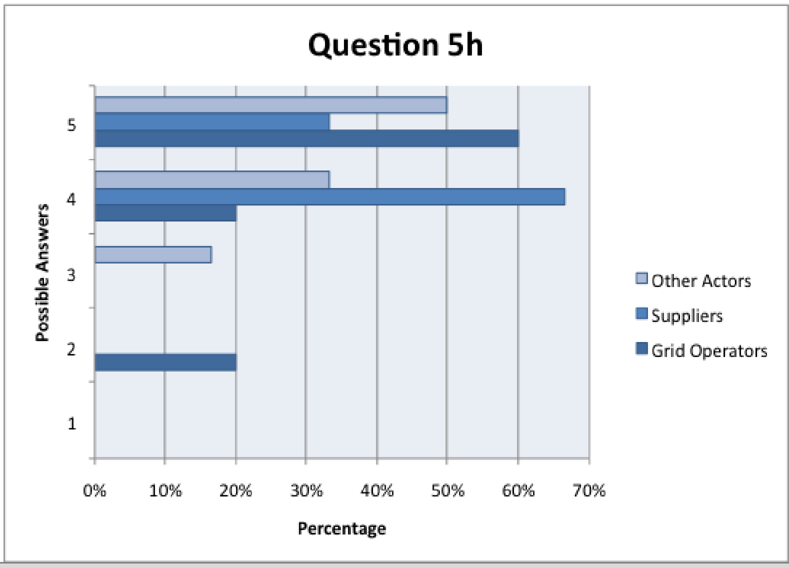


Toelichting "Grid Operators"
Ik denk dat de relatie eerder anders om is. Niemand gaat zomaar "Smart Grids" ontwikkelen. BSS zal een vrijheidsgraad creëren die je ga benutten met Smart Grids. Smart Grids is nog een lastig fenomeen, want welke waarde wordt er mee gecreëerd, wie moet de investering maken, etc? De definitie Smart Grids is hierdoor voorlopig niet gemaakt. Er bestaat dus zeker een relatie, maar wat de oorzaak en wat het gevolg is kan over worden getwist. Smart Grids zullen zodanig worden uitgerust dat indien het ICT systeem faalt het elektriciteitssysteem gewoon kan door functioneren, desnoods door lokale regelingen. Dit betekent dat het elektriciteitssysteem niet afhankelijk wordt van Smart Grids en daarom zullen de investeringen die nu gemaakt worden in het fysieke deel van het elektriciteitsnetwerk niet anders worden. De rol van Smart Grids zal dus voornamelijk zijn waarde halen uit het balanceren van elektriciteit en het niet onnodig verbranden van energie (efficiëntie). Smart grids zal dus alleen een functie krijgen in systeem diensten, niet in transport diensten.
Toelichting "Other Actors"
Dit hangt af van de kritische succesfactoren. Als deze succesfactoren overwonnen kunnen worden, dan zeker veel. Wederzijdse invloed

g) Intelligente huizen (Smart Homes)

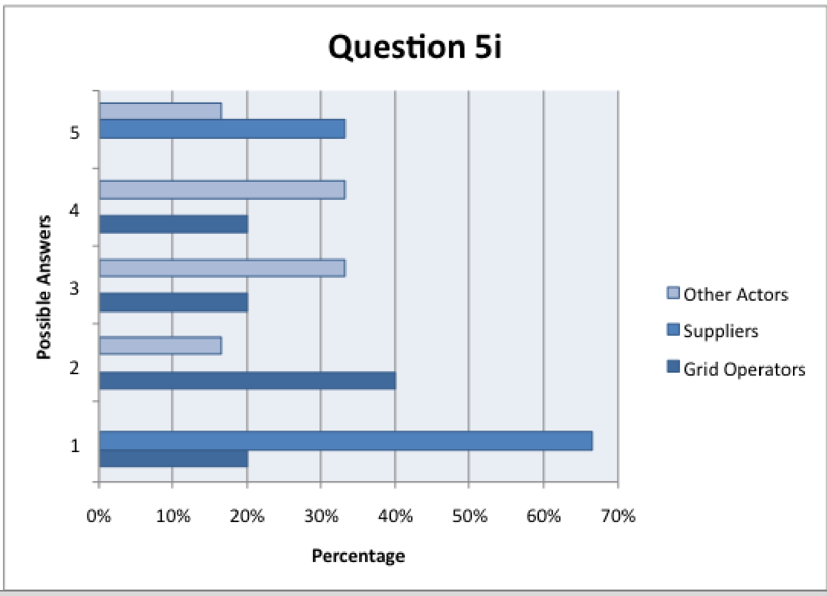


h) Voldoen aan individuele behoeften ("Mass-individualisation")



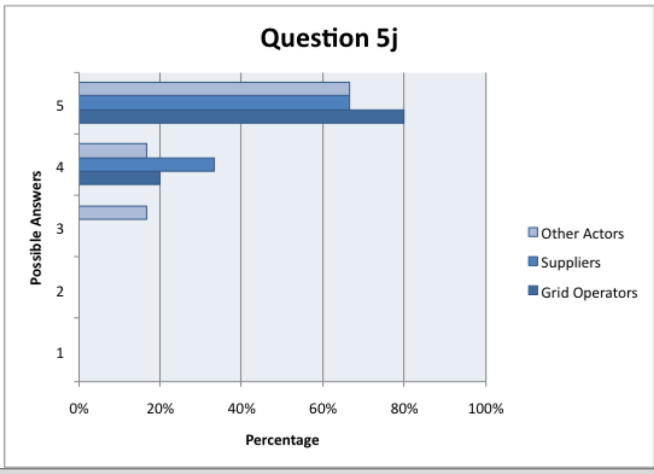
Toelichting "Grid Operators"
Hier gelooft een netbeheerder niet echt in. Wij blijven uitgaan van de "grijze" massa.
Toelichting "Electricity Providers"
Ik vraag me af of dit echt massaal de toekomst zal worden, wel zie ik op dit moment enige behoefte hiernaar ontstaan. Ik verwacht namelijk dat we het beter groter kunnen opzetten dan "individueel", wat naar mijn mening veel kosten efficiënter is.
Toelichting "Other Actors"
Dit is nu nog geen "mass" en de toekomst is nog te onzeker. Dit wel met de gedachte dat de elektrische auto een onderdeel van het intelligente huis is.

i) Emissiehandel



Toelichting "Electricity Providers"
Dit zie ik kosten technisch niet gebeuren. In het verhandelen van emissierechten/credits gaat het om bulk hoeveelheden, waarvoor ik batterij opslag systemen niet geschikt acht.

j) Decentrale productiefaciliteiten



Toelichting "Other Actors"
Zeker veel! Denemarken is hier een goed voorbeeld van. Zij denken na over hoe kunnen we onze overcapaciteit binnen Denemarken houden) Decentrale productiefaciliteiten neutraal, maar voor de flexibiliteit zou het wel veel zijn (gerelateerd aan het voldoen aan individuele behoeften).

Research question 3 (Q16)

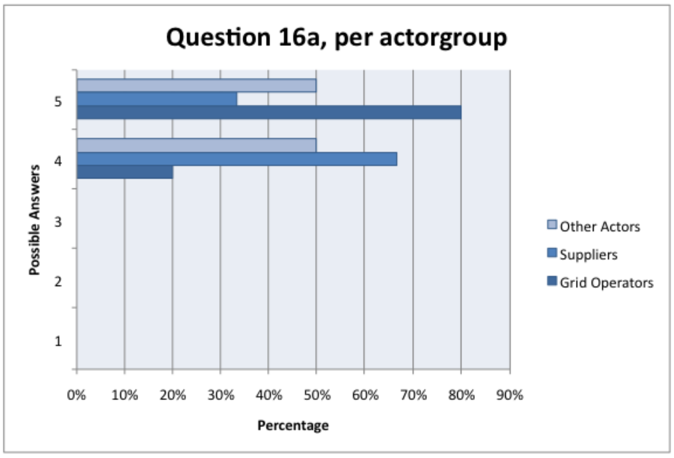
Which requirements of the future electricity grids can be supported with BSS?

Interview Question 16

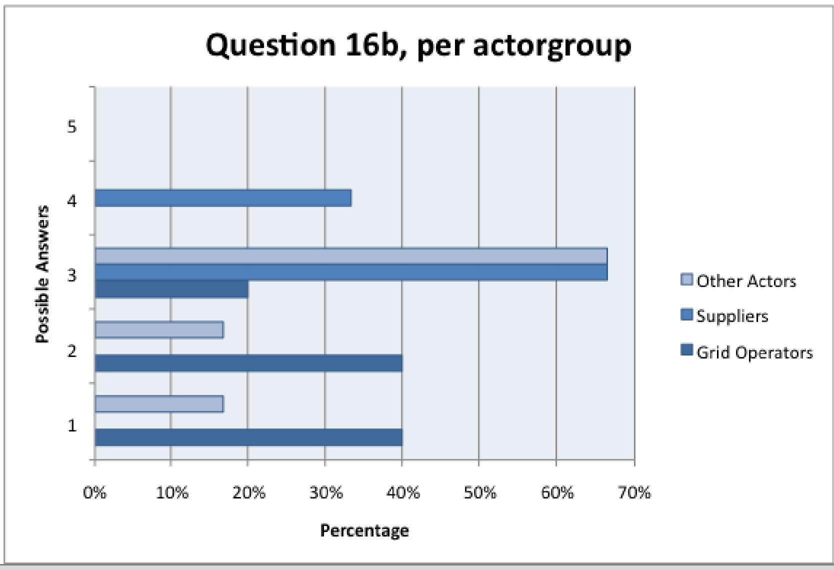
Tijdens mijn onderzoek zijn een aantal criteria/doelstellingen van het Nederlandse elektriciteitssysteem geïdentificeerd. In welke mate verwacht u dat Batterij Opslag Systemen zou kunnen bijdragen aan de volgende criteria/doelstellingen?

Criteria/doelstelling	**Mate van bijdragen**				
	Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)

a) Betrouwbaarheid / Beschikbaarheid

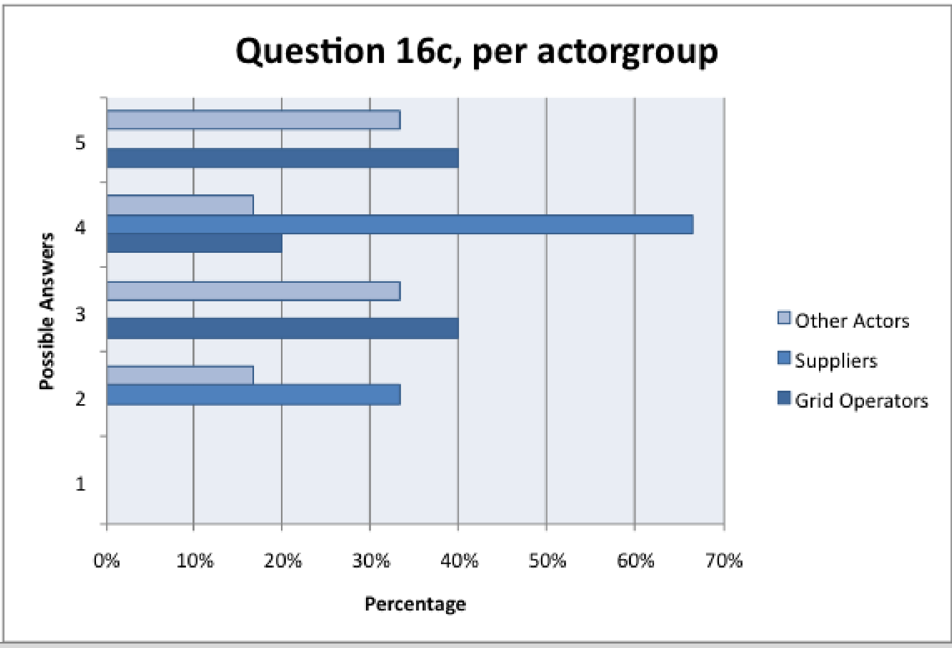


b) Veiligheid



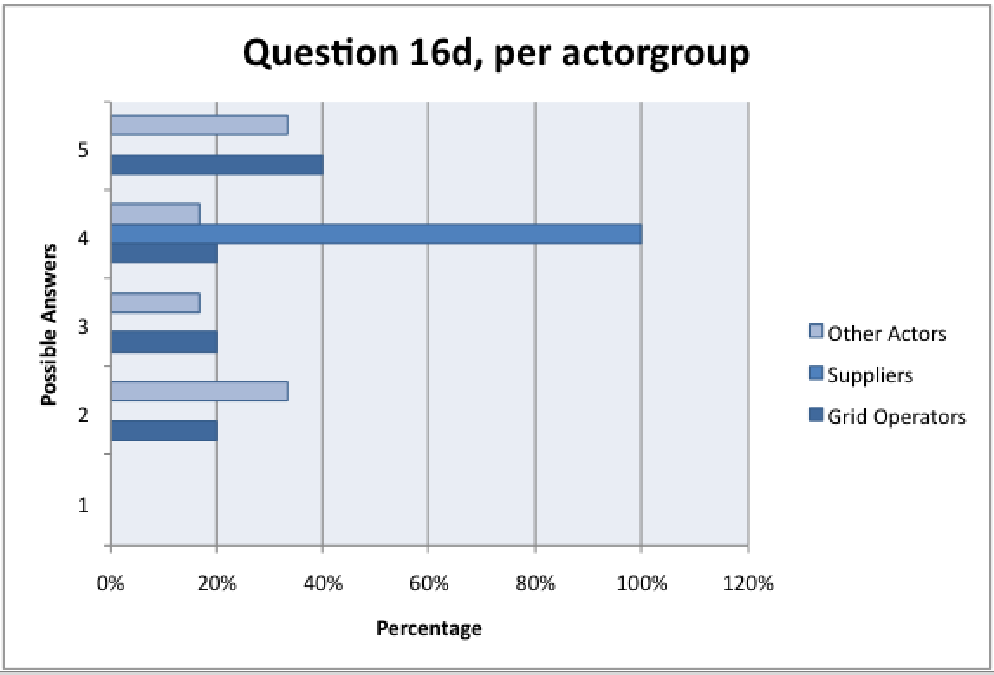
Toelichting "Other Actors"
Dit kan twee kanten op gaan. Het inbedrijf kunnen houden kan de veiligheid vergroten, maar voor monteurs is dit onveiliger. Introduceren van een extra element dat kan ontploffen, kortsluiting kan veroorzaken, etc.

c) Economisch verantwoord



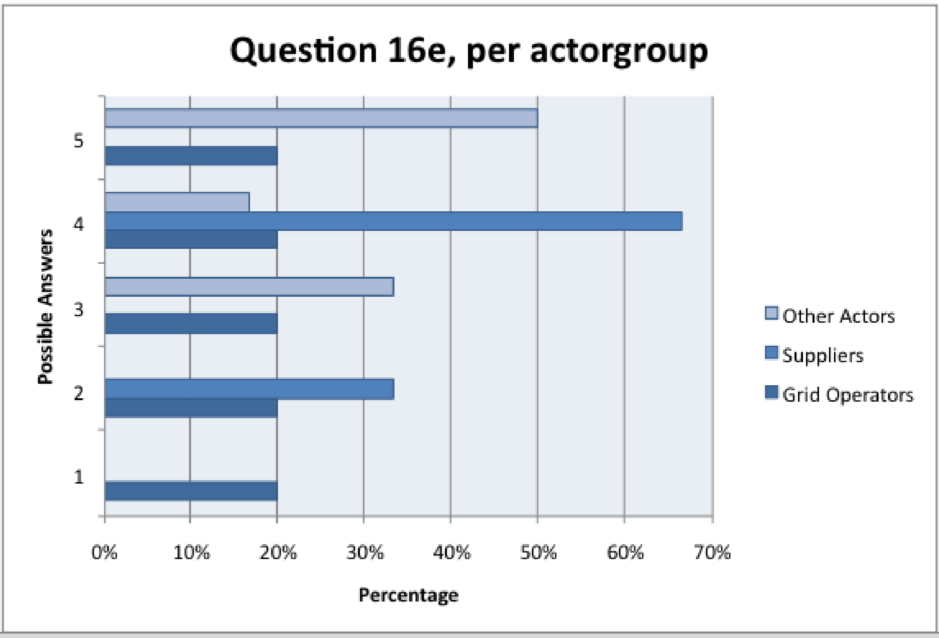
Toelichting "Other Actors"
Of dit echt kostenefficiënt is valt nog te betwisten.

d) Maatschappelijk verantwoord ondernemen



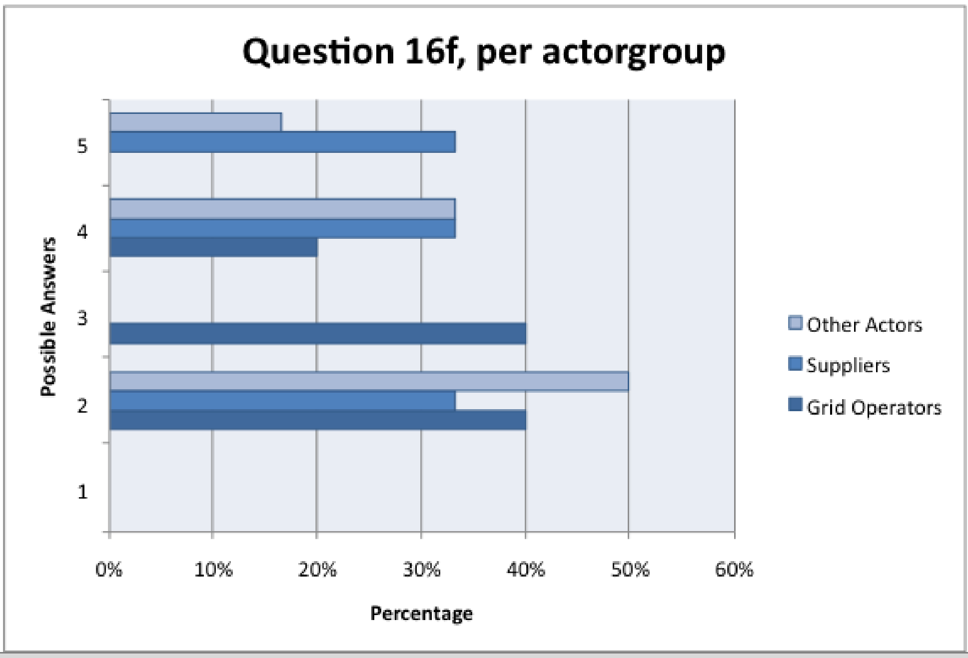
Toelichting "Other Actors"
Of dit echt kostenefficiënt is valt nog te betwisten. Indirect via de vraag naar renewables, waarbij BOS de integratie efficiënter mogelijk maakt.

e) Betaalbaarheid



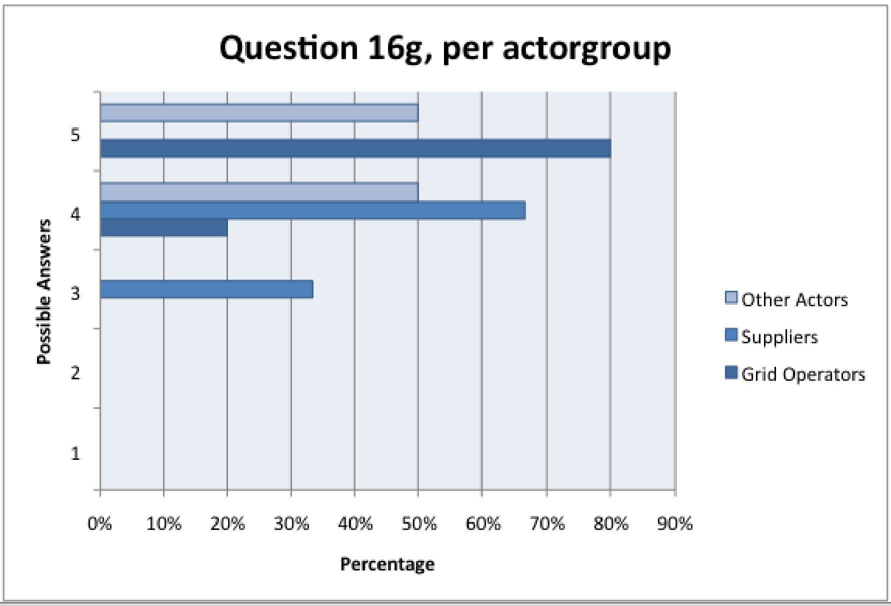
Toelichting "Grid Operators"
Dit zal geheel afhangen van de kosten ontwikkeling van de technologie, daarom neutraal.

f) Reduceren van energietarieven



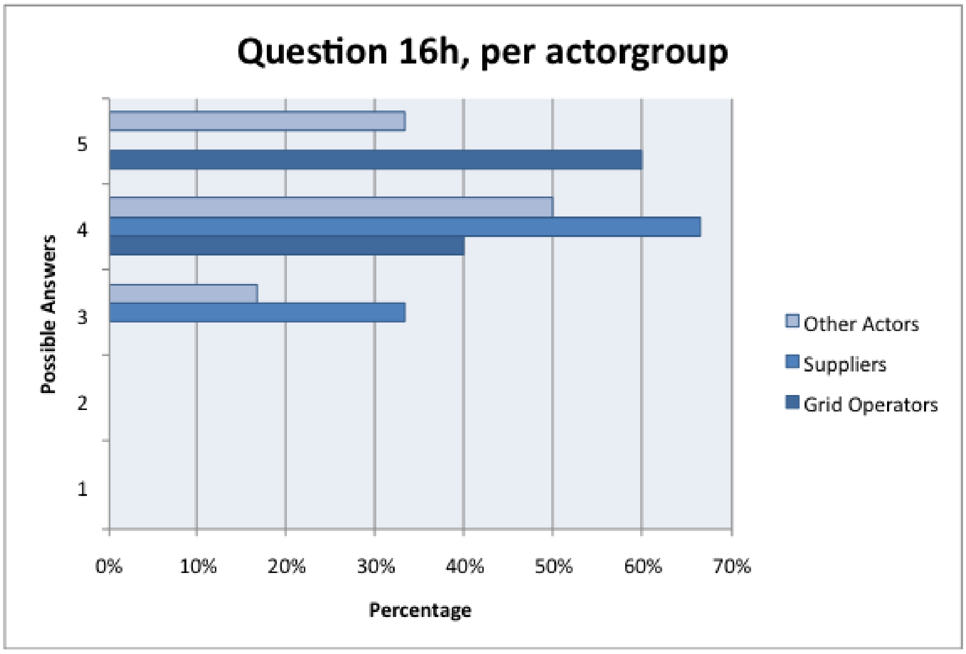
Toelichting "Grid Operators"
Dit zal geheel afhangen van de kosten ontwikkeling van de technologie, daarom neutraal.

g) Kwaliteit

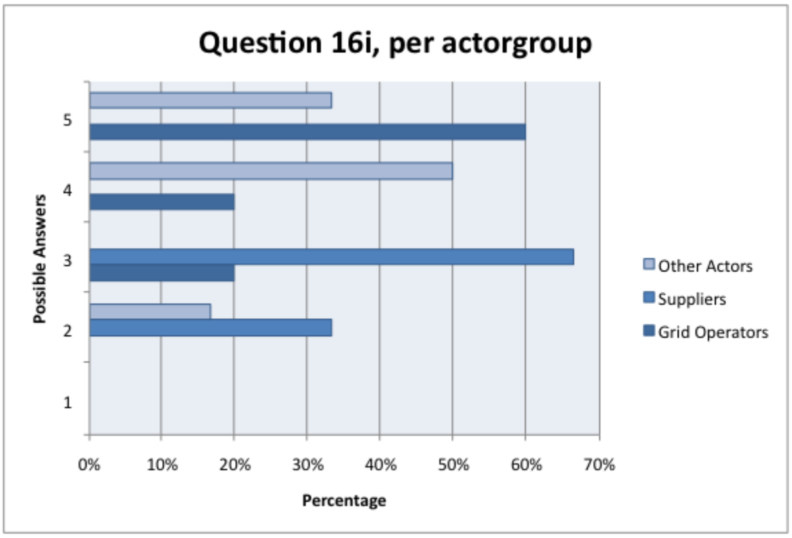


Toelichting “Grid Operators”
Dit zou gepaard kunnen gaan met differentiatie, namelijk op sommige plekken gaan we het systeem verbeteren door BOS te installeren en ter gelijkertijd ga je zo’n systeem niet plaatsen voor een kabel waar 1 klant op zit.

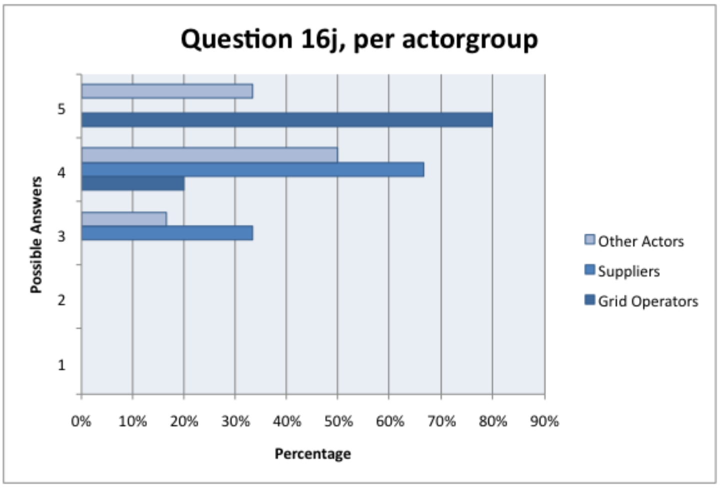
h) Balanceren voorspellingsfouten



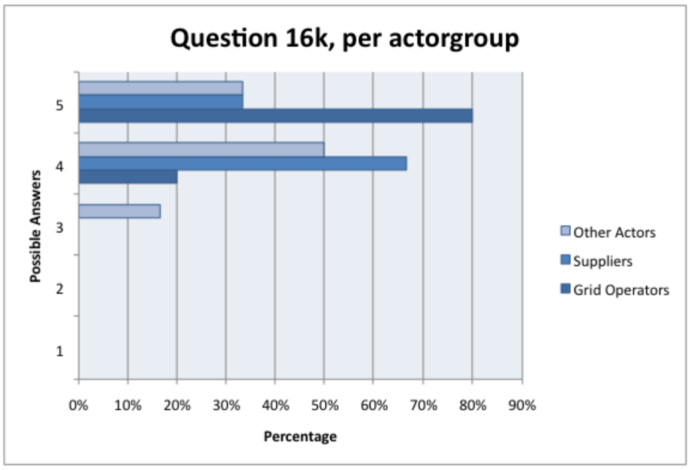
i) Energie efficiëntie



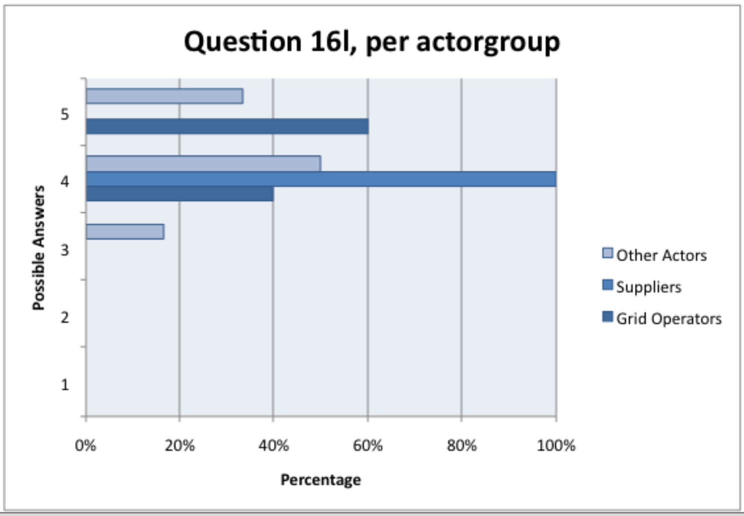
j) Leveringszekerheid



k) Duurzaamheid

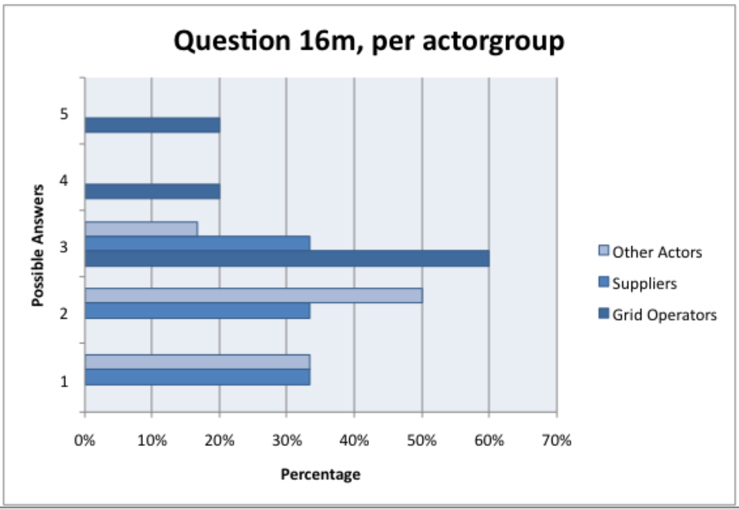


l) Veroudering van fysieke delen van het elektriciteitsnetwerk, verspreiden investeringen



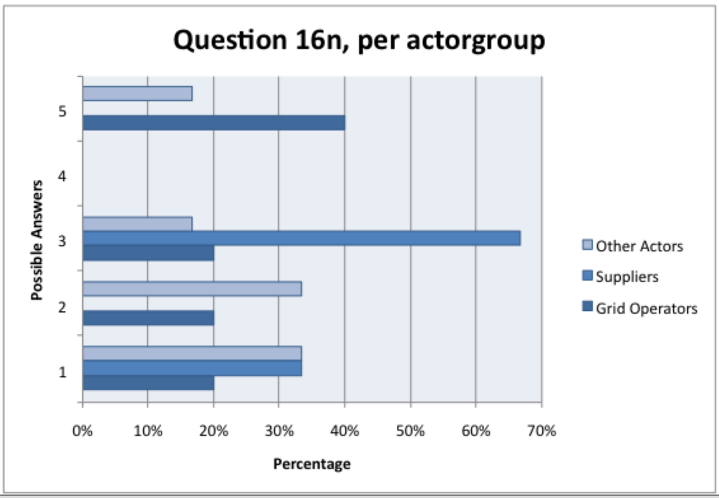
Toelichting "Other Actors"
Of dit echt kostenefficiënt is valt nog te betwisten.

m) Liberalisering & privatisering (delen van het elektriciteitssysteem)



Toelichting "Grid Operators"
Dit zou de ingewikkelde onbalansmarkten kunnen opheffen door flexibiliteit bij de netbeheerder te creëren, zodanig dat ook de elektriciteitsmarkt een normale marktwerking krijgt. Dit zal ingewikkelder worden, omdat deze technologie precies op de "splitsing" ligt.
Toelichting "Electricity Providers"
Hiervoor zouden batterij opslag systemen echt een significante invloed moeten hebben en dus ook op zeer grote schaal zijn opgenomen in het netwerk. Deze visie deel ik niet en dus zal het geen invloed hebben.
Toelichting "Other Actors"
Alleen voor private netten, maar niet voor de reguliere netten. Bijdrage niet echt. Dit komt omdat het een omgekeerd effect heeft. L&P heeft invloed op BOS.

n) Transparantie in het elektriciteitssysteem



Toelichting "Grid Operators"
De totaal niet transparante onbalansmarkt en de bijbehorende risico's (b.v. voorspellingsfouten van duurzame opwekking) vallen weg en daarom wordt de markt zeker transparanter. Dit zal afhankelijk zijn van wie de elektriciteit gaat opslaan. Het heeft zeker invloed, maar afhankelijk van de toekomstige mogelijkheden en het geïnstalleerd opslag vermogen kan het twee kanten opgaan. Of je creëert meer congestiemanagement en daarom minder transparantie of marketen kunnen verdwijnen (zoals de onbalansmarkt) waardoor het transparanter wordt.
Toelichting "Electricity Providers"
Hiervoor zouden batterij opslag systemen echt een significante invloed moeten hebben en dus ook op zeer grote schaal zijn opgenomen in het netwerk. Deze visie deel ik niet en dus zal het geen invloed hebben.
Toelichting "Other Actors"
Dit wordt eerder complexer. Dit zal eerder complexer worden.

Research question 4 (Q6, 7)

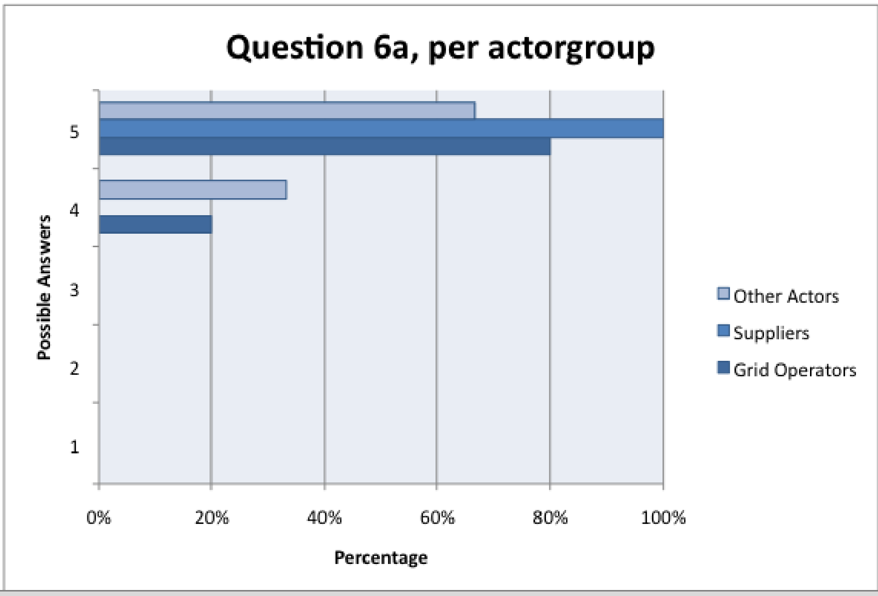
Which applications can be interesting for BSS?

Interview Question 6

Beoordeel de volgende toepassingen naar mate u verwacht dat deze een onderdeel zal gaan vormen van het elektriciteitssysteem, d.m.v. Batterij Opslag Systemen.

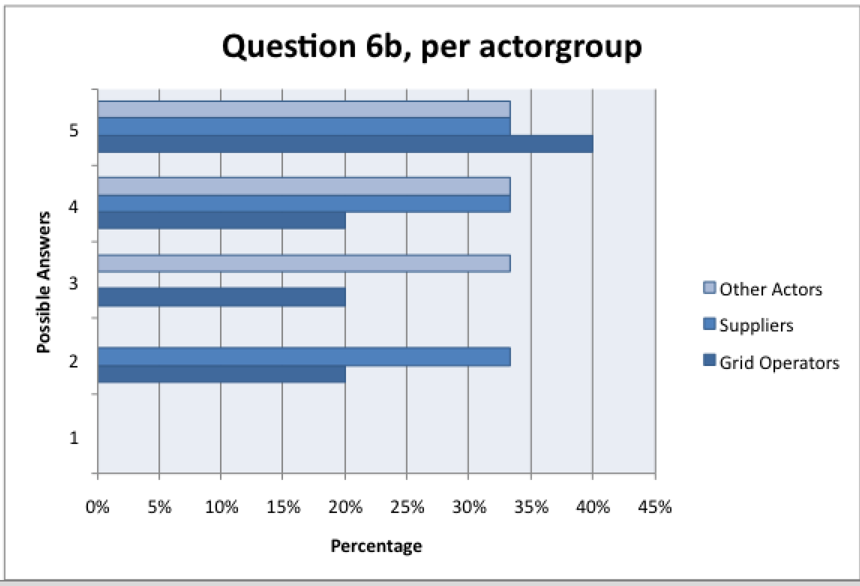
Toepassing	Mate van verwachting				
	Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)

a) Verschuiving in tijd (v.b. Peak shaving)



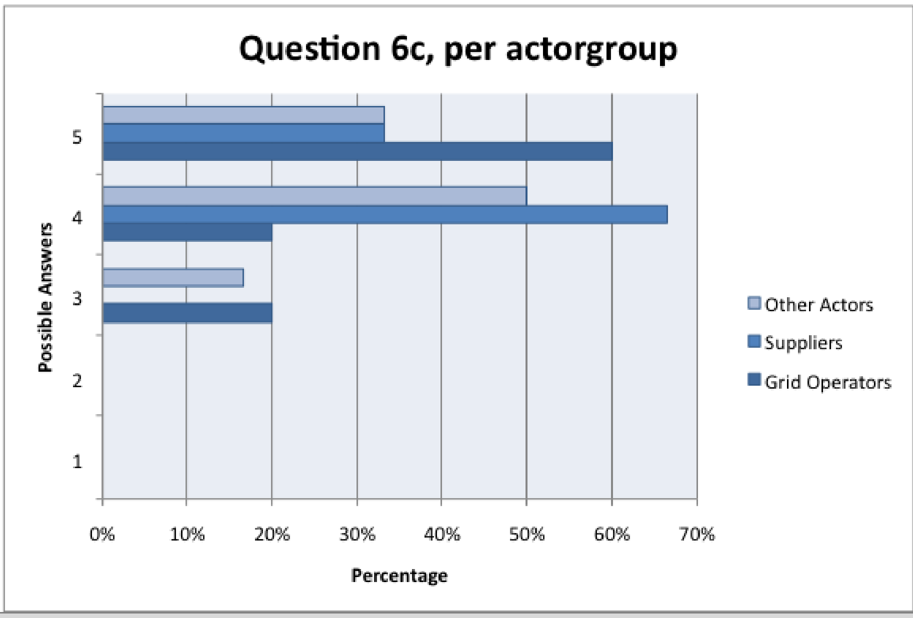
Toelichting "Grid Operators"
Deze kan je in principe verdelen in 2 categorieën, namelijk: (1) Verschuiven naar prijs (Goedkoop elektriciteit opslaan en tijdens dure periodes gebruiken) of (2) naar volumes (pieken verschuiven in de tijd wegens capaciteitbeperkingen).
Toelichting "Electricity Providers"
Voor "peak shaving" zou ik "erg" zeggen, maar voor andere doeleinden om te verschuiven in de tijd "niet erg".

b) Load Following



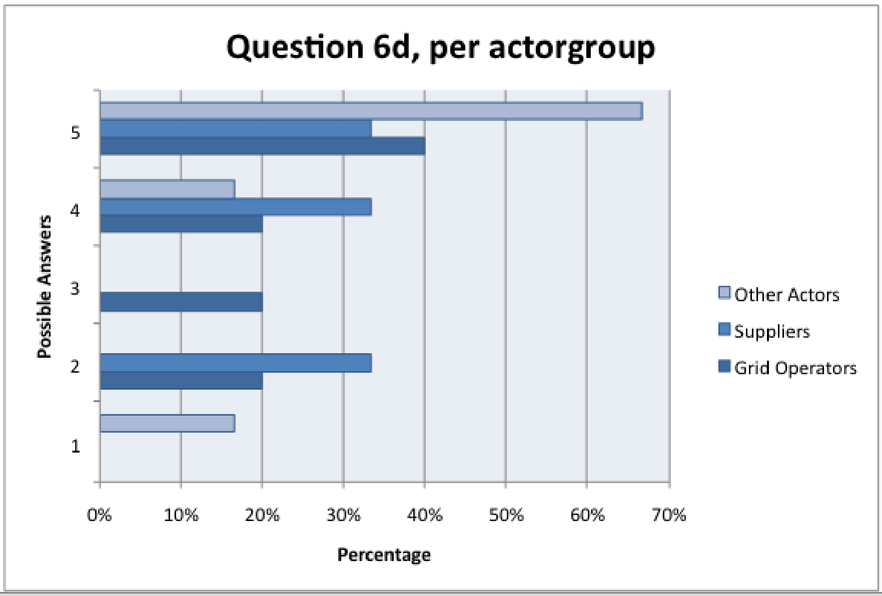
Toelichting "Other Actors"
De vraag is hierbij vooral of andere technologieën hier geen beter antwoord op hebben. Dit kan dus twee kanten op gaan.

c) Area regulation



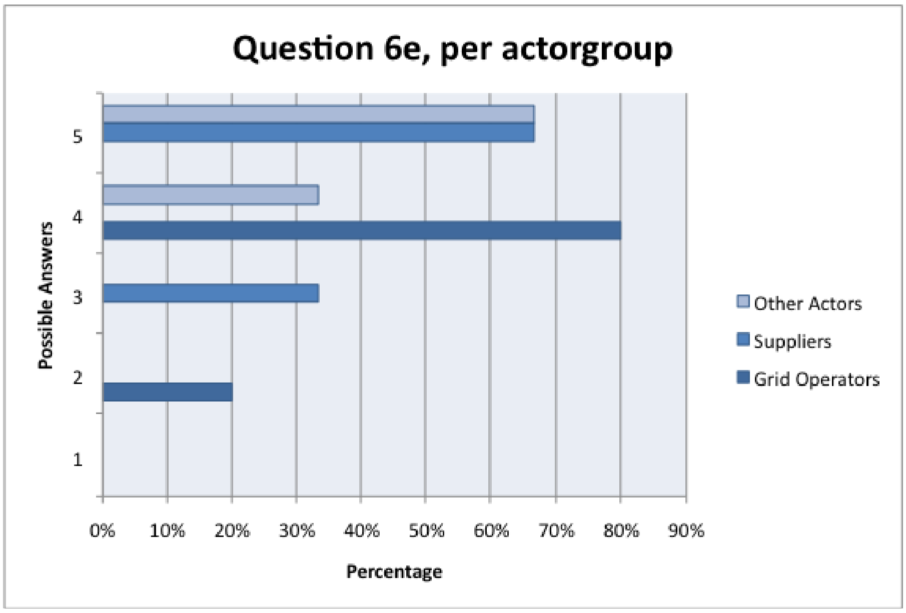
Toelichting "Other Actors"
De vraag is hierbij vooral of andere technologieën hier geen beter antwoord op hebben. Dit kan dus twee kanten op gaan.

d) Regulation, Reserve and Emergency power

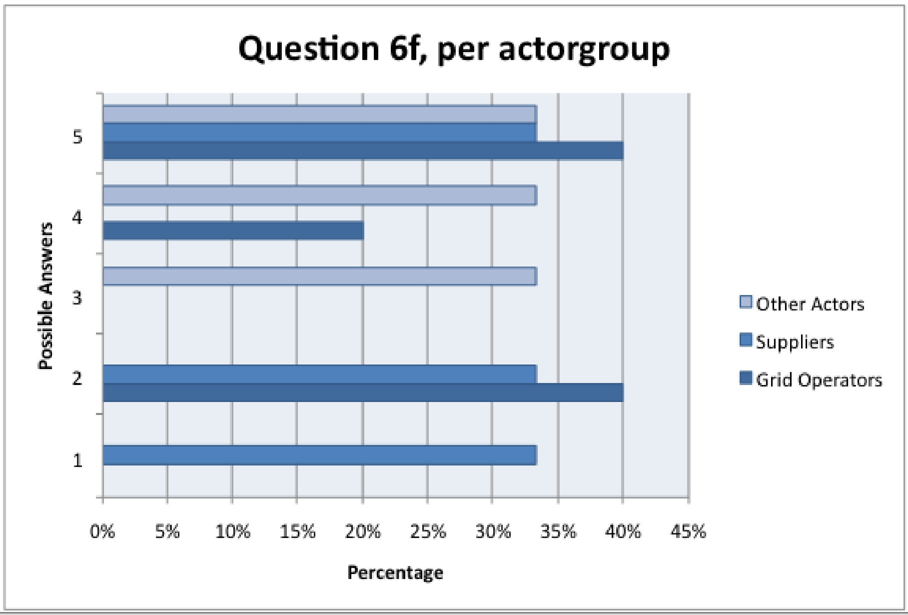


Toelichting "Grid Operators"
Deze zullen in de toekomst niet meer nodig zijn met BSS. Voorwaarde is hier wel dat er genoeg batterijen in het net moeten zitten.
Toelichting "Other Actors"
Veel op het moment dat de E-auto grootschalig wordt ingezet, anders niet. De omvang van batterij pakketten in het netwerk zal voor deze dus groot moeten zijn. Zolang dit alleen op hoogspanningsniveau geregeld wordt zullen batterijen niet veel waarde kunnen toevoegen.

e) Voltage support

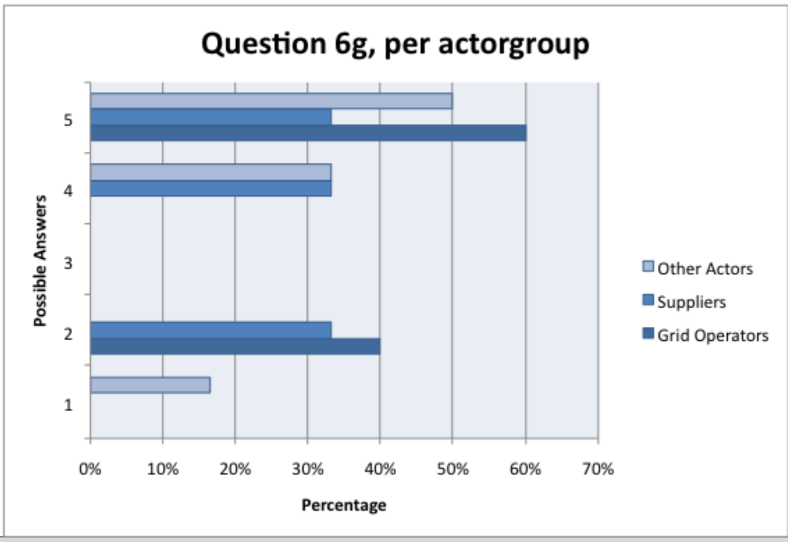


f) Spinning reserve



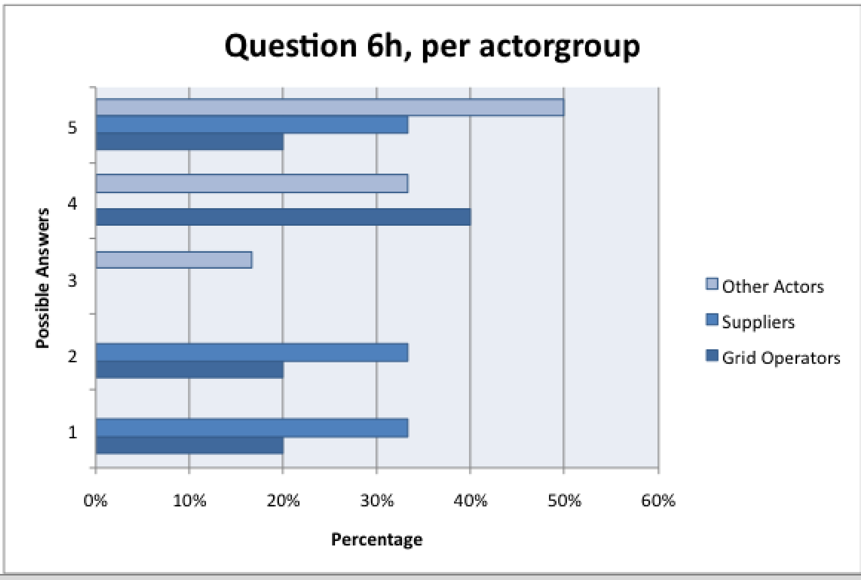
Toelichting "Grid Operators"
Deze zullen in de toekomst niet meer nodig zijn met BSS. Voorwaarde is hier wel dat er genoeg batterijen in het net moeten zitten.
Toelichting "Other Actors"
Veel op het moment dat de E-auto grootschalig wordt ingezet, anders niet. De omvang van batterij pakketten in het netwerk zal voor deze dus groot moeten zijn. Dit kan wel, maar ik zie hier eerder een rol voor de micro-wkk's. Maar dan moet ook dit onderdeel belangrijk gaan worden op distributienet niveau. Dit bestaat nu alleen nog maar op hoogspanningsniveau.

g) Black Start



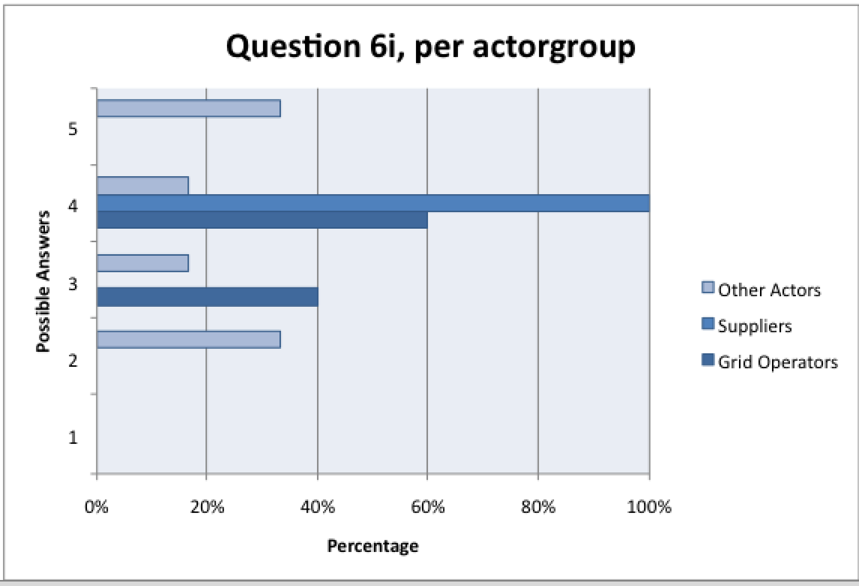
Toelichting "Grid Operators"
Deze zullen in de toekomst niet meer nodig zijn met BSS. Voorwaarde is hier wel dat er genoeg batterijen in het net moeten zitten.
Toelichting "Electricity Providers"
Concurrent is een diesel aggregaat. Hier speelt de tijdsduur, de frequentie van gebruik (wegens milieu eisen) en de kostprijs een belangrijke rol in de keuze tussen de twee alternatieve.
Toelichting "Other Actors"
Veel op het moment dat de E-auto grootschalig wordt ingezet, anders niet. De omvang van batterij pakketten in het netwerk zal voor deze dus groot moeten zijn. Maar dan wel in combinatie met slimme meters/grids.

h) Frequency control



Toelichting "Grid Operators"
Deze zullen in de toekomst niet meer nodig zijn met BSS. Voorwaarde is hier wel dat er genoeg batterijen in het net moeten zitten.

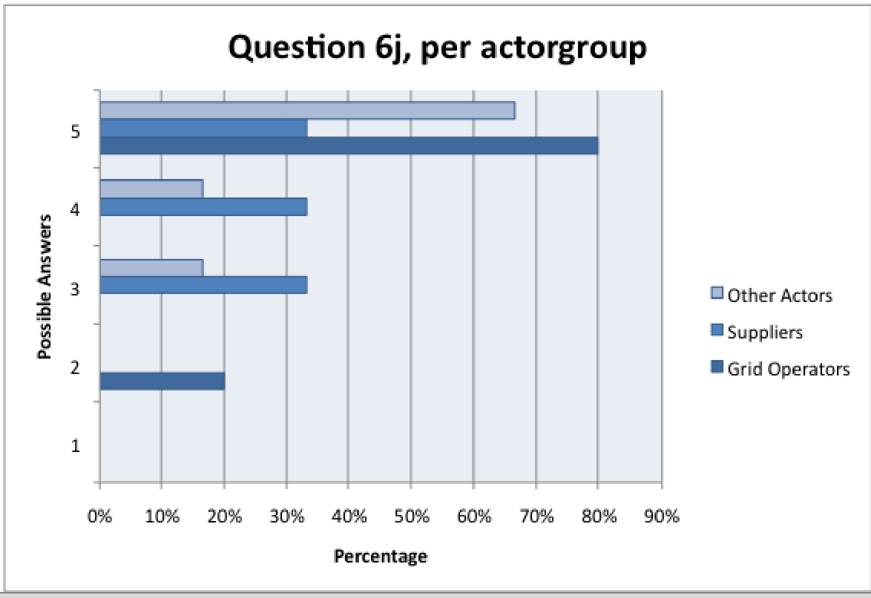
i) Intra PTU



Toelichting "Electricity Provider"
Hierbij heb ik wel mijn twijfels in de waarde. Is dit een technische of een economische wens/probleem?

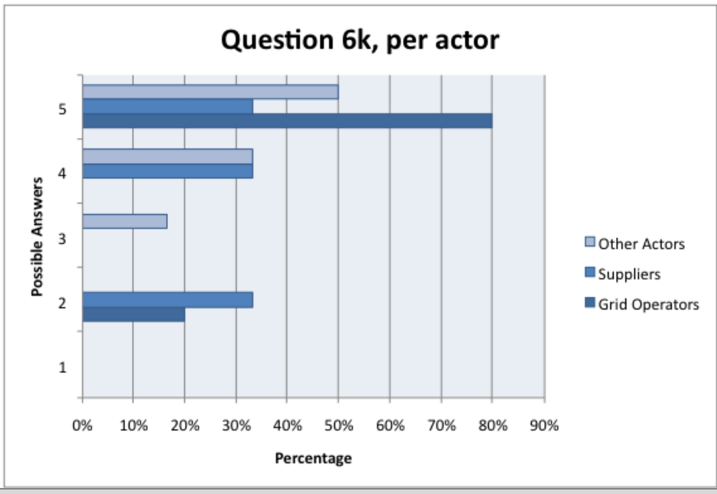
Toelichting "Other Actors"
Veel op het moment dat de E-auto grootschalig wordt ingezet, anders niet. De omvang van batterij pakketten in het netwerk zal voor deze dus groot moeten zijn. Dit is zeer afhankelijk van de waarde van deze applicatie en de prijs ontwikkeling van energie. In de huidige markt is het nog niet relevant.

j) Congestiemanagement (distributie niveau)



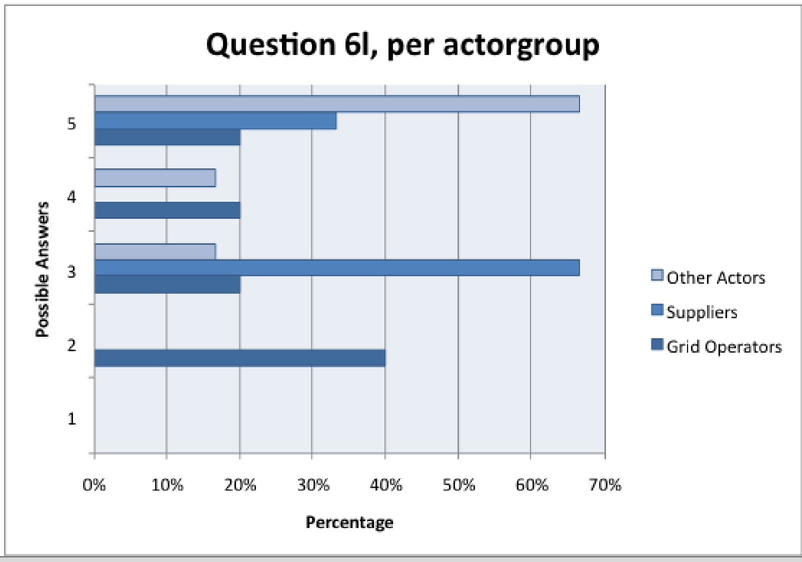
Toelichting "Other actors"
Maar dan wel geconstateerde congestie. Meten is weten, wat nu nog te weinig gebeurt.

k) Uitstellen van distributienet investeringen



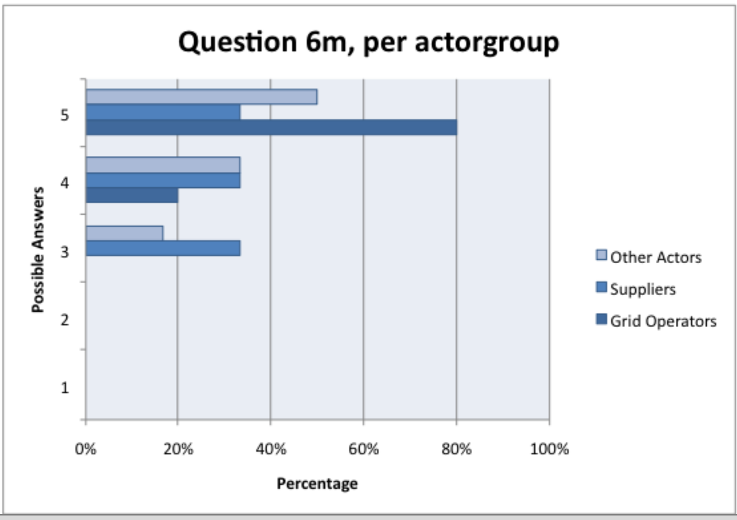
Toelichting "Grid Operators"
Deze zou wel in combinatie moeten met een andere toepassing, omdat ik niet geloof dat hiervoor alleen door netbeheerders batterijen zullen worden geplaatst. Zeker voor deze toepassing moet de prijs nog wel drastisch omlaag.
Toelichting "Electricity Providers"
Dit zou ook kunnen d.m.v. het inzetten van intelligente netten met focus op demand side management, waar ik persoonlijk meer in zie.
Toelichting "Other Actors"
Of misschien wel het helemaal niet hoeven uitvoeren van bepaalde investeringen.

l) Power quality



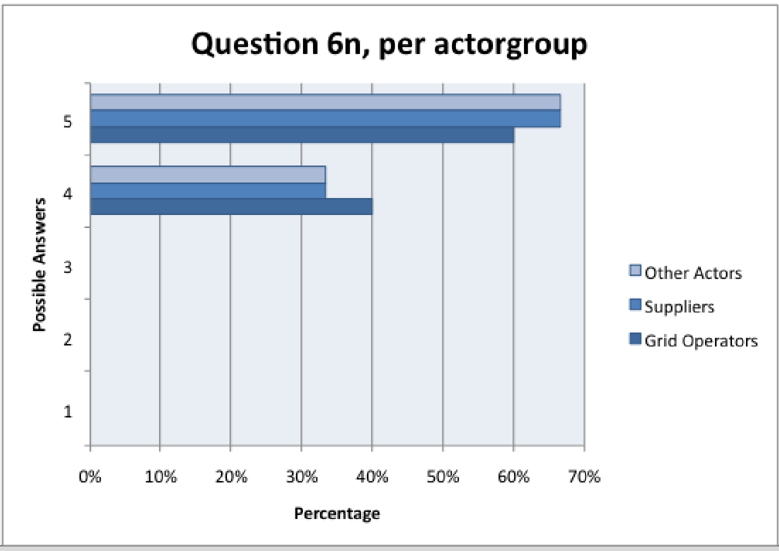
Toelichting "Grid Operators"
Niet zo belangrijk in Nederland!
Toelichting "Other Actors"
Niet echt relevant in Nederland. Desondanks is deze technologie er goed geschikt voor.

m) Integratie van duurzame energie bronnen, met name het balanceren van voorspellingsfouten



Toelichting “Electricity Providers”
In zijn algemeenheid zie ik geen doorbraak voor Batterij Opslag Systemen voor grootschalige toepassingen (productie, netten en afgeleide), maar met name in decentrale netwerken en kleinschalige / locale productiefaciliteiten. De beredenering hiervoor komt in eerste instantie vanuit de optiek van financiële haalbaarheid. Tevens verwacht ik dat er kostenefficiëntere oplossingen voorhanden komen en twijfel ik of Batterij Opslag Systemen ontstaan voor vele tientallen MW geïnstalleerd vermogen, waarbij naast financiële faalbaarheid ook technische haalbaarheid een belemmering kan zijn. Voor decentrale productie zou ik “erg” zeggen, maar “niet erg” voor de grote centrale productie zoals bij offshore windmolenparken. Mijn eindconclusie is daarom “enigszins”. Ik zie dit vooral i.c.m. de elektrische auto en i.c.m. de automatische vraag response (demand-side management).
Toelichting “Other actors”
Wel gelimiteerd tot distributienet niveau.

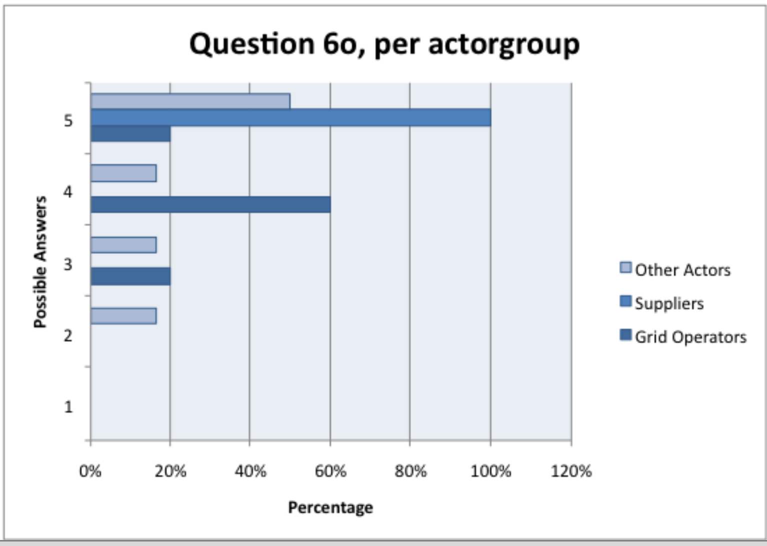
n) Microgrids / onafhankelijke netten



Toelichting “Grid Operators”
Als deze er komen zullen lokale opslag systemen noodzakelijk zijn, waarvoor BOS zeker een reële mogelijkheid is.

Toelichting "Other Actors"
Dit komt ook naar Nederland, maar dan moeten de baten wel eerst duidelijker worden. Ook moet duidelijk worden voor wie de baten precies zijn. Hier is het vooral de vraag komt het en in welke mate. Zodra deze marktontwikkeling daadwerkelijk de toekomst is zal het veranderen naar "veel".

o) Opslag bij klanten, incl.: Individueel vraag matching, Elektriciteit gemeenschappen



Toelichting "Grid Operators"
Dit zal geen verschil maken voor de netbeheerder, wel voor andere partijen (b.v. energieleveranciers). De vraag die hierbij gesteld kan worden of deze aanpak niet heel erg inefficiënt is, hiervoor is tenslotte de netbeheerder rol ontstaan (alleen kijkend naar de taken van de netbeheerder)! Ik zie dit eventueel als taak ontstaan voor de Netbeheerder, verkopen aan de buren zal namelijk toch via een netwerk moeten gaan. Opslag systemen zullen in de toekomst voor meerdere toepassingen tegelijkertijd worden ingezet, ondanks dat niet alle combinaties mogelijk zullen zijn.
Toelichting "Other Actors"
Dit is een mooie, wat ik zeker verwacht in de toekomst! Apeldoorn is hier een voorbeeld van. Hier is het vooral de vraag komt het en in welke mate. Zodra deze marktontwikkeling daadwerkelijk de toekomst is zal het veranderen naar "veel".

Toelichting algemeen "Other Actors"
bij deze vraag moet goed worden gedacht "kan batterij opslag systemen dit beter dan demand-side management?". En welke prijs heeft men hiervoor over!?!

Interview Question 7

Verwacht u dat de bovenstaande lijst compleet is of ziet u nog andere toepassingen?

Toelichting "Grid Operators"
De elektrische auto's zou wellicht een goede aanvulling zijn. Als Netbeheerder houden wij ons op dit moment voornamelijk bezig met de vraag (gerelateerd aan BSS) "Hoe kunnen wij ons netwerk zodanig geschikt maken voor de eventuele komst van de elektrische auto's dat de benodigde investeringen in ons netwerk zoveel mogelijk beperkt blijven?". Waarbij vooral wordt gekeken naar secundaire diensten (de primaire dienst is het auto rijden zelf), b.v. van wind naar auto. Elektrisch vervoer Noodstroomvoorziening
Toelichting "Other Actors"
Misschien kan het optimaliseren van centrales ook gezien worden als een losse applicatie die hier tussen gezet zou kunnen worden. Piekcentrales zijn de grootste vervuilers wat veel efficiënter kan, o.a. door middel van deze technologie. • Elektrisch vervoer • Retail modellen (b.v. gratis opslag bij een 5-jarig contract), ook wel de nieuwe energie diensten genoemd. Electric Vehicle (V2G & G2V), al heb ik nog wel vraagstekens staan bij de huidige gedachten over deze concepten. V.b. gaat de consument echt toelaten dat hun auto wordt gebruikt voor nettoepassingen? Het zou hier interessant zijn om het te combineren met andere markten (product/diensten), zoals het linken aan domotica. Hieruit zouden echte innovaties kunnen ontstaan (significante veranderingen t.o.v. het huidige systeem).

Research question 5 (Q8)

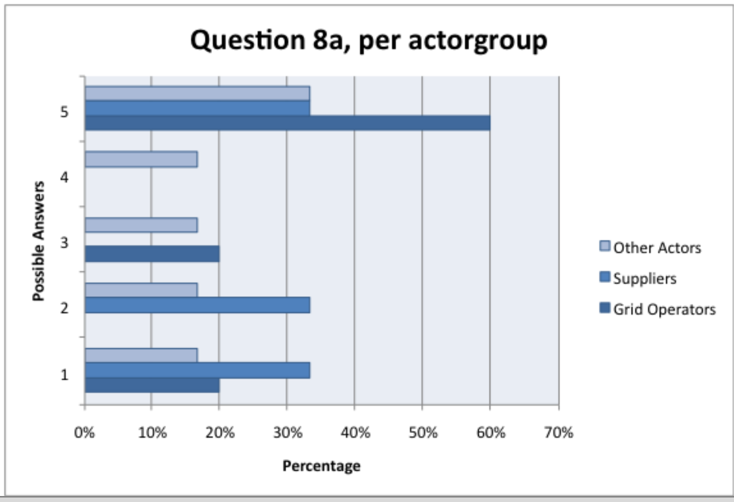
Which actors can gain significant benefits with BSS?

Interview Question 8

Voor welke actor in het Nederlandse elektriciteitssysteem ziet u de meeste voordelen van deze applicaties?

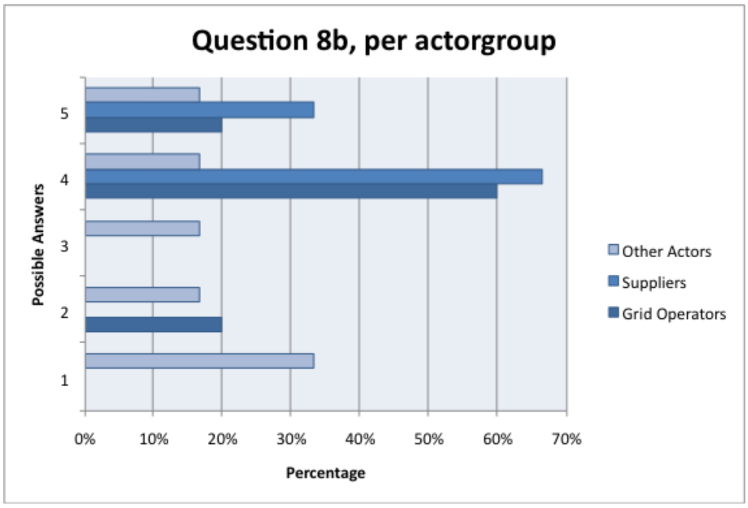
Actor	**Mate van voordeel**				
	Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)

a) Producenten

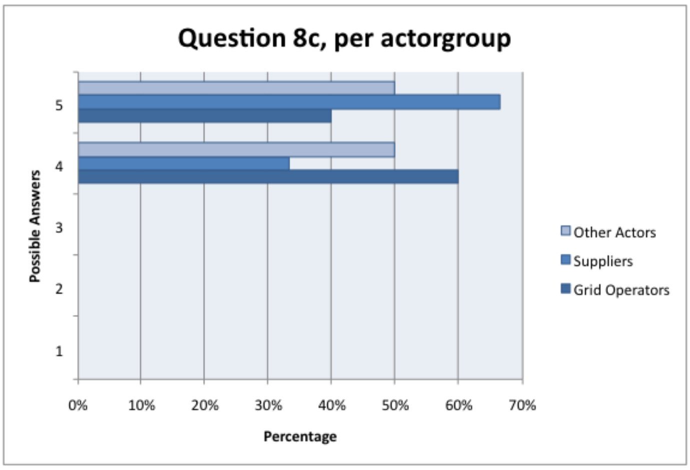


Toelichting "Grid Operators"
Deze zouden hun centrales efficiënter kunnen inzetten (constante belasting)

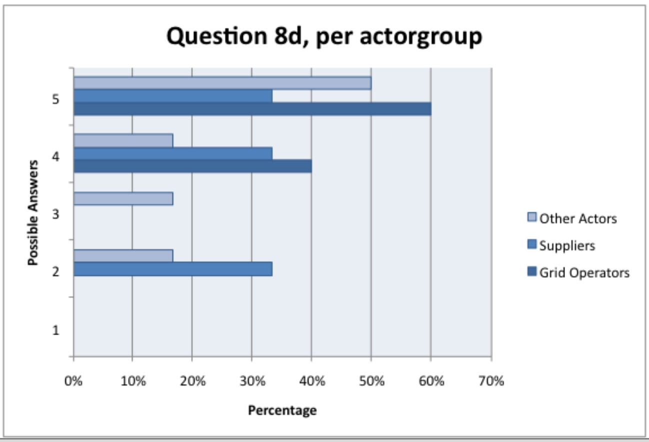
b) TSO TenneT



c) Regionale netbeheerders

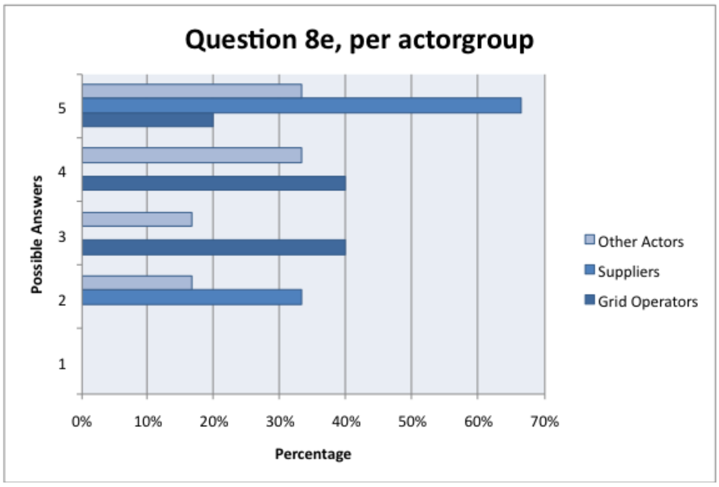


d) Consumenten

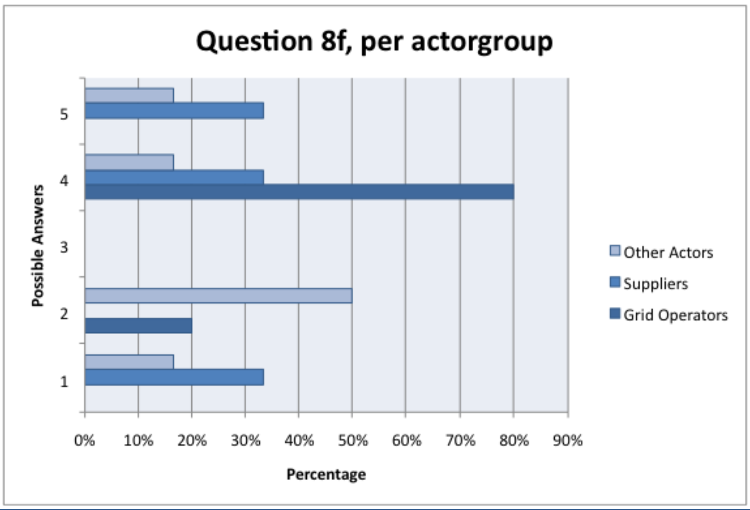


Toelichting "Grid Operators"
Verschil: fase 1 & 2 klanten wel, fase 3 klanten niet. Deze zullen er hoe dan ook indirect baten bij moeten hebben.

e) Programma verantwoordelijke

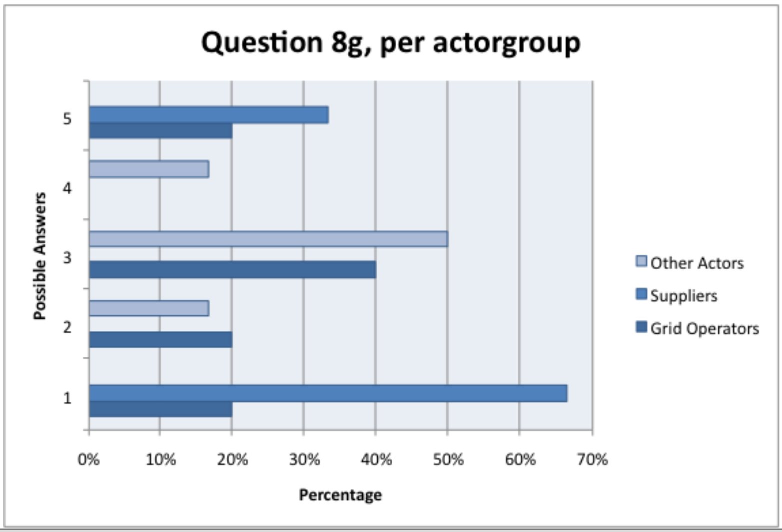


f) Handelaren (Wholesale market)



Toelichting "Grid Operator"
Als macht mechanisme om druk uit te kunnen oefenen op prijzen vanuit interconnecties (vb. In Denemarken moet men de hoofdprijs betalen als ze zelf weinig wind energie hebben en als ze veel wind energie hebben moeten ze het voor dump prijzen verkopen). En ook piekshaving zou voor hun interessant kunnen zijn.
Toelichting "Electricity Providers"
Uitgaande dat handelaren hier slim op zullen gaan inspelen, anders zou deze technologie juist een bedreiging kunnen gaan vormen.
Toelichting "Other Actors"
Gezien vanuit het scenario dat er steeds meer lokaal zal worden geregeld. Indien deze actor met een andere actor, zoals producent, opgenomen is in hetzelfde bedrijf zouden ze wel een voordeel kunnen hebben. Maar puur deze actor separaat niet, omdat ze juist hun geld verdienen door onbalans.

g) Retailers (Suppliers)



Toelichting "Other Actors"
Gezien vanuit het scenario dat er steeds meer lokaal zal worden geregeld.

Research question 6 (Q9, 10)

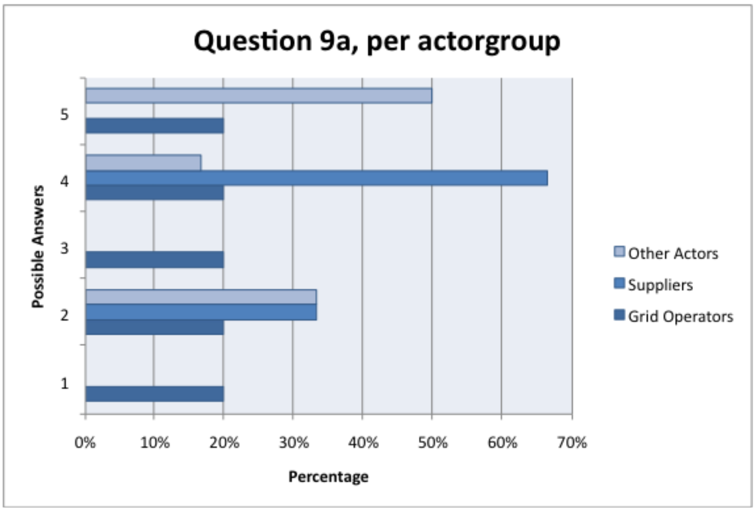
Does distributed storage facilities fit to the strategies of the RGO's and electricity providers?

Interview Question 9

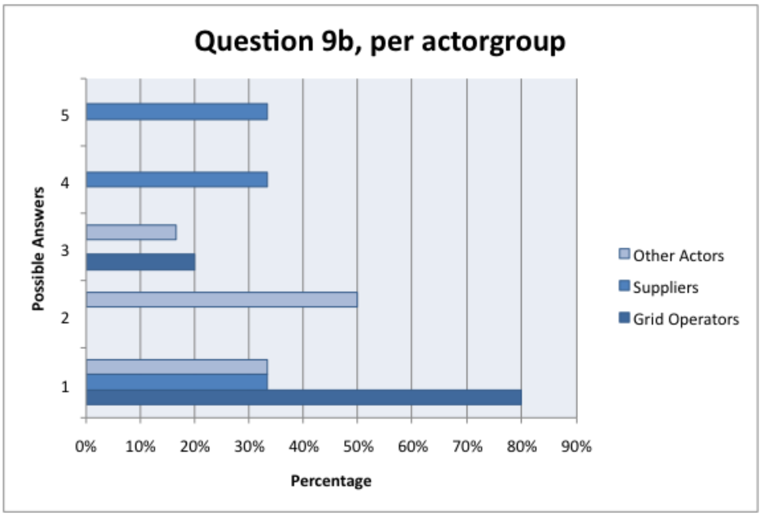
Verwacht u dat deze technologie (incl. de mogelijke toepassingen) bijdraagt aan een van de onderstaande doelstellingen?

Doelstelling	**Mate van verwachting**				
	Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)

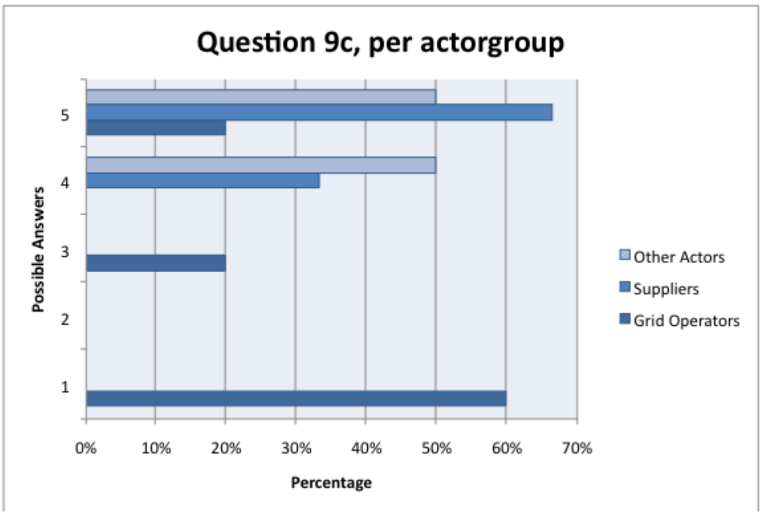
a) Prijs reductie voor energie



b) Het behalen van een grotere afzet (groei van uw klanten groep en/of hun afname)



c) Maakt het mogelijk u verder te onderscheiden van uw concurrenten

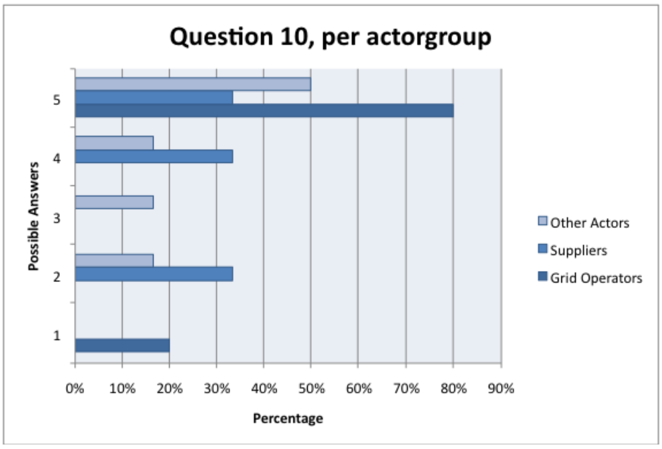


Toelichting "Grid Operators"
a) Complex, ligt namelijk aan de ontwikkeling van deze technologie.
a) Niet echt reductie, maar juist minder hard te laten stijgen.
a) Voorlopig nog te duur, maar afhankelijk van de technologische ontwikkeling, kan dit veranderen in de verre toekomst (minimaal 2030).
a) Voorlopig nog niet erg, maar toekomstige ontwikkelingen zouden dit kunnen veranderen in de toekomst.
C) Netbeheerders hebben geen concurrentie. Wel is er een onderlinge "competitie" tussen de netbeheerders, waardoor efficiëntie wel een belangrijke is voor ons bedrijf om ons te "onderscheiden" van onze collega netbeheerders.
C) Minder storingsminuten, lager tarief, andere diensten (b.v. leveren van opslag systemen), etc.
C) Wij hebben geen concurrentie
C) Netbeheerders hebben geen concurrentie, misschien is dit wel wat voor handelaren en retailers.
Toelichting "Electricity Providers"
b) Met name afname.
C) Ik verwacht dat we met deze diensten sommige klanten zeker meer kunnen bieden, b.v. piek beheersing zou voor vele waardevol kunnen zijn. Zeker in combinatie met hoe het tariefstructuur op dit moment in de markt geregeld is.
C) Hier kunnen nieuwe diensten en producten uit ontstaan die wij kunnen gaan aanbieden. Snelheid van inzetten op deze nieuwe diensten en producten is hierbij een belangrijke succes factor.
Toelichting "Other Actors"
a) Minder hard stijgen geloof ik wel in, maar niet in het reduceren van de huidige energie prijzen.
a) Zoniet, dan komt het er niet
a) De noodzakelijke investering is gewoon nog te hoog.
C) Concurrentie verschil zou maar heel even stand kunnen houden in deze "copy market".
C) Niet echt onderscheiden, maar wel voor het zoeken naar betere oplossingen, wat onze taak is
C) De snelheid zal hierbij cruciaal zijn.

Interview Question 10

Past deze technologie (incl. de mogelijke toepassingen) binnen de strategieën van de netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate waarin deze technologie waarde bijdraagt aan de strategieën				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)



Toelichting “Grid Operators”
Elke technologie past binnen de strategie van ons bedrijf, als deze technologie maar meer toegevoegde waarde creëert t.o.v. de oude/vorige situatie. Jazeker en dan met name de elektrische auto’s en als toepassing/onderdeel van Smart Grids. Wij zijn op dit niveau actief aan het bekijken wat we met opslag zouden kunnen en moeten doen. Opslag is bv. een onderdeel van ons innovatieprogramma. Deze technologie past zeker bij onze strategie. Deze technologie maakt het namelijk mogelijk om (deels) onze strategische doelstellingen te behalen. b.v. storingsminuten te reduceren (wij willen de beste zijn in ons vak).
Toelichting “Electricity Providers”
Vraag sturing is wel een duidelijk speerpunt, maar batterij opslag systemen niet echt. Wij focussen ons dus vooral op het beïnvloeden van de vraag en daarom invloed uitoefenen op wanneer klanten consumeren. Voor decentrale oplossingen, in de richting van “Smart Homes”, zou hij wel beperkt passen binnen de strategie. Maar dit is maar zeer beperkt en dus overal gezien “niet echt”. • We zetten erg in op duurzame energie bronnen, en dan met name op wind, dus hebben we behoefte aan een buffer/flexibiliteit. • Blijven onderscheiden in de markt, wij kunnen hiermee nieuwe diensten en proposities maken die ons in staat stelt nieuwe klanten te werven en huidige klanten te behouden.
Toelichting “Other Actors”
Dit is puur gebaseerd op eigen ervaring met deze actoren. Hierbij moet wel een uitzondering worden gemaakt voor innovatieve / nieuwe energieleveranciers (meer ondernemend), waarbij de organisatie flexibeler is en daardoor beter kan omgaan met zulke technologische veranderingen. De huidige grote spelers in het veld zijn wat stugger en houden daardoor wat meer vast aan de oude vertrouwde situatie. Ja, BOS wordt momenteel in samenwerking met netbeheerders getest in de praktijk. Een voorbeeld is het slimme distributiestation in Apeldoorn. Wel is dit nog in de testfase. Dit is afhankelijk van welk energie scenario de werkelijkheid zal gaan worden (zie antwoord vraag 1 voor de scenario’s). Maar niet voor TenneT. Deze technologie past binnen de strategie van ons bedrijf, al zijn we zelf geen technologie ontwikkelaar. De technologie zal dus niet “inhouse” worden ontwikkeld, maar in samenwerking met ons is zeker mogelijk. Op het moment dat deze technologie zodanig ver is uitontwikkeld passen ook de toepassingen goed binnen onze strategie, waardoor implementatie in de toekomst zeker mogelijk is. Wel zou deze technologie de huidige werkprocessen volledig verstoren, waardoor er intern flinke veranderingen zullen moeten worden ondergaan. Voor de ontwikkeling van deze technologie, en in combinatie met andere technologieën, zullen voornamelijk start-ups en/of kleine ondernemingen een belangrijke rol spelen. Deze organisaties zijn vele male flexibeler dan grote “logge” organisaties. Past zeker, maar de splitsingswet zit hier wel dwars. Deze technologie kan bijdragen aan de betrouwbaarheid en op de lange termijn aan het balanceren van de distributienetten.

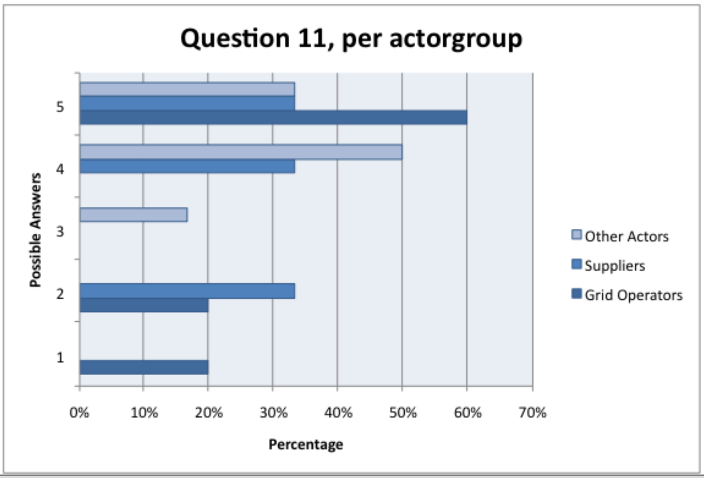
Research question 7 (Q11, 12, 13, 14, 15)

How will the business model of the RGO's and electricity providers change, when implementing BSS?

Interview Question 11

Verwacht u dat deze technologie effect zal hebben op de bedrijfsactiviteiten van de netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate van verwachting				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)



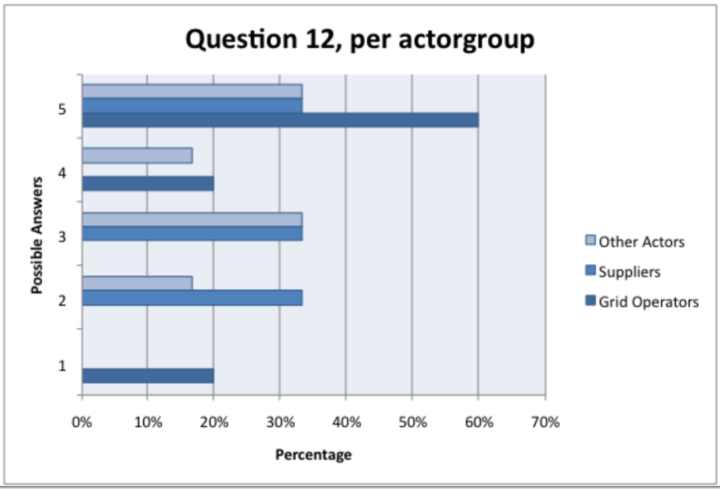
Toelichting "Grid Operators"
Zodra opslag een onderdeel zal gaan worden van de bedrijfsactiviteiten van de Netbeheerder dan krijgen de bedrijfsactiviteiten een dynamische vormgeving. Nu is het meer een statisch doorgeefluik, zonder enige tijdvertraging. Hier zullen wel de wetten voor moeten worden aangepast. Dit zou een evolutie in het Nederlandse elektriciteitssysteem zijn. Het systeem word anders georganiseerd en opgebouwd, maar ook de manier hoe men omgaat met dit systeem zal veranderen. Al is het niet direct voor ons net, we hebben ook te maken met de hele marktfacilitering. We zouden dus moeten gaan bemeteren, bepalen hoe opslag gebruikt moet worden, etc. Ik weet nu niet hoe we dit gaan onderbrengen in onze organisatie, maar het zal waarschijnlijk een onderdeel worden van. Een echt significante verandering zie ik hier dus niet ontstaan. Wat wel een significante verandering zou kunnen zijn is het "Smart Grid" in zijn geheel.
Toelichting "Electricity Providers"
Het antwoord op deze vraag volgt automatisch uit de vorige vraag, namelijk de technologie past "niet echt" binnen onze strategie en zal daarom ook "niet erg" onze (kern) activiteiten beïnvloeden. Binnen de handel kan dit een techniek worden die onderdeel gaat uitmaken van onze portfolio, wat natuurlijk afhankelijk is van de kostprijs ontwikkeling, de penetratiegraad, etc. Ook een extra product/dienst kan hier uit ontstaan, wat nieuwe/veranderende bedrijfsactiviteiten met zich mee brengt.

Toelichting "Other Actors"
Zeker bij E-auto's kan ik me goed voorstellen dat dit het geval zal zijn in de toekomst. Het fenomeen opslag is gewoon nieuw wat ook nieuwe activiteiten met zich mee zal brengen. Hierbij zullen verschillende partijen samengebracht moeten worden om het maximale uit deze technologie te halen, waardoor samenwerken steeds belangrijker zal worden. Ik verwacht dat dit ook zal gelden voor de andere vormen van batterij opslag systemen. Als je voor deze technologie kiest zal het ook moeten worden beheerd, onderhouden, aangestuurd, etc. Het is een nieuw onderdeel in hun activiteiten, maar of dit echt fundamentele veranderingen met zich mee zal brengen ben ik nog niet zeker van. Als de netbeheerders energie willen gaan leveren voor bv. onbalans, dan moet dit systeem ontwikkeld worden. Momenteel is dit systeem er nog niet en daarom mag netbeheer dit dus ook nog niet doen. Mocht netbeheer deze kant op gaan, dan zal het zeker de bedrijfsactiviteiten beïnvloeden. Desondanks zie ik dit niet gebeuren voor het grootschalig energie leveren en dus gaat het niet om significante veranderingen, maar meer om een extra taak. Het heeft effect op de lange termijn, omdat de activiteiten rondom deze technologie nog niet zijn opgenomen in de huidige bedrijfsactiviteiten

Interview Question 12

Ziet u deze technologie als een belangrijk toekomstig onderdeel van de bedrijfsbezittingen van netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate van verwachting				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)



Toelichting "Grid Operators"
BSS zal eigendom worden van de netbeheerder. Hierbij gaat het niet om de batterijen in auto's, want die zullen eigendom worden van de gebruiker. De focus is dus op batterij opslag systemen die geplaatst zullen worden (fysiek) in het netwerk zelf. Eventueel geven wij de batterijen een second life door batterijen op te kopen uit de elektrische auto's. Deze batterijen zullen niet meer geschikt zijn voor automobiele toepassingen, maar nog wel voor onze netwerk toepassingen.

Dit zou twee kanten op kunnen gaan (extremen), namelijk

- Alleen in voertuigen en/of woningen, dan mag "de rest" blij zijn dat ze er gebruik van mogen maken.
- In het elektriciteitsnetwerk zelf, b.v. als second life.

Mijn bovenstaande antwoord is gebaseerd op een combinatie tussen deze twee extremen, wat ik het meest waarschijnlijk acht.

Opslag is op dit moment veel te duur en daarom bestaat er geen fealible business case voor opslag. Als we deze techniek toch willen gaan toepassen in het elektriciteitsnetwerk wegens duurzaamheid issues zal niemand hier in willen investeren. Dit is het zelfde verhaal als voor onze kabels die wij plaatsen met een terugverdientijd van 40 jaar. Er is geen commercieel bedrijf dat een investering maakt die pas wordt terugverdient over 40 jaar. BOS zal waarschijnlijk een levensduur hebben van ~10 - 15 jaar, en ook dat is te lang voor een commercieel bedrijf om in te investeren. Als maatschappelijke taak zie ik dit dus zeker gebeuren. Dit zou betekenen dat de netbeheerder met bv. een biedladder zou gaan werken net als het systeem van TenneT om vervolgens de energie aan te bieden aan programmaverantwoordelijke. Deze aanpak zou het investeringsprobleem kunnen wegnemen.

Dit is sterk afhankelijk van de prijs verhouding in vergelijking met alternatieve oplossingen. En daardoor ook afhankelijk van de penetratiegraad van deze technologie in ons netwerk

Toelichting "Electricity Providers"

Ik zie eerder dat wij zo'n systeem zouden verkopen als dienst dan als bedrijfsbezitting. Hierbij gaat het vooral om de dienst die wij (kunnen) leveren aan klanten betreft het beter en efficiënter managen van hun eigen energieverbruik.

Tevens zie ik meer in het afsluiten van contracten met klanten voor vraagsturing, zeker met de invoering van elektrische auto's en smart homes. Hier zou batterij opslag systemen eventueel in zeer beperkte mate onderdeel van kunnen worden ter ondersteuning.

Hier zie ik eerder nieuwe bedrijven ontstaan. Of eventueel de infra bedrijven die b.v. ook ketels verhuren. Voor ons bedrijf is het afhankelijk van veel factoren, daarom neutraal tot enigszins.

Ik zie hier zeker een rol voor ons bedrijf, alleen in welke vorm is nog onduidelijk. Dit is ook afhankelijk voor welke applicaties deze technologie ingezet gaat worden en waar deze technologie zal worden geïmplementeerd in het elektriciteitsnetwerk. Desondanks verwacht ik dat deze technologie een onderdeel zal gaan uitmaken van onze bedrijfsbezittingen in de toekomst.

Zeker voor de elektrische auto is deze discussie zeer actueel, waarin ik verschillende scenario's al voorbij heb zien komen, o.a.:

- Banken als eigenaar van de batterij: lease constructie;
- Energieleverancier / netbeheerder als eigenaar van de batterij, batterij wordt gezien als een verlenging van het elektriciteitsnetwerk;
- Consument als eigenaar;
- Nieuwe innovatieve marktmodellen, zoals Betterplace;
- Etc.

De vraag die bij deze modellen vaak centraal staat is of het de core business versterkt. Het model dat gekozen zal gaan worden is voorlopig nog niet duidelijk.

Toelichting "Other Actors"

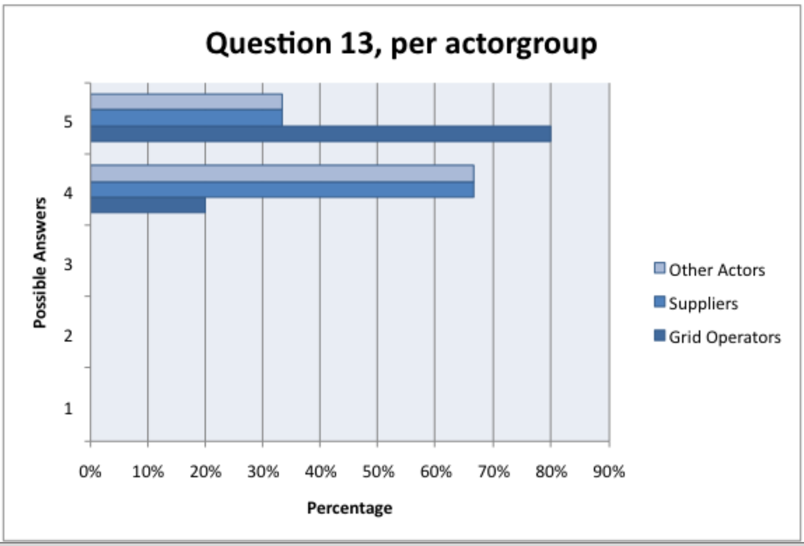
Als we ons systeem zodanig gaan inrichten dat opslag een belangrijk onderdeel wordt van het geheel zal het zeker een belangrijke bezitting zijn. Van wie deze technologie precies eigendom zal worden is nog wel onduidelijk, maar omdat deze vraag zowel netbeheerder als leverancier omvat is het antwoord op deze vraag "erg".

Hier bestaan nog teveel onzekerheden die invloed hebben op welke richting we op gaan, daarom neutraal. De vraag is alleen of het een regulated of een unregulated asset is. Ik verwacht dat deze technologie geen significant onderdeel zal gaan uitmaken van de assets waarover de netbeheerders beschikken. De reden hiervoor is dat ik verwacht dat de huidige assets de boventoon zullen blijven voeren Dit is afhankelijk van wie de eigenaar gaat worden van deze batterij. Zodra het een substantiële asset van de netbeheerders moet gaan worden, zullen er wel heel veel batterijen geplaatst moeten gaan worden. De totale assets van de Netbeheerders hebben al een te grote omvang hiervoor. Daarentegen zou het voor de leveranciers wel een (substantieel) belangrijke asset kunnen worden, mits deze leverancier ook niet de actor producent omvat

Interview Question 13

Verwacht u dat er enige samenwerkingsverbanden ontstaan door de introductie van deze technologie? b.v. hardware is in het bezit van een andere actor dan de actor die gebruik maakt van de service.

Mate van verwachting				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)



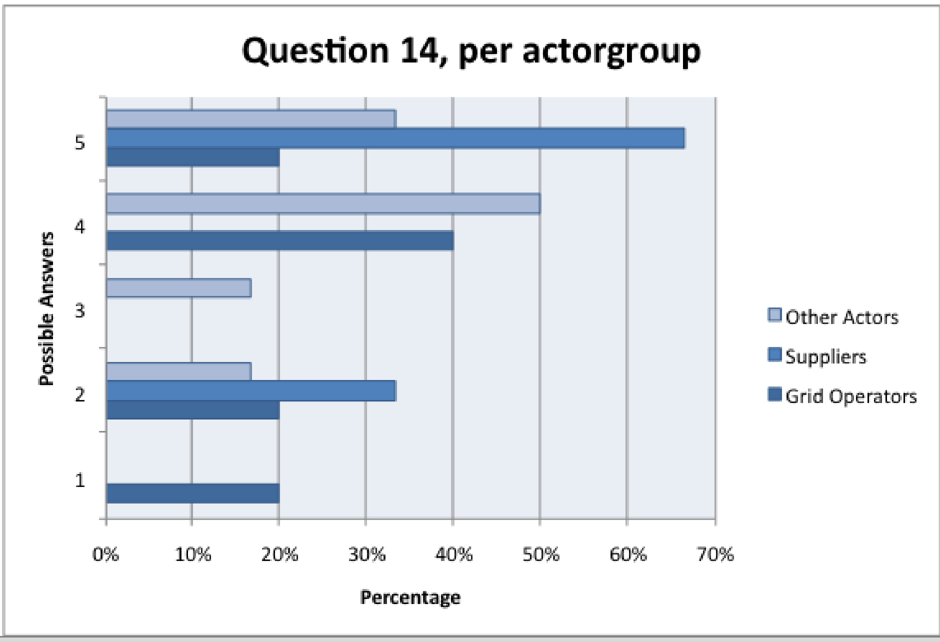
Toelichting "Grid Operators"
Dat is zeker een mogelijkheid. Commerciële bedrijven zullen dan gebruik kunnen maken van onze assets. Maar ook anders om, waarin wij gebruik maken van de batterij gestationeerd in de elektrische auto's, indien deze niet worden gebruikt en is aangesloten aan het elektriciteitsnetwerk. Hier zullen nieuwe diensten en producten uit ontstaan, vooral diegene die we nu nog niet (kunnen) voorzien. Dit zou ik mezelf kunnen voorstellen, bijvoorbeeld een regionale netbeheerder in combinatie met een leveringsbedrijf.

Dit is afhankelijk van het toekomstige marktmodel, waar de wet en regelgeving een belangrijke rol in gaat spelen. Desondanks denk ik dat er meer en nauwere samenwerkingsverbanden gaan ontstaan door deze technologie en "Smart Grids" in zijn geheel.
Toelichting "Electricity Providers"
Dit zou ik me enigszins kunnen voorstellen en dan met name als second life van de batterijen uit auto's. Hiervoor zijn verschillende scenario's betreft samenwerkingsverbanden denkbaar. Aanvullend op mijn vorige antwoord: Ik zie hier 4 verschillende samenwerkingsverbanden ontstaan, namelijk tussen: • Klant/consument • Netbeheerder • Energiebedrijf • Nieuwe tussenliggende bedrijven (b.v. de batterij eigenaren) Dit is dus heel erg afhankelijk van wie de eigenaar van de BOS moet/zal worden. Afhankelijk van toekomstige beslissingen, zoals geantwoord in de vorige vraag.
Toelichting "Other Actors"
Zoals al aangegeven/besproken in vraag 11, samenwerking is nodig om het meeste en beste uit deze technologie te halen. Dit geldt zeker voor het geval van elektrische auto's. Zeker, maar hoe precies zal gaan afhangen van de keuzes die gemaakt gaan worden en voor welke applicaties ze ingezet gaan worden. Hier zullen vooral de nieuwe energie diensten een belangrijke rol kunnen spelen. Omdat we deze nieuwe diensten nog niet helder hebben neutraal tot erg. Ja, bijvoorbeeld door de introductie van ESCO's (Energy Service Company). Dit zou zeker kunnen, wat de invoering van deze technologie waarschijnlijk makkelijker zou maken. Hierbij moet vooral worden gelet op de rol die bepaalde actoren moeten uitvoeren en het "onderdeel" van BOS wat het beste past bij deze rol. Netbeheer heeft bijvoorbeeld een asset management rol waarbij het fysieke apparaat goed past. De energie leveranciers hebben de rol om energie te leveren, wat goed past bij de dienst die geleverd kan worden met BOS Samenwerkingsverbanden zullen gaan ontstaan, maar dit zal wel beperkt blijven tot een beperkt aantal actoren

Interview Question 14

Verwacht u dat deze technologie invloed zal hebben op het klantensegment en relaties van de netbeheerders (inclusief TenneT) en/of energieleveranciers?

Mate van verwachting				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)



Toelichting “Grid Operators”

Dit is veelal afhankelijk van de wet en regelgeving en dan met name hoe deze zal veranderen. B.v. er mag niet zomaar een kabel in de grond gestopt worden, dus ondanks dat men wilt clusteren zal er (nu nog) niet kunnen worden ontkomen aan een netbeheerder.

Als microgrids gaan komen dan zou de hoeveelheid klanten kunnen gaan afnemen (en eventueel de gemiddelde capaciteit per klant kunnen gaan toenemen), indien wij de netten ook daar niet gaan beheren.

Tevens zouden ook de handelaren en programmaverantwoordelijke klant kunnen worden, zoals beschreven in het antwoord op vraag 12.

Ik verwacht dat er veel meer communicatie in de toekomst zal gaan plaatsvinden met onze klanten. Zeker als de batterij, zowel in auto’s als eventueel stationair, bij de klanten/consumenten komt te staan.

Toelichting “Electricity Providers”

Antwoord is gerelateerd aan de antwoorden op vraag 11 en 12.

Nieuwe diensten, niet alleen producten leveren.

Erg, maar wel in combinatie met andere technologische ontwikkelingen, zoals duurzame opwekking bij consumenten thuis en elektrische auto’s. Deze vraag is tevens beantwoord in de antwoorden op vraag 10 en 12.

Toelichting “Other Actors”

Dit zal gewoon allemaal anders worden in de toekomst, b.v. een energie gemeenschap zou een klant kunnen worden waarbij klanten “groepen” worden i.p.v. “individuen”. Hierbij zou het zelfs zo kunnen zijn dat de Netbeheerders een cruciale rol gaan spelen in het samenbrengen van deze energie gemeenschappen (hogere laag in “cel” denken, integrator rol).

- Netbeheerders enigszins, de hele smart grid filosofie zal het klanten segment gaan veranderen, bv. de bevoegdheid om te gaan sturen.
- Leveranciers erg, ze kunnen zich gaan onderscheiden.

Enigszins omdat dit zeer afhankelijk zal zijn van de technologisch ontwikkeling en de mogelijkheden die

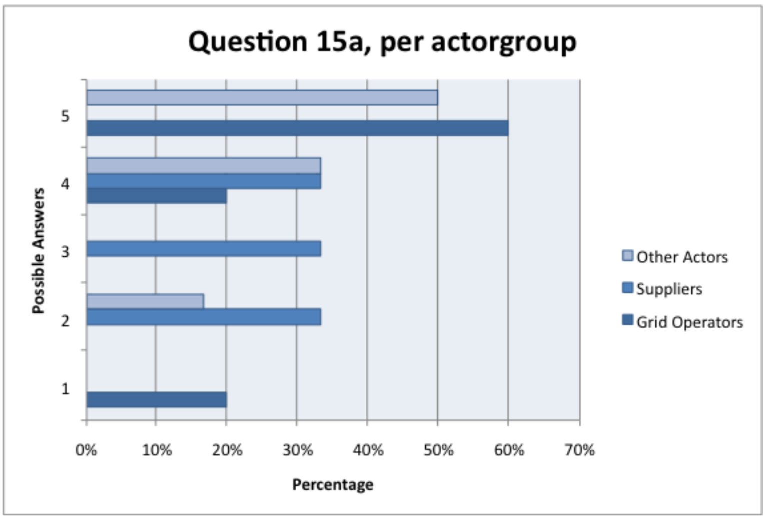
hierdoor beschikbaar worden. Maar ook hoe men verwacht hier geld aan te kunnen gaan verdienen. Enigszins, bijvoorbeeld door de ESCO's. De verandering acht ik niet significant Afhankelijk van wie de eigenaar zal gaan worden en hoe het marktmodel wordt ingericht

Interview Question 15

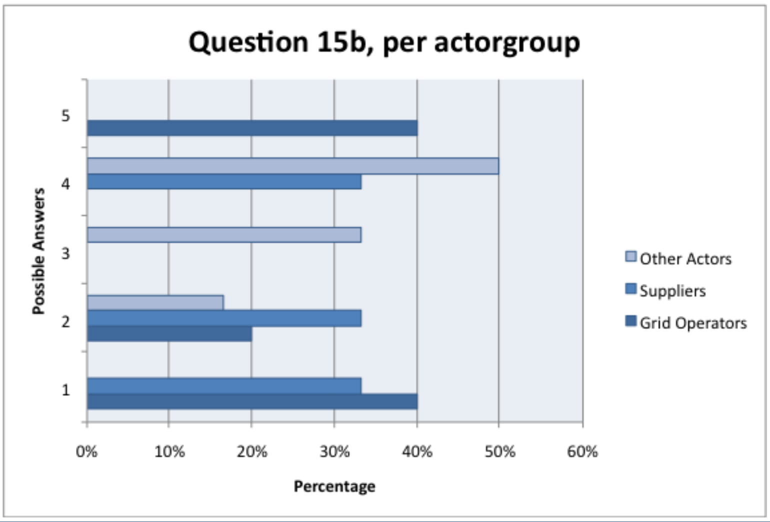
Verwacht u dat deze technologie het mogelijk maakt om interne kosten van de netbeheerders (inclusief TenneT) en/of energieleveranciers te reduceren en/of inkomsten te vergroten? Zo ja, aan welke kosten en/of inkomsten zou dan moeten worden gedacht?

Mate van verwachting				
Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)

a) Kosten reductie



b) Inkomsten verhoging



Toelichting "Grid Operators"
Kosten reductie door het beter benutten van de assets. Inkomsten verhoging door andere ook instaat te stellen hun assets beter te benutten / efficiënter in te zetten, b.v. door wind op te slaan in de nacht. Inkomsten verhoging zie ik niet significant veranderen door deze technologie. Kosten daarentegen zullen wel degelijk veranderen. Hier moet voornamelijk worden gedacht aan het reduceren van dure netwerk investeringen en het efficiënter kunnen gebruiken van de netten. Kosten zouden relatief kunnen worden gereduceerd door het efficiënter om te gaan met onze assets. Inkomsten verhoging door het kunnen aanbieden van meer diensten, zoals beschreven in vraag 12. Dit betekent niet het verhogen van de winst, omdat dit niet ons doel/taak is. a) Al is dit wel heel erg afhankelijk van de toekomstige technologische en economische ontwikkeling van de batterij.
Toelichting "Electricity Providers"
Voor inkomsten verhoging zie ik dit zeker niet en bij kosten reductie hangt het sterk af van de kosten ontwikkeling van de technologie. Desondanks verwacht ik geen significant verschil. **Kosten reductie:** Onbalans kosten verminderen en betere/goedkoper inkopen **Inkomsten verhoging:** Marges hoger maken (prijs minder verlagen dan de kosten reductie) Geheel afhankelijk van de technologische ontwikkeling en de markt ontwikkeling waarin de penetratiegraad van decentrale duurzame energieopwekking centraal staat. Het zal eerder de manier waarop inkomsten gegenereerd worden veranderen dan echt inkomsten verhogen (aanbieden van nieuwe energie diensten).
Toelichting "Other Actors"
Kosten worden zeker gereduceerd, b.v. door piek prijzen, transportkosten, etc. te vermijden Het kostenstructuur zal zeker gaan veranderen, maar of dit ook hogere inkomsten met zich mee zal brengen weet ik niet, daarom neutraal. Op dit moment is de technologie nog heel duur door de zeer beperkte beschikbaarheid van deze technologie op de markt, maar dit zal zeker gaan veranderen in de toekomst. a) Vooral NB, c) vooral leveranciers! De antwoorden zijn wel gebaseerd op een optimaal balans tussen verschillende alternatieven, bv. in combinatie met demand-side management. **Kosten reductie:** Op dit moment niet. Op het moment dat de technische specificaties en de gemoeide kosten verbeteren zou dit kunnen veranderen. **Inkomsten vergroten:** Zou kunnen maar niet op de basis van de huidige wetgeving, afhankelijk van de veranderingen die gaan plaatsvinden neutraal tot enigszins. De kosten reductie ligt heel erg aan de situatie. Niet in elke situatie zal BOS kosten verlagend zijn.

Deze vraag is voornamelijk beantwoord vanuit een netbeheerders positie. De kosten reductie zal vooral voortkomen uit het efficiënter kunnen inzetten van de assets. Om inkomsten te verhogen zal deze "opslag dienst" moeten worden aangeboden door derden, wat momenteel nog niet kostenefficiënt zal zijn. Op korte termijn zullen er grote investeringen moeten worden gedaan wat niet echt tot kosten reductie zal leiden. Op de lange termijn daarentegen wel, maar dan alleen voor de netbeheerders. Voor de leveranciers zal het verhogen van de inkomsten afhankelijk zijn van welke business modellen er gekozen gaan worden. Is het alleen om energie te gaan verschuiven in de tijd zal het minimaal tot niets zijn, maar gaan ze ook de hardware leveren dan zullen ze zeker wel de inkomsten kunnen verhogen.

Research question 8 (Q17)

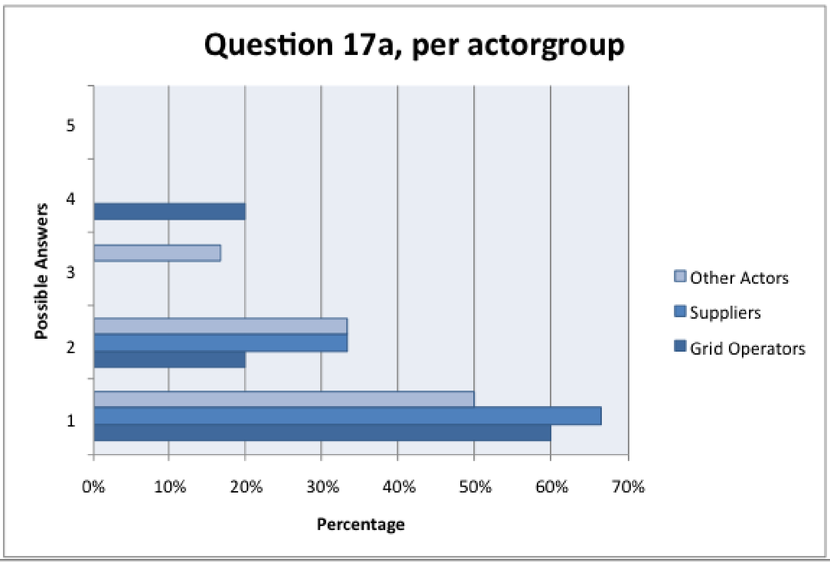
Are there actors in the electricity system that will try to block this development?

Interview Question 17

Verwacht u weerstand vanuit (andere) actoren op de ontwikkeling en/of introductie van deze technologie (incl. de applicaties)?

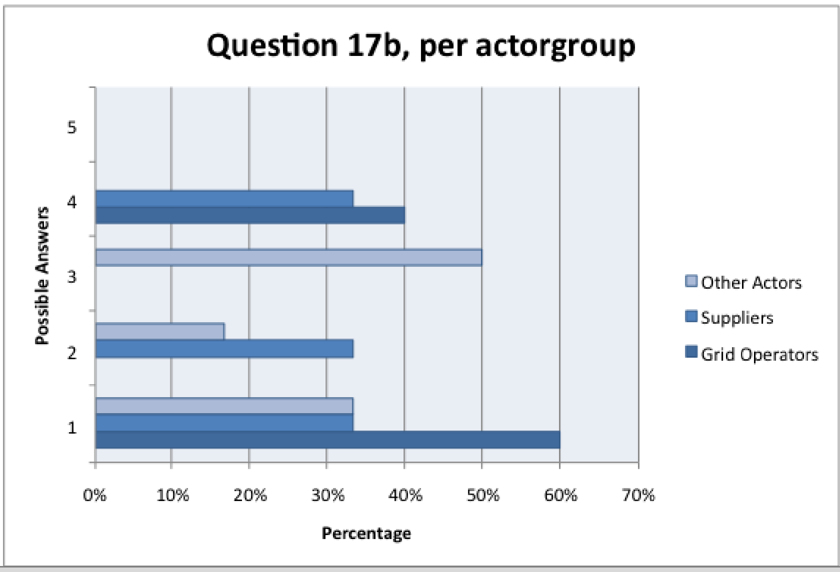
Actor	**Mate van weerstand**				
	Helemaal niet (1)	Niet erg (2)	Neutraal (3)	Enigszins (4)	Erg (5)

a) EU



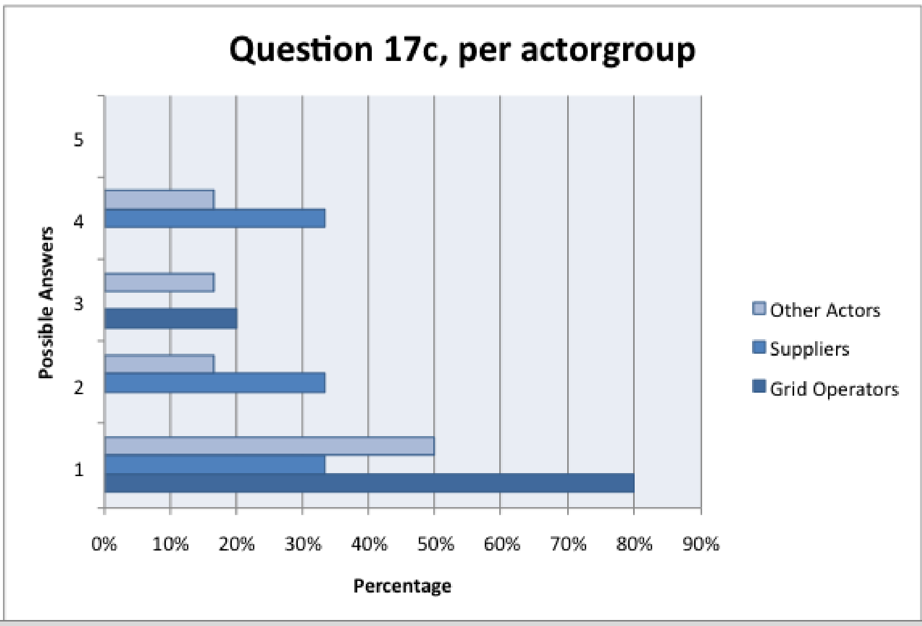
Toelichting "Grid Operators"
Geen echte weerstand maar juist eerder weinig meewerking, hun intentie is namelijk wel meedoen!

b) NMa Energiekamer (en het ministerie van economische zaken)



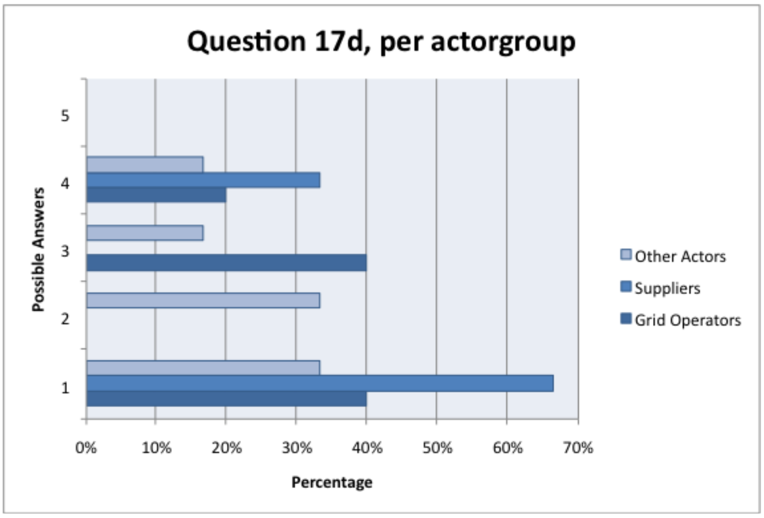
Toelichting “Grid Operators”
Weerstand/vertraging om de wetten en regelgeving aan te passen, al is hun intentie wel om mee te werken.

c) Programmaverantwoordelijke

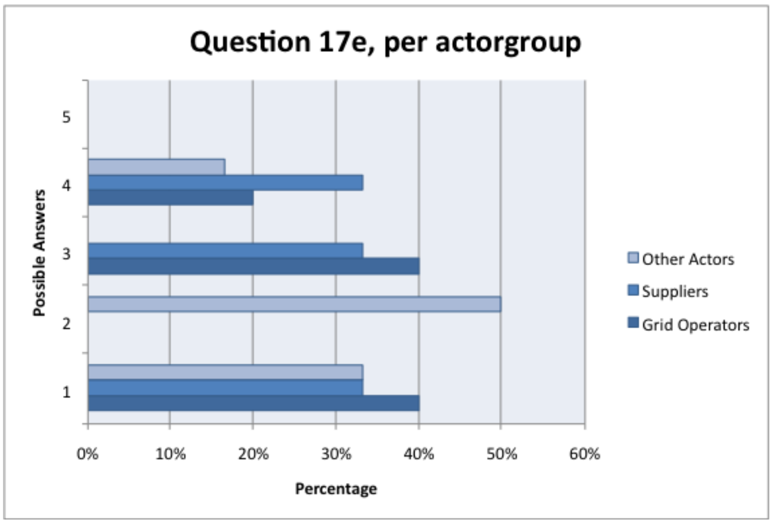


Toelichting “Other actors”
Onduidelijkheid in de onbalans en hoe dit te voorspellen. Dit wordt complexer.

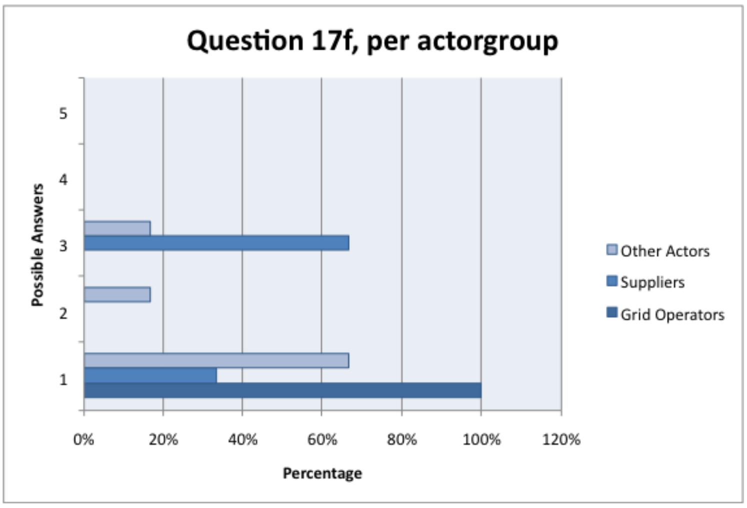
d) Handelaren (Wholesale market)



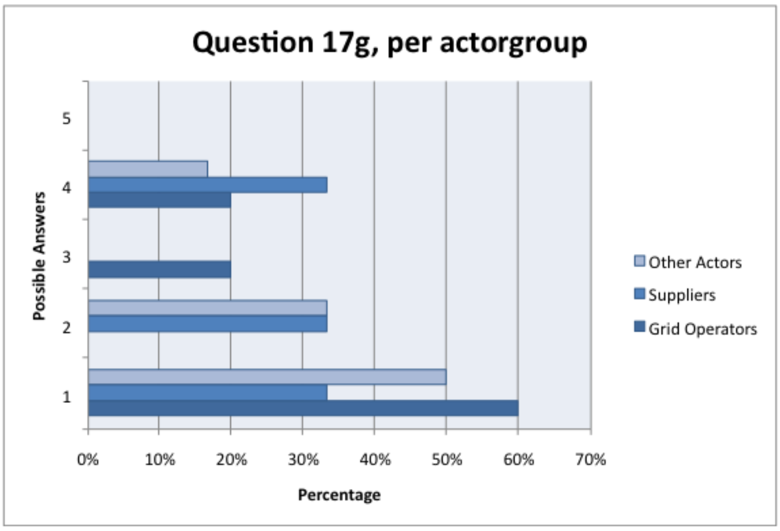
e) Retailers (suppliers)



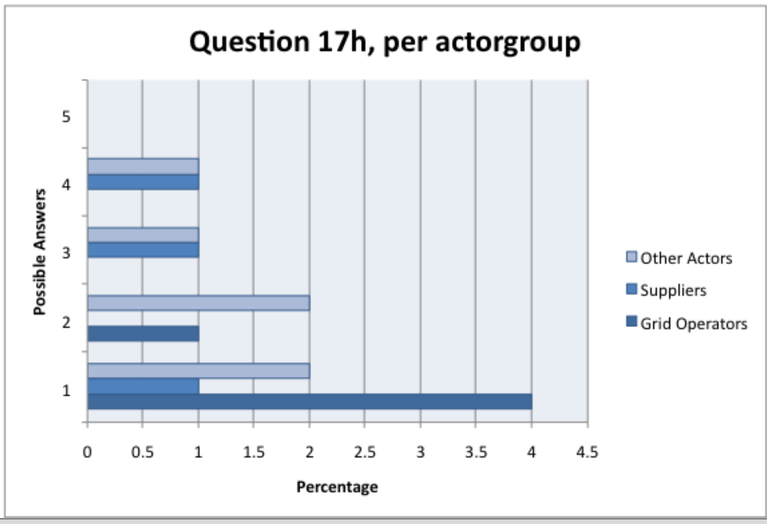
f) Meterverantwoordelijke



g) Producenten

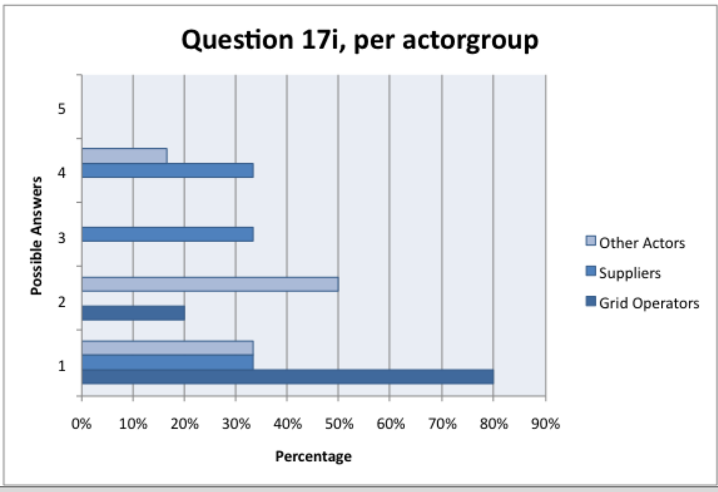


h) TSO TenneT



Toelichting "Grid Operators"
Eventueel omdat ze de onbalans markt zouden moeten aanpassen als dit nodig is.
Toelichting "Electricity provider"
Deze technologie zou eventueel negatief kunnen uitpakken, door b.v. kwaliteit te differentiëren over de gebruikers (v.b. een batt. voor kwaliteit verbetering is alleen economisch haalbaar als er meerdere consumenten mee voorzien kunnen worden, wat dan voor die ene consument iets verder op?)
Toelichting "Other actors"
NMa Energiekamer en het ministerie van economische zaken hebben wezenlijk verschillende rollen, die moeilijk onder één en de zelfde noemer kunnen worden geschoven. Desondanks verwacht ik voor beide een weerstand die "niet erg" zal zijn. Tevens zie ik ook bij de andere partijen geen weerstand ontstaan als dit echt een oplossing voor een bepaald probleem zal zijn

i) Regionale netbeheerders



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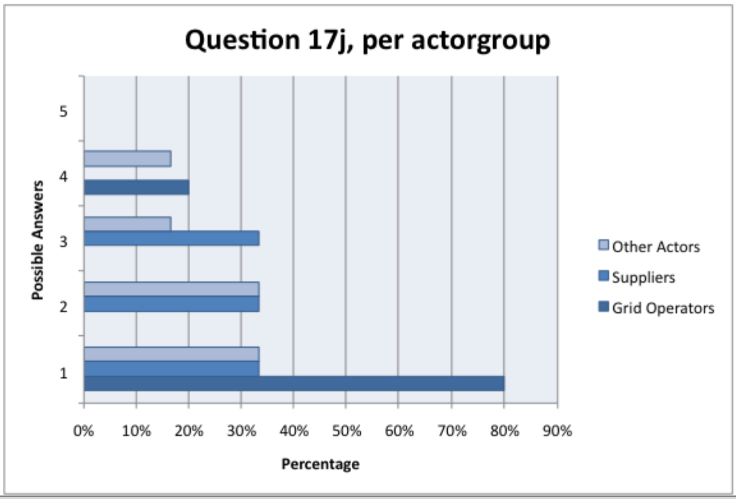
j) Klanten / Consumenten



Toelichting "Grid Operators"
Als iets een goed idee is komt het er wel. Het creëert gewoon een nieuwe vrijheidsgraad die hooguit door Duitse autofabrikanten negatief beoordeeld kan worden. Voor de handelaren en retailers geldt dat hun toegevoegde waarde minder wordt, maar aan de andere kant worden hun risico's ook minder groot. Dit zal elkaar dus opheffen, waardoor ook deze actoren geen weerstand zullen bieden. Handelaren en retailers verdienen nu veel geld aan het feit dat opslag nu niet mogelijk is. Voor producenten kan het twee kanten opgaan, er zitten namelijk zowel negatieve als positieve kanten aan. Positief is dat de centrales constant kunnen draaien en errors (b.v. van wind) kunnen worden gebalanceerd, maar negatief dat het ineens moeten verhogen van de productie veel geld op kan leveren op de APX of onbalansmarkt.

Als deze technologie bijdraagt aan de duurzaamheid van het systeem in zijn geheel, wat vanuit de EU en EZ hoog op de politieke agenda staat, dan verwacht ik eerder een stimulans dan een weerstand. Alleen bij producenten zou ik een weerstand kunnen verwachten, omdat je macht bij hun wegneemt. Al vraag ik me af of ze iets zouden kunnen bereiken als alle andere actoren positief ingesteld zullen zijn.
Toelichting "Electricity Providers"
Waar ik eventueel weerstand zou verwachten is bij gemeentes in de vorm van sociaal ruimtelijke ordening die verstoord zou kunnen worden. Hierbij moet dan worden gedacht aan veiligheid, aanzien van de wijk, etc.
Toelichting "Other Actors"
Er zal vooral weerstand ontstaan doordat de routine van het dagelijkse werk zal worden verstoord. NMa Energiekamer en het ministerie van economische zaken hebben wezenlijk verschillende rollen, die moeilijk onder één en de zelfde noemer kunnen worden geschoven. Desondanks verwacht ik voor beide een weerstand die "niet erg" zal zijn. Tevens zie ik ook bij de andere partijen geen weerstand ontstaan als dit echt een oplossing voor een bepaald probleem zal zijn Het zal hooguit als niet prettig kunnen worden ondervonden, omdat het momenteel niet is opgenomen in het huidige systeem.

Research question 9 (Q18)

Does the current system enable distributed storage facilities?

Interview Question 18

Voorziet u enige problemen in de huidige wet en regelgeving betreffende de introductie van deze technologie in het Nederlandse elektriciteitssysteem?

Toelichting "Grid Operators"
Wetten die het onmogelijk maken om batterij opslag systemen zo efficiënt mogelijk in te zetten zullen bezwijken onder de druk. Dit is een kwestie van tijd. Tevens zal het grootste probleem de statische rol (doorgeefluik) zijn die de netbeheerder moet uitvoeren volgens de wet en regelgeving. Om de maximale toegevoegde waarde uit deze technologie te halen mag de wet en regelgeving geen partij elimineren van het gebruik hiervan en zal daarom aangepast dienen te worden. Desondanks zal de eerste hindernis niet vanuit de wet en regelgeving komen, maar vanuit het kostenstructuur. De technologie moet namelijk goedkoper worden wilt men een "viable" business case kunnen realiseren. Ja. Ik verwacht dat er wel het een en ander in moet worden aangepast, waarbij ik vooral aan het volgende denk: • Levering en teruglevering; • Stuursignalen; • Prioriteiten van stuursignalen; • Etc.

Opslag staat nu niet in de wet en regelgeving en dus moeten er aanpassingen in gemaakt worden om opslag mogelijk te maken. Uiteraard moet dit afgestemd worden met de huidige wetten en regels, wat veel werk met zich mee zal brengen. Zie ook antwoord op vraag 17. Zeker als het onderdeel zou moeten worden van netbeheerder zie ik veel problemen, omdat het nu simpelweg gewoon niet mag volgens de wet en regelgeving.
Toelichting "Electricity Providers"
Ik verwacht hier niet echt een groot conflict, buiten het feit om dat er iets aangepast zou moeten worden omdat opslag nu nog niet echt bestaat.
Toelichting "Other Actors"
Ja zeker! Het fenomeen opslag is gewoon geheel onbekend in de wet en regelgeving. De komst van deze technologie vraagt om een paradigma wisseling en zal een van de belangrijkste struikelblokken zijn die overwonnen dient te worden. Opslag is een van de belangrijkste onderdelen in het "Smarst Grid" denken, maar dit past zeker niet in het markt denken van nu waarop de wet en regelgeving is afgestemd. Dit geldt vooral voor de rol die de netbeheerders hebben in dit systeem. De energiekamer heeft laatst wel aangegeven om ruimte te gaan ontwikkelen voor proefprojecten waar de wet en regelgeving technologische ontwikkelingen betreft "Smart Grids" in de weg staat. Ja, alles wat we anders gaan doen dan voorheen geeft problemen op dit vlak, denk hierbij bijvoorbeeld aan de taken van programmaverantwoordelijke en netbeheerders. Ja, de wet en regelgeving is op dit moment nog onbekend met opslag. Dit betekent dat als men opslag gaat toevoegen aan het huidige systeem de wet en regelgeving hierop moet worden aangepast. Ook de splitsing van baten en lasten kan hier nog een belangrijke rol in gaan spelen. B.v. hoe gaat namelijk de afrekening plaatsvinden? Ja zeker, om twee redenen: • Splitsingswet • Cash Flow Allocation Niet als een netbeheerder deze technologie zou willen gebruiken voor spanningskwaliteiten, al zal dit wel de vraag oproepen of dit handelen/leveren in energie zal zijn. Zou een netbeheerder deze technologie willen gaan gebruiken voor het balanceren van het distributienet, dan voorzie ik zeker problemen in de huidige wet en regelgeving. Op dit moment mag een netbeheerder deze taak niet op zich nemen volgens de wet en regelgeving. Zouden we dit wel willen, dan zouden we voor de regionale netbeheerders een systeem taak in het leven moeten roepen. Deze taak bestaat nu alleen op transmissie niveau (TenneT). Ja, omdat het marktmodel veranderd zal moeten worden. Opslag is namelijk nog geen onderdeel van het huidige systeem / marktmodel.